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Editorial

Dear authors, reviewers, and readers

It has been a month since I was given the privilege to serve as the Chief Editor of the International Journal for Innovation Education and Research (IJIER). It is a great pleasure for me to shoulder this duty and to welcome you to **THE VOL-8, ISSUE-7 of IJIER** which is scheduled to be published on **01st July 2020**.

International Journal for Innovation Education and Research (IJIER) is an open access, peer-reviewed and refereed multidisciplinary journal which is published by the International Educative Research Foundation and Publisher (IERFP). IJIER aims to promote academic interchange and attempts to sustain a closer cooperation among academics, researchers, policy makers and practitioners from a wide range of disciplines, which contribute to state of the art in science, education, and humanities. It provides a forum for the exchange of information in the fields mentioned above by welcoming original research papers, survey papers, and work-in-progress reports on promising developments, case studies, and best practice papers. The journal will continue to publish high-quality papers and will also ensure that the published papers achieve broad international credibility.

The Chief Editor, appointed by the Associate Editors and the Editorial Board, is in charge for every task for publication and other editorial issues related to the Journal. All submitted manuscripts are first screened by the editorial board. Those papers judged by the editors to be of insufficient general interest or otherwise inappropriate are rejected promptly without external review. Those papers that seem most likely to meet our editorial criteria are sent to experts for formal review, typically to one reviewer, but sometimes more if special advice is needed. The chief editor and the editors then make a decision based on the reviewers' advice.

We wish to encourage more contributions from the scientific community to ensure a continued success of the journal. We also welcome comments and suggestions that could improve the quality of the journal.

I would like to express my gratitude to all members of the editorial board for their courageous attempt, to authors and readers who have supported the journal and to those who are going to be with us on our journey to the journal to the higher level.

Thanks,

Dr Eleni Griva

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Clinical Data, Echocardiography and Surgical Wound Infection of Patients Undergoing Cardiac Surgery

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ABSTRACT

Introduction: Due to importance of surgeries for treatment of heart diseases, it is necessary to recognize surgical site infection and other Healthcare-Related Infections as the main post-surgical complications.

Objective: To analyze the association and correlation between clinical and propaedeutic variables with the prevalence of wound infection in patients undergoing cardiac surgery **Methodology:** Quantitative, analytical study with a retrospective approach. Data collection was performed in the Medical Archive Sector of the Clinical Hospital of Uberlandia (HCU), using a previously structured instrument. **Results:** A total of 453 medical records were evaluated, mainly masculine gender ($n=313$; 69.1%). A time patient hospital stays had a mean of 36.47 ± 28.7 days, surgical indication of myocardial revascularization ($n=278$; 61.4%). The rate of surgical wound infection (SWI) found was 19%. Correlation and clinical associations were: Time of surgery and left ventricle ejection fraction (LVEF) ($r=0.10$; $p<0.05$); time hospital stay and almost all echocardiographic variables, weight and height ($p=0.01$); Systolic blood pressure (SBP) and left ventricle posterior wall (LVPW) ($r=0.16$), LVEF ($r=0.12$) and intraventricular septum ($r=0.13$), ($p<0.01$); Diastolic blood pressure (DBP) and left ventricle posterior wall (LVPW) ($r=0.10$; $p<0.01$). **Conclusion:** The study has high potential to increase scientific evidences and improving cardiovascular care, cardiovascular surgery field and prevention of healthcare-associated infections.

Keywords: Cardiac surgery; Hospital infection; Health care

INTRODUCTION

Currently, heart diseases represent one of the main causes of hospital admissions, as well as morbidity and mortality, both worldwide and nationally (BRANT et al, 2017). According to data from the World Health Organization (WHO), the estimate of annual deaths caused by cardiovascular diseases from the year 2030 is about 23 million (BARREIROS et al, 2016).

Despite the great benefit of cardiovascular surgeries, the possibilities of postoperative complications in this treatment are directly related to their complexity. Among the main postoperative complications, the most prominent are infections, with emphasis on surgical site infections and Health Care-Related Infections (BRAZ et al, 2018).

Such infections allow the prolongation of the patient's hospitalization, which favors the exposure of the patient to other possible complications. Furthermore, infections directly influence morbidity and mortality rates, besides increasing the cost of treatment (VIEIRA et al, 2018).

In view of the aforementioned panorama related to the control of microorganisms causing infection, as well as the impact of postoperative infections of cardiac surgeries on public health, scientific and technological investments are necessary to adoption of measures to prevent and control infection, since the hospital context itself threatens patient safety (LEMOS et al, 2018).

In addition, care based on scientific knowledge and through results and research are essential to reduce THE RIS. As well as, such care has an impact on the reduction of morbidity and mortality of patients undergoing cardiac surgery (RODRIGUES, FERRETTI-REBUSTINI & POVEDA, 2016).

However, surgeries can evolve postoperatively with several complications, and currently the focus, both nationally and internationally, is directed to postoperative infections, with emphasis on surgical site infections (BECCARIA et al, 2015). There is a scarcity of research and publications that address the proposed theme.

It is then perceived the need for studies that can observe and correlate the preoperative clinical aspects with the development of complications, as well as to evidence the main microbiological agents involved in these infections.

This study seeks to analyze associations and correlations between clinical and propaedeutic variables with the prevalence of wound infection in patients undergoing cardiac surgery, as well as correlate the echocardiographic profile with the prevalence of surgical wound infection in patients undergoing cardiac surgery in a high complexity hospital.

Methodology

Design

Quantitative, analytical study of retrospective approach of the documental analysis.

Site and Population

Data were collected from the documentary clinical records contained in the medical records, by the researchers, in the Medical Archive Service (SAME) of the Clinical Hospital of the Federal University of Uberlandia (HCU). The population consists of patients who underwent cardiac surgery in the HCU from January 2014 to January 2019, according to data provided by the statistics department of the locus institution, 453 cardiac surgeries were performed within the given period.

Data Collection

The HCU statistics department provided a survey of cardiac surgical procedures from January 2014 to January 2019. Thus, the researchers performed the full reading of all medical records so that the data collection instrument was later completed, which was structured according to the classical literature in the area of cardiovascular nursing and surgical cardiology (RODRIGUES, FERRETTI-REBUSTINI & POVEDA, 2016).

Data Collection Instrument

The data collection instrument was semi-structured from a broad bibliographic review, containing admission data, clinical data (reason for surgery, categorized in myocardial revascularization, valve replacement, abdominal aortic aneurysm and other, weight and height, obtained from the medical records, vital signs, obtained by the shock sheet present in medical records, presence of dyspnea, edema and atrial fibrillation, obtained by the nursing note) propaedeutic data (echocardiography and coronary angiography), data related to surgical wound (infectious signs, dressings and microorganisms isolated), medications used and occurrence of surgical reproach.

Inclusion, exclusion and ethical aspects.

Patients who underwent cardiac surgery during the period determined were included, with age equal to or greater than 18 years and who were not hospitalized during the time of data collection. We excluded patients with the diagnosis of infection prior to the surgical procedure and those with data incomplete fillings. This study has approved by the local ethics committee under no. 1,715,990.

Statistical analysis

The data were entered in the Excel program® in double typing and later perform validation between the two worksheets. Then, the data were imported into the Statistical Package for the Social Science (SPSS) Program, version 21.0, where descriptive statistical analysis and simple frequency were performed, as well as chi-square test for data with categorical outcomes and Pearson correlation test for continuous quantitative data.

Results

Table 1 refers to quantitative variables about the clinical profile of patients. Regarding the time that the surgery had been performed, it is possible to notice the mean of 2.79 ± 1.4 years, while the length of hospitalization was approximately 36.47 ± 28.7 days.

Table 1 - Descriptive analysis of continuous quantitative variables about the clinical profile of patients undergoing cardiac surgery, Clinical Hospital of Uberlandia, 2020

VARIABLE	MINIMUM	MAXIMUM	MEAN $\pm$ SD
Surgery time (years)	1	5	2,79 $\pm$ 1,4
Length of stay (days)	2	190	36,47 $\pm$ 28,7
Age (years)	19	97	59,93 $\pm$ 12,2
Weight (kg)	35	127	73,38 $\pm$ 14,0
Height (cm)	133	201	166,1 $\pm$ 8,4
Axillary temperature (°C)	33	97	36,08 $\pm$ 2,9
Respiratory Rate (rpm)	10	77	19,37 $\pm$ 5,1
Sat O2% (%)	51	100	95,18 $\pm$ 3,6
Heart Rate (bpm)	16	149	76,98 $\pm$ 16,8
Systolic Blood Pressure (mmHg)	62	212	129,7 $\pm$ 22,8
Diastolic Blood Pressure (mmHg)	38	120	76,19 $\pm$ 14,3

Source: the author. Sat O2%: Peripheral oxygen saturation.

Table 2 shows the categorical quantitative variables related to the sociodemographic profile of the analyzed sample alone. It is possible to visualize a higher proportion in male patients (n=313; 69.1%). Regarding the self-reported color, a predominance of white color (n=280; 61.8%), followed by brown color (n=148; 32.7%).

Table 2 - Simple frequency analysis of categorical quantitative variables about the sociodemographic profile of patients undergoing cardiac surgery, Clinical Hospital of Uberlandia, 2020

VARIABLE	n	%
Gender		
Male	313	69,1
Female	140	30,9
Self-reported color		
White	280	61,8
Brown skin	148	32,7
Black skin	22	4,9
Other	3	0,7
Civil Status		
Single	160	35,3
Married	253	55,8
divorced	24	5,3
Widower	16	3,5
TOTAL	453	100

Source: The author.

The surgical indication is shown in Table 3. Myocardial revascularization (n=278; 61.4%), valve change (n=93; 20.5%) and abdominal aortic aneurysm (n=50; 11%) were the most prevalent. It should be noted that the same patient could have more than one reason for surgical indication.

Table 3 - Simple frequency analysis of categorical quantitative variables regarding the surgical indication of patients undergoing cardiac surgery, Clinical Hospital of Uberlandia, 2020

SURGICAL INDICATION	n	%
Myocardial Revascularization	278	61,4
Valve change	93	20,5
Abdominal Aortic Aneurysm	50	11,0
Pericardial Stroke	8	1,8
Interatrial Communication	12	2,6
Valve prosthesis implant	6	1,3
Angioplasty	16	3,5
Pacemaker implant	21	4,6
TOTAL	453	100

Source: The author.

Regarding the prevalence of infection, the surgical wound infection (SWI) (n=86; 19%), respiratory system infection (n=48; 10.6%), and subsequently infection of the cardiovascular system and infection in the genitourinary system, both with statistically equal proportions (n=30; 6.6%), as shown in Table 4, stands out.

Table 4 - Simple frequency analysis of the prevalence of infection in patients undergoing cardiac surgery, Clinical Hospital of Uberlandia, 2020

VARIABLE	n	%
Surgical Wound Infection	86	19,0
Respiratory System Infection	48	10,6
Cardiovascular System Infection	30	6,6
Digestive System Infection	4	0,9
Osteoarticular System Infection	8	1,8
Genitourinary System Infection	30	6,6
Tegumental System Infection	17	3,8
Idiopathic Infection	20	4,4
TOTAL	453	100

Source: The author.

Table 5 shows correlations between clinical data and pre-surgical echocardiographic. The time of surgery had a positive, strong ($r=0.10$) and significant ($p<0.05$) correlation with the left ventricle ejection fraction (LVEF). The length of hospitalization established a positive, strong and significant correlation ($p=0.01$) with most of echocardiographic variables, as well as the variables weight and height. Systolic blood pressure (SBP) was positively, strongly and significantly correlated ($p<0.01$) with the variables left ventricle posterior wall (LVPW) ($r=0.16$), LVEF ($r=0.12$) and intraventricular septum ($r=0.13$). Diastolic blood pressure (DBP) was correlated with LVPW ($r=0.10$; $p<0.01$)

Table 5 –Correlations between clinical data and echocardiographic variables of patients undergoing cardiac surgery, Clinical Hospital of Uberlandia, 2020

VARIABLE	AO. Diam (mm)	LA. Diam (mm)	DLV. Diam (mm)	SLV. Diam (mm)	LVPW (mm)	LVEF (%)	IV.SEP (mm)
Surgery time (years)	- 0,04	0,07	0,05	0,01	0,02	0,10*	- 0,05
Hospital stay (days)	0,06	0,16**	0,14**	0,14**	0,13**	- 0,12**	0,09
Age	0,03	- 0,01	0,03	0,03	0,13**	- 0,07	0,15**
Weight (kg)	0,25**	0,20**	0,16**	0,11**	0,17**	0,00	0,14**
Height (cm)	0,35**	0,13**	0,20**	0,18**	0,12**	- 0,07	0,11**

Ax. T (°C)	0,01	- 0,00	- 0,06	- 0,02	0,03	0,05	0,02
R.R. (rpm)	- 0,02	0,02	- 0,05	- 0,04	0,06	0,04	0,08
O₂ Sat (%)	0,03	- 0,03	0,01	0,00	- 0,03	0,00	- 0,05
C.R (bpm)	0,03	0,02	- 0,00	0,03	0,03	- 0,11	0,00
SBP (mmHg)	0,06	- 0,07	- 0,00	- 0,05	0,16**	0,12**	0,13**
DBP (mmHg)	0,08	- 0,05	- 0,07	- 0,08	0,10*	0,05	0,06

Source: The author. **Ax. T:** axillary temperature; **R.R:** respiratory rate; **O₂ Sat.:** oxygen saturation; **C.R:** cardiac rate; **SBP:** systolic blood pressure; **DBP:** diastolic blood pressure. **AO. Diam:** Diameter aortic; **LA Diam:** diameter left atrium; **DLV. Diam:** diastolic diameter left ventricle; **SLV. Diam:** systolic diameter left ventricle; **LVPW:** left ventricular posterior wall; **LVEF:** left ventricle ejection fraction; **IV. SEP:** intraventricular septum

*p<0,05; **p<0,01

Association tests demonstrate clinical and propaedeutic data with the prevalence of Surgical Wound Infection (SWI) demonstrates an association with longer hospital stay (p=0.00), and higher RATES of SWI in patients with an older age (p=0.00). As for the association between the dependent variable (SWI) and the R.A diameter realizes that the higher the L.A diameter higher infection rates (p=0.02), as shown in Table 6.

Table 6 - Association between clinical and propaedeutic profile with the prevalence of Surgical Wound Infection in patients undergoing cardiac surgery, Clinical Hospital of Uberlandia, 2019.

VARIABLES	SWI		
	Yes	No	p
Surgery Time (years)	2,56	2,85	0,08
Hospital Stay (days)	52,55	32,70	0,00**
Age (years)	63,34	59,13	0,00**
Weight (kg)	74,12	73,20	0,59
Height (cm)	165,07	166,36	0,23
Ax.T (°C)	35,91	36,12	0,28
R.R (rpm)	20,69	19,06	0,09
O₂ Sat(%)	94,88	95,25	0,38
C. R (bpm)	79,09	76,48	0,24
SBP (mmHg)	132,43	129,05	0,22
DBP (mmHg)	77,90	75,78	0,21

Diameter R.A (mm)	35,08	34,99	0,88
Diameter L.A (mm)	43,80	41,79	0,02*
DLV. Diameter (mm)	53,38	51,31	0,16
SLV. Diameter (mm)	36,57	35,19	0,31
LVPW (mm)	10,23	10,03	0,34
LVEF (%)	54,27	56,36	0,22
Intraventricular Septum (mm)	10,64	10,50	0,55

Ax. T: axillary temperature; **R.R:** respiratory rate; **O₂ Sat.:** oxygen saturation; **C.R:** cardiac rate; **SBP:** systolic blood pressure; **DBP:** diastolic blood pressure. **R.A:** right atrium; **L.A:** left atrium; **DLV.** diastolic left ventricle; **SLV:** systolic left ventricle; **LVPW:** left ventricular posterior wall; **LVEF:** left ventricle ejection fraction;

*p<0,05; **p<0,01

DISCUSSION

Clinical and sociodemographic profile

The length of hospitalization of the patient is intrinsically related to the occurrence of infectious processes in view of the high exposure of invasive procedures and microbiological exposure in the hospital context. A previous study conducted in 2019 showed that the mean length of hospital stay of patients after cardiac surgery was about 31.8 days, a result that is similar to the present study (KANASIRO, TURRINI & POVEDA, 2019).

On the other hand, other studies show lower means, also leading to lower mortality rates and hospital costs (KOERICH, LANZONI & ERDMANN, 2016; SILVEIRA et al., 2016). The individual clinical picture, presence of comorbidities and type of procedure should be taken into account in the analysis of length of hospitalization.

The age group of patients in this study is in line with several recently published investigations, demonstrating greater involvement in patients over 50 years of age (KANASIRO, TURRINI & POVEDA, 2019; DORDETTO, PINTO & ROSA, 2016; SILVA et al., 2019; BRAZ et al., 2018; SILVEIRA et al., 2016).

With regard to the gender variable, it is perceived that the predominance in male patients observed as a result of this study corroborates with data available in the literature. Men have a lower tendency of self-care when compared to women (SILVA et al., 2019; SILVEIRA, et al., 2016; VELLONE et al., 2017; NORDGREN, SÖDERLUND, 2017; DORDETTO, PINTO & ROSA, 2016; (MOREIRA, GOMES; RIBEIRO, 2016). Although research indicates black populations genetically vulnerable to heart disease, the findings in the present study contradict this statistic. This result can be hypothetically explained by two reasons: self-declaration of ethnicity and spontaneous demand of white participants to be included in the study. White and married marital patients were predominantly found in other investigations (DORDETTO,

PINTO & ROSA, 2016; DE ALMEIDA NETO, et al. 2016; KOERICH, LANZONI & ERDMANN, 2016; BRAZ et al., 2018; SHUBERT et al., 2018).

Surgical Indication

Procedures such as myocardial revascularization, valve replacement and aortic aneurysm found in this study are in line with the literature (DORDETTO, PINTO & ROSA, 2016; SILVA et al., 2019; BRAZ et al., 2018). Other studies also describe other procedures (aortic reconstruction and angioplasty) as highly prevalent (SILVEIRA et al., 2016; MURAKAMI et al., 2017). It is noted that the higher prevalence of revascularization in the present study may result from another previous cardiac event, the most common being acute myocardial infarction (SILVA et al., 2018).

Regarding the non-modifiable factors that are closely linked to the risk for the development of heart disease, it is worth noting age, gender, race and/or ethnicity and family history. As previously presented, male patients have a greater predisposition to heart diseases, especially with regard to AMI, even older age increases this risk (OLIVEIRA et al., 2018). In relation to modifiable factors, it is of paramount importance to cite chronic diseases as factors directly linked to cardiac involvement, the main ones pointed out by an integrative review of systemic arterial hypertension, dyslipidemia, and diabetes mellitus caused by life habits such as sedentary lifestyle, smoking and alcohol consumption (COSTA et al., 2018; ANDRADE et al., 2019; OLIVEIRA et al. 2018; FREIRE et al. 2017).

Prevalence of Body Site Infection

The present study shows an incidence rate of surgical wound infections of 19%, given this is consistent with a previous study, where the infection rate was 18.6% (BRAZ et al., 2018; TAUFFER et al., 2019). Other studies that investigated factors associated with mortality in the postoperative period of cardiac surgery, there was a higher prevalence of respiratory tract infections, which also includes the analysis performed (KOERICH, LANZONI & ERDMANN, 2016; TAUFFER et al., 2019). Infectious rates in the cardiovascular and urinary tract systems also corroborate the literature, with similar statistics resulting from invasive procedures, health care-related infection, long-stay invasive devices and the patient's clinical picture (TAUFFER et al., 2019; SOUSA, OLIVEIRA & MOURA, 2016; RODRIGUES et al., 2019).

Correlations between clinical and echocardiographic data

Correlations between surgery time and LVEF suggests an improvement in cardiac function over the years following surgical correction (TOMÉ, 2018).

With regard to age, it is known that aging promotes several both anatomical and physiological changes in the body, with regard to changes in the cardiovascular system we can perceive the increase in cardiac muscle mass due to the increase in greater peripheral arterial resistance, changes that prove the significant correlation between age and thickness of the LVPW and the Intraventricular Septum (ANDRADE et al., 2016; AMBROSIM, 2019).

Also, it is possible to perceive the correlation between anthropometric variables, weight and height, and echocardiographic data, this, as a function of body composition. Patients with a larger body surface have a

deviation from the normality of echocardiographic findings due to the need for the cardiac system to adapt to promote adequate blood supply (FARIA et al., 2018; DORDETTO, PINTO & ROSA, 2016).

Regarding SBP, it is perceived that due to the aging process the aorta acquires a greater rigidity, thus causing the increase of this vital sign to occur (ANDRADE et al. 2016). This increase promotes hypertrophy of the cardiac muscles of the left ventricle, which explains the correlation between this variable and the increase in LVPW and intraventricular septum (BERTOLUCI et al., 2019; ALBUQUERQUE et al., 2017; BRAZILIAN SOCIETY OF CARDIOLOGY, 2016).

Associations between clinical and echocardiographic data and SWI rate

Significant associations were established between length of hospital stay and wound infection. As already mentioned, patient exposure in the hospital context increases the risk for the development of infections. The SWI are mainly related to the surgical procedure, but also to the care provided to the client during his hospitalization. In addition, it is dependently related to the clinical status of patients before the procedure (RODRIGUES et al., 2019). It is also worth noting the two-way association that the length of hospitalization has with the rates of SWI and other infections (SILVA et al., 2016).

Another variable that is significantly associated with SWI indices is age. The mean age of patients who underwent cardiac surgery in the period analyzed, as stated above, was around 60 years. It is at this stage of life that the immuno senescence process begins, thus leaving the individual more exposed and prone to acquiring infections and developing other types of comorbidities (ZONTA et al., 2018).

Conclusions

The study has achieved all proposed objectives, showing clinical and sociodemographic profile of patients undergoing cardiac surgery in a high complex hospital. Furthermore, a rate of surgical wound infection has found (19%) as well as the mainly procedures (myocardial revascularization, valve change and abdominal aortic aneurysm). Important statistical clinical outcomes were established, for instance, correlations between echocardiographic parameters and clinical profile. Moreover, association tests demonstrate clinical and propaedeutic data with the prevalence of Surgical Wound Infection.

Limitations need to be appointed, such as uncompleted medical archives leading to data collected limitations and reduction in the sample. In other hand, that study has potential to show scientific evidences in the cardiovascular care, cardiovascular surgery field and prevention of healthcare-associated infections. Other kind of studies, methodologies and statistical approaches must be developing in order to provide new data and improving that scientific field.

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The Lean Healthcare Approach in Health Services: A Systematic Review of The Literature

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Abstract

Lean principles are being successfully applied in the most diverse sectors beyond industry. In the health area, the so-called Lean Healthcare is gaining space with the implementation of lean methods that contribute to the maximization of value and quality to the patient. The objective of this work was to carry out a systematic review of the literature to identify and analyze the practice of Lean Healthcare and its tools in hospital environments. Scientific articles available in the database of the CAPES Periodic Portal were selected, and 161 articles were found, among which, 16 were selected. The results point to recent research, with practical applications where case studies are predominant. Lean tools have been applied in several countries to promote improvements in hospital environments, and the main ones are MFV, 5S, Standardization, Kaizen and Kanban. With this study, it was possible to observe that the use of lean techniques in health has been promoting significant benefits in the work environments, in the team's conduct, and the patients' experience, and that the human factor is what most hinders the implementation of these techniques.

Keywords: Lean Healthcare; Hospital applications; Systematic review.

1. Introduction

In essence, the lean philosophy implements several tools and techniques that aim to reduce waste and reduce costs, in the search for sources of competitive advantage. The objective is also to maximize the

value for the customer, where value means the ability to offer services and products according to the customer's needs, at the exact moment and with convenient prices (Bhamu & Sangwan, 2014; Lacerda, Xambre & Alvelos, 2016).

However, lean principles are not exclusive to the industrial sector and have been used with success in the operations of various sectors, an example of supply chains, in the education, administration, maintenance, product development and also in hospitals (Rauch, Damian, Holzner & Matt, 2016; Dias, Reis, Oliveira, Maruyama & Martinez, 2018).

When it comes to the health sector, the product expected by patients is the cure of their ills, which translates into the value of these services (Spagnol, Min & Newbold, 2013). Therefore, every day, health organizations seek to improve the quality of work and management practices to offer assistance benefits to their target audience, which are the patients (Dias et al., 2018).

Studies report that as a result of applying lean presuppositions to health services, projects are intensifying with the implementation of safe and quality techniques to patients, with the so-called Lean Healthcare (Ferreira, Silva, Tanaka & Zampini, 2016; Costa, Godinho Filho, Rentes, Bertani & Mardegan, 2017).

In this sense, and considering the benefits of Lean philosophy when applied to processes, this study set out to answer the following question: What tools or Lean methods are being applied to promote benefits to health services? As an objective, this study intended to carry out a literature review on Lean Healthcare, derived from the use of Lean principles in health services, to identify and analyze the practice of lean techniques in hospital environments.

The work is divided into five parts: After the introduction, a brief theoretical framework of the concept of lean production and the evolution of its presuppositions to other areas is presented. Next, the methodology that led the research work is presented. The results are presented based on the detailing and analysis of the selected productions. Ultimately, the conclusions are presented.

2. The Lean Concept

The term lean expresses the idea of doing more using less, based on a system where multiple outputs are created with the possible inputs (Bhamu & Sangwan, 2014; Hallam & Contreras, 2018).

The Toyota Production system changed the scenario of mass production with the lean implementation of smaller batches and varied products. Thus, lean production brought the focus on reducing production waste and also on the customer, working to provide products at the right time, with quality and at the lowest cost (Dias et al., 2018; Oliveira, Sousa & Campos, 2019).

As basic principles, Lean presents: 1- Identification of value; 2 - Value stream Mapping; 3 - Creation of continuous flow; 4 - Let the customer pull the service; and 5 - Always seek perfection (D'Andreanatteo, Ianni, Lega & Sargiacomo, 2015; Rauch et al., 2016).

On the other hand, among the tools or techniques are: Just in Time, Jidoka, 5S, Value Stream Mapping (VSM), Quick Tool Change, Standardized processes, Takt time, Cellular Layout, Visual control, Training, Empowerment, Total Productive Maintenance, Level Production (Heijunka) and Zero Defect Quality Control (Regis, Gohr & Santos, 2018).

Given the aspects exposed and its applicability, studies show that the Lean concept has evolved and

extended to other operations and services, such as office processes - Lean Office, in the construction sector - Lean Construction, and also to health area - Lean Healthcare (Ferreira et al., 2016; Rauch et al., 2016; Dias et al., 2018).

2.1 Lean Healthcare

The literature shows that several studies have addressed the lean philosophy in the health sectors since the early 2000s. Bearing in mind that administrative processes are the basis for implementing lean techniques, it is considered that such practices are equally applicable to health care (D'Andreanmatteo et al., 2015; Dias et al., 2018; Hallam & Contreras, 2018).

Lean Healthcare adds culture to hospitals based on increasing patient satisfaction through continuous improvements, in which employees identify and eliminate what does not add value (Costa & Godinho Filho, 2016; Doğan & Unutulmaz, 2016).

The main objectives of its implementation are to improve patient care and safety, reduce the patient's stay in hospital facilities, reduce the patient's waiting time and reduce the hospital stock (Rauch et al., 2016; Hallam & Contreras, 2018).

Since the lean focus is reducing waste, Table 1 shows the seven wastes adapted to Lean Healthcare.

Table 1. The seven wastes adapted to Lean Healthcare.

Type of waste	Description	Adapted to Lean Healthcare
Defects	Quality problems during the processes: they require to rework. They are related to the lack of standardization or production control systems	Medical errors
Waiting time	Every pause during the production process of a product, whether due to a lack of people, materials or equipment, means a non-added value for the customer	Waiting for professional assistance, medical prescription, or test results
Inventory	Raw material waiting to be processed. Often the stock of products or materials is associated with production bottlenecks	The excessive stock of medicines
Movement	Unnecessary movement of workers, machines or tools slows down execution and does not add value to the product	Unnecessary movements of people looking for information or documents
Processing	Any operation or step in a process that does not contribute to generating value for the product is considered a waste of production	Excessive processing with unnecessary Form
Excessive Production	Producing more than the demand at the moment are resulting in unnecessary use of resources without a financial return, in addition to generating a lot of stock	Conduct an unnecessary medical investigation
Transport	A product or material transported from one place to another is not being processed, so it does not add value to the customer. In addition, there are costs for transport and	From patients, samples or hospital supplies

maintenance equipment itself

Source: Elaborated from Zakaria *et al.* (2017) and Hallam and Contreras (2018).

Lacerda, Xambre and Alvelos (2016) and Oliveira, Sousa and Campos (2019) mention that an eighth waste must be added to lean processes: wastage with the non-use of human potential. Similarly, in the health sector, the eighth waste is also referred to when reporting that in Lean Healthcare there is a flaw in the “human talent” factor when there is no medical training for agents who could assist in diagnoses (Costa & Godinho Filho, 2016).

3. Methodology

The methodology used in this study was a systematic literature review. An effective literature review is one that creates a firm basis for the advancement of knowledge (Levy & Ellis, 2006). For Tranfield, Denyer and Smart (2003) the importance of this technique is in the survey of the best scientific productions on the theme that is to be addressed.

Levy and Ellis (2006) describe that the literature review process consists of three main steps, being perfectly applied to any field of study. Figure 1 illustrates this process.

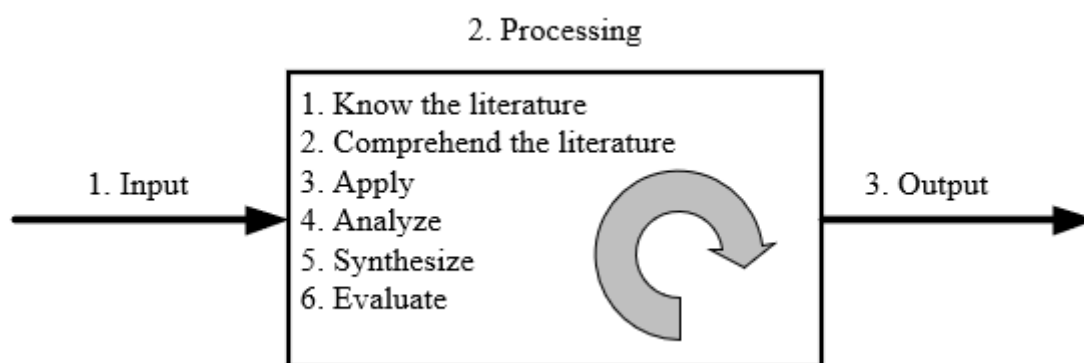


Figure 1. The three phases of the effective literature review process

Source: Levy and Ellis (2006).

The entry phase consisted of literary research adopting a literature review according to the procedures described by Cronin, Ryan and Coughlan (2008) in their article entitled: Undertaking a literature review: a step-by-step approach, as detailed below.

1 - Selection of the database: studies were made available on the CAPES Periodic Portal, which allows free institutional remote access to teachers, technicians, and students, in addition to concentrating a range of easily accessible databases.

2 - Search terms: the “lean healthcare” research axis was defined, which was combined with the Boolean inclusion operators “AND” and “OR,” aiming to retrieve posts in the title, abstracts, or even in the keywords

of the articles related to the question and the research objective. Thus, the key terms combined to the axis were: "5S," "kanban," "kaizen," "just in time," "in time," "jidoka," "value stream mapping," "TQM," "TRF," "layout."

3 - Type of material used and period of publication: papers of the type Articles of journals, published in the last five years, from 2015 to 2019 were selected. It should be noted that the period was established to obtain several recent works that address the theme and meet the research objective.

4 - Exclusion Criteria: show only "peer-reviewed journals," "complete texts available for download," and "non-duplicated texts."

In the Processing phase, after applying the parameters: search terms; publication period; show only peer-reviewed journals; and all studies of the Articles type, the result presented a total of 161 productions.

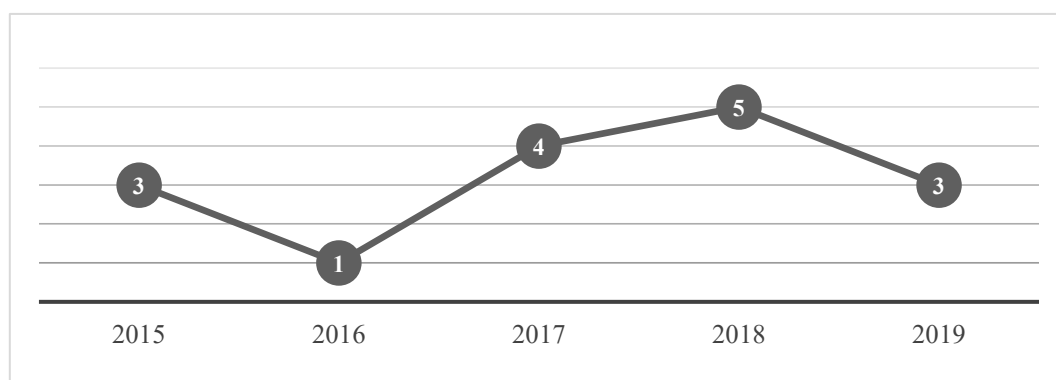
Based on the title of the articles, 3 were duplicated and 10, apparently related, did not present the full texts, so 13 were discarded. Other criteria applied were: adequacy of the title to the objective of the research and reading of the abstracts, from which were excluded: 28 articles where lean techniques or principles were applied in services other than health; 65 articles that did not present empirical studies; 39 articles that did not answer the research question.

After this process, 16 articles remained to be analyzed in full. For this purpose, the final phase of the review was carried out to classify the findings regarding the research methodology, and the tools used. The "Outputs" are exposed in "Analysis and Results."

4. Analysis and Results

Considering the publications in the period defined for the review, the research pointed out that the productions had their growth in the years of 2017 and 2018, with 4 and five articles published, respectively. As shown in Graphic 1, 2016 was the year with the least number of studies that applied lean healthcare tools, however, it is worth mentioning that among the selected period, there was at least one publication related to the theme, demonstrating that the subject remains current and relevant.

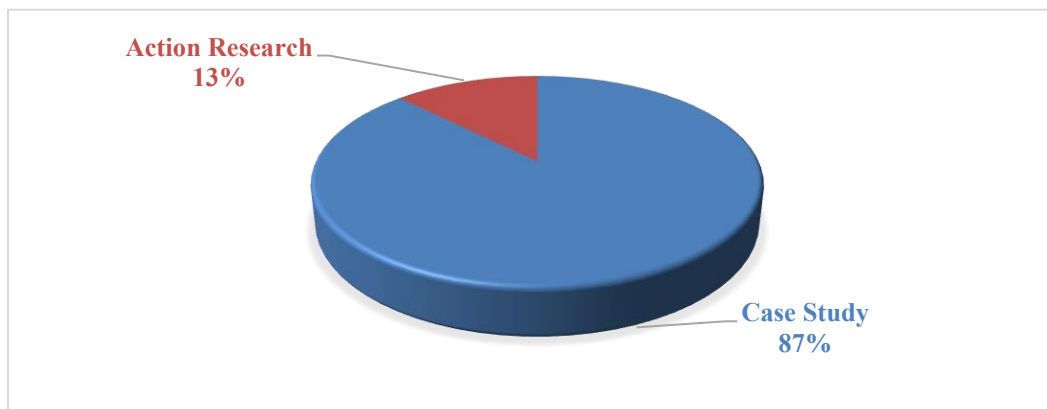
Graphic 1. Production by year



Source: Survey data (2020).

Analyzing the portfolio, tried to identify the methodology addressed in each empirical study. Thus, it was found that the methods adopted in the research were: the Case Study and Action Research. The case study stands out as the most used method among the materials, as shown in Graphic 2:

Graphic 2. Methodologies used in the articles

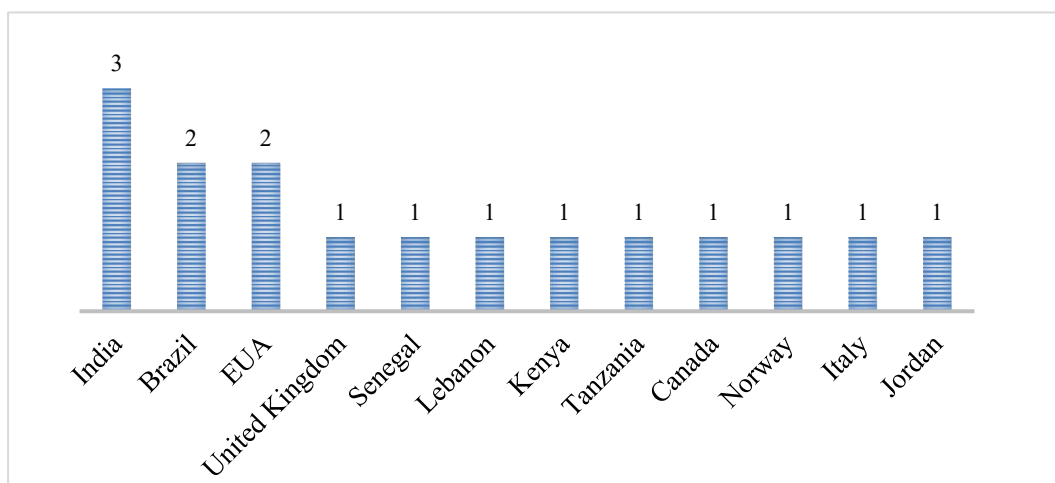


Source: Survey data (2020).

The case study appears as the main methodology among the texts, used in 14 articles and representing a total of 87% of the portfolio. According to Yin (2015), the case study focuses on the analysis of specific phenomena to help in understanding the events that involve individuals and jobs. In that sense, they can perfectly help in expanding the knowledge about the implementation of lean techniques and their different results.

Furthermore, it is worth noting that among the studies, the use of lean techniques in health services proved to be quite comprehensive. According to Graphic 3, the research reports the application of lean tools in environments located in different countries.

Graphic 3. Research countries



Source: Survey data (2020).

4.1 Portfolio analysis

In this step, the information will be listed that will support the analysis of the content of the selected works.

Table 2 shows the list of chosen articles in which the results were achieved with the application of the same tool.

Table 2. Use of the 5S technique

Authors	Objectives	Results
KANAMORI, S <i>et al.</i> (2015)	To assess how the 5S method creates changes in the workplace, in the process and the results of health services, and how it can be applied in a low-resource environment	1) Organization of the work environment; 2) Improvement in the attitude and behavior of employees; 3) Improvement in patients' behavior; 4) Increase in the quality of services.
KAMIYA, Y <i>et al.</i> (2017)	To evaluate the impact of implementing continuous quality improvement (CQI) methods on patient's experiences and satisfaction in Tanzania.	1) Improvement in the cleanliness of the hospital, in the waiting time and the general classification evaluated by the patients in the outpatient clinic; 2) The effect of 5S on patient satisfaction was not strong.

Source: Survey data (2020).

Considering that 5S is a management tool focused on cleaning and organizing workplaces (Young, 2014; Veres, Marian, Moica & Al-Akel, 2018), Kanamori *et al.* (2015) and Kamiya *et al.* (2017) studied the implementation of this technique in healthcare environments located in Senegal and Tanzania.

As a result, 5S made it possible to improve environments, raise awareness of teams and patients; increase the quality of services in terms of efficiency, patient-centeredness, and safety, and also demonstrated that, even though it did not have such strong effects on patient satisfaction in Tanzania, 5S improved the waiting time and the evaluation performed by patients.

Table 3 shows that the use of this lean tool was useful in the studies to identify bottlenecks, improve the value and reduce outpatient waiting times, remodel hospital discharge planning processes, improve the quality of care in environments and redesign urgency departments, showing significant results in all studies.

Table 3. Use of the VSM technique.

Authors	Objectives	Results
MILLER, R; CHALAPATI, N (2015)	Demonstrate how lean tools have been applied to some issues unique to health service delivery in a developing country	1) Average outpatient waiting times reduced from 1 hour to 15 minutes; 2) Redesigning the process resulted in more than 70% of patients pre-scheduling their appointments; 3) Higher productivity.
MCDERMOTT, C; VENDITTI, F (2015)	To explore the implementation of Lean techniques in the discharge planning process (DPP)	1) Creation of standard work; 2) Reduction of 17 minutes (average) in-hospital stay.
RAMASWAMY, R <i>et al.</i>	Apply Value Stream Mapping to improve service quality	1) More transparency and ease of sharing between the clinical and support staff;

(2017)		2) Created a consensus around the definition of common work in the organization.
JOHANNESSEN, K. A; ALEXANDERSEN, N (2018)	Demonstrate that long waiting times and waiting lists are not necessarily associated with increased demand or changes in resources	1) The average waiting time in all clinics has been reduced; 2) Reduction in the number of new waiting patients from 15,874 to 8,922; 3) Reduction from 18,700 to 5,993 in the number of patients who returned late.
AL HROUB, A. et al. (2019)	Improve clinic time efficiency, decrease clinic waiting time and increase patient satisfaction	1) Reduction in waiting time at the clinic to 19.5 and 21 minutes in the two post-intervention conditions; 2) Increase in patient satisfaction to 100% and 96.7% in the two post-intervention trimesters.

Source: Survey data (2020).

Miller and Chalapati (2015), Mcdermott and Venditti (2015), Ramaswamy *et al.* (2017), Johannessen and Alexandersen (2018) and Al Hroub *et al.* (2019) used the VSM (Value Stream Mapping) in their studies as it is a tool that allows them to visualize what happens during the work, identify what adds value or not, and enable the improvement of flows (Verma & Amar, 2015; Suarez-Barraza; Miguel-Davila; Vasquez-García, 2016).

New *et al.* (2016) made use of training and standardization, which consists of constant improvement of the organization, reducing variations, and improving the quality of processes and products (Míkva, Prajová, Yakimovich, Korshunov & Tyurin, 2016). With that, they proposed to improve the lean participatory process in trauma orthopedics in a UK hospital and as shown in Table 4, they achieved specific improvements in this surgical care.

Table 4. Use of the Standardization technique.

Authors	Objectives	Results
NEW, S et al. (2016)	To examine the effectiveness of a “systems” approach using Lean methodology to improve a hospital's surgical care	1) 33% increase in the presence of anesthesiologists at the trauma meeting; 2) The number of changes in the list of operations has decreased; 3) Patients arriving at the anesthesia room 20 minutes before.

Source: Survey data (2020).

Improta *et al.* (2018) and Vashi *et al.* (2019) combined the techniques of 5S, VSM and Standardization to improve processes, reduce times and redesign operations, which after the implementation of the techniques and the respective changes, could see reductions in the waiting time of many processes, as illustrated in the Table 5.

Table 5. Use of 5S, VSM and Standardization techniques.

Authors	Objectives	Results
IMPROTA, G <i>et al.</i> (2018)	Increase the flow of patients, improving the processes that contribute to facilitate the flow of patients through the various stages of medical treatment and eliminating all bottlenecks (queue) as well as all activities that generate waste	1) Reduction of the total time of the five phases: screening, examination, diagnostic test, counselling and dispensation; 2) Reduction in post lean performance measurements.
VASHI, A. A <i>et al.</i> (2019)	To describe the extent and depth to which Lean methodologies are used to quickly redesign the operations of a US emergency department to reduce waiting times, as well as assess whether the intervention achieved its goal	1) Reduction of Door to the Triage time 16.4 to 10.1 minutes; 2) Reduction in Door to Doctor's time from 34.7 to 22.1.

Source: Survey data (2020)

Considering the multiple tools applied in the other selected studies, below (Table 6), the result of the joint use of the mentioned techniques with at least two or more is presented.

Table 6. Use of various techniques.

Authors	Objectives	Results
COSTA, L.B.M <i>et al.</i> (2017)	Assess how five sectors of two Brazilian hospitals have implemented lean health care concepts in their operations	Sterile service's sector: 1) 94% reduction in surgery delay; 2) Reduction of 1 to 1.5% to 0.21% in the infection rate; 3) Reduction of the preparation time between the autoclave cycles by 30 minutes; 4) Reduction of the autoclave cycle time by 30 minutes. Pharmacy Sector 1) Reduction of the inventory balance (monthly average) from R \$ 2,000,000.00 to R \$ 1,600,000.00. Chemotherapy sector: 1) 23% increase in the number of chemotherapy applications 2) 42% reduction in the patient's average waiting time;

		3) 50% reduction in the number of patients waiting for chemotherapy to start. Surgery room: 1) Creation of central scheduling surgery. Radiotherapy sector: 1) Reduction of the time between one application of radiology and another; 2) Increase in the time that professionals had been available for patient care.
HITTI, E. A et al. (2017)	To assess the impact of a Lean intervention on the response time of transport for simple radiography in an emergency room at a tertiary care center in Lebanon.	1) Transport response time (TAT) dropped from 22.9 to 9.9 minutes; 2) Process reliability improved from 32.3% to 71.6%, with patients being transported in 10 minutes.
GUPTA, S; KAPIL, S; SHARMA, M (2018)	Discuss the implementation of lean methodology to reduce the response time (TAT) of a clinical laboratory in an Indian hospital	1) Reduction in TAT of the CBC laboratory from 179.49 to 94.70 minutes; 2) Reduction in the biochemistry laboratory's TAT from 267.71 to 208 minutes.
BLOUIN-DELISLE, C.H. et al. (2018)	To increase efficiency in the operating rooms without affecting the quality of care, improving workflow processes	1) Reduction of 68% of the time lost in the ward; 2) 25% increase in all patient admissions; 3) 29% reduction in time spent in the recovery ward.
REGIS, T.K.O; SANTOS, L.C; GOHR, C.F. (2018)	Analyze the process of implementing lean healthcare in three Brazilian hospitals	Hospital A 1) 23% increase in the capacity to apply chemotherapy; 2) Reduction of the patient's waiting time for chemotherapy infusion to 1h; 3) Reduction in the loading time of the armchairs by 40 minutes (chemotherapy); 4) 74% reduction in the patient's lead time (authorization of procedures); 5) 90% reduction in exam deadlines (laboratories); 6) Increased productivity in the handling of medicines (pharmacy); 7) Reduced waiting time from 50 minutes to 20 (radiotherapy).

		Hospital B 1) Reduction of waiting time (surgical scheduling and reception); 2) Reduction of bed turning time from 5:30 am to 2:30 am; 3) Reduction of time when the patient is admitted to the inpatient unit; 4) Rotation time reduction from 100 to 16min (operating room); 5) 3% reduction in inventory (supplies) Hospital C 1) 30% reduction in waste at the reception; 2) 90% reduction in the central guide; 3) Real-time billing (billing) 4) 70% reduction in inventory (supplies); 5) 170% increase in the capacity of consultations in outpatient clinics; 6) Reduction of waiting time for radiotherapy from 44% to 70%.
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BHAT, S; GIJO, E; CUDNEY, E (2019)	To explore tools and techniques commonly used to implement the Lean Six Sigma (LSS) strategy in private Indian hospitals.	Hospital A 1) 65% reduction in the average cycle time; 2) 79% reduction in standard deviation; 3) Savings of US \$ 7,000 / year in indirect costs.
		Hospital B 1) Reduction of the TAC of the IP-MRD process to 39 minutes; 2) Savings of approximately US \$ 10,000 / year in indirect costs and human resources.
		Hospitals C and D 1) Improvement in the provision of services; 2) 94% reduction in queue length and a 48% decline in scheduled staff utilization.
		Hospital E

- 1) Reduction of the average waiting time to 9.27 minutes;
- 2) Improvement in the service quality of the system; 3) Increased productivity;
- 4) Decrease in absenteeism rates;
- 5) Savings of approximately US \$ 15,000 in reducing overtime at the production center

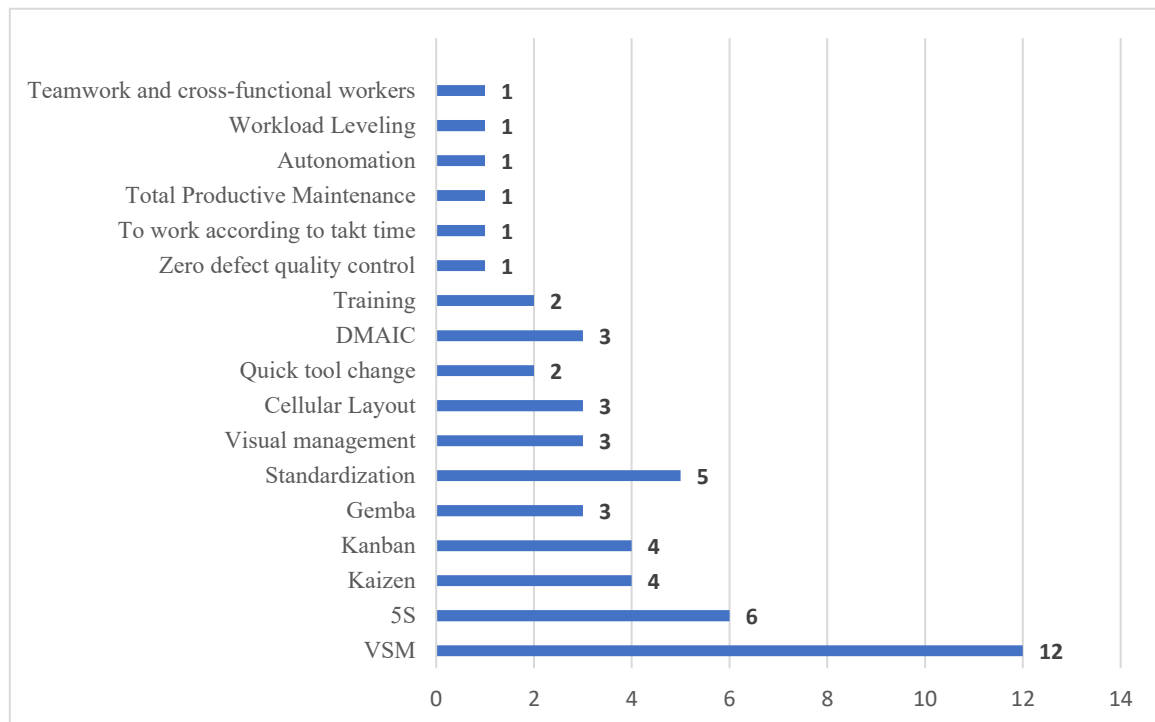
Source: Survey data (2020).

The studies listed in Table 6 report results of using other tools such as Kaizen, Kanban, Gemba, Cellular Layout, TAKT time, DMAIC, Quick tool change, Zero defect quality control, Visual management, Teamwork and multifunctional workers, Leveling of workload, DMAIC, Training, Autonomation and Total Productive Maintenance.

With this, they showed significant reductions in processes/response times, identified sources of waste, improved the reliability of the work, reduced the percentage of cancellation of surgeries, in addition to savings in terms of indirect costs and human resources.

Given the aspects observed, in all studies the most diverse techniques of lean production were applied. In this sense, Graphic 4 shows the synthesis of the techniques used and the number of mentions made with these tools considering the total of studies.

Graphic 4. Techniques and number of uses.

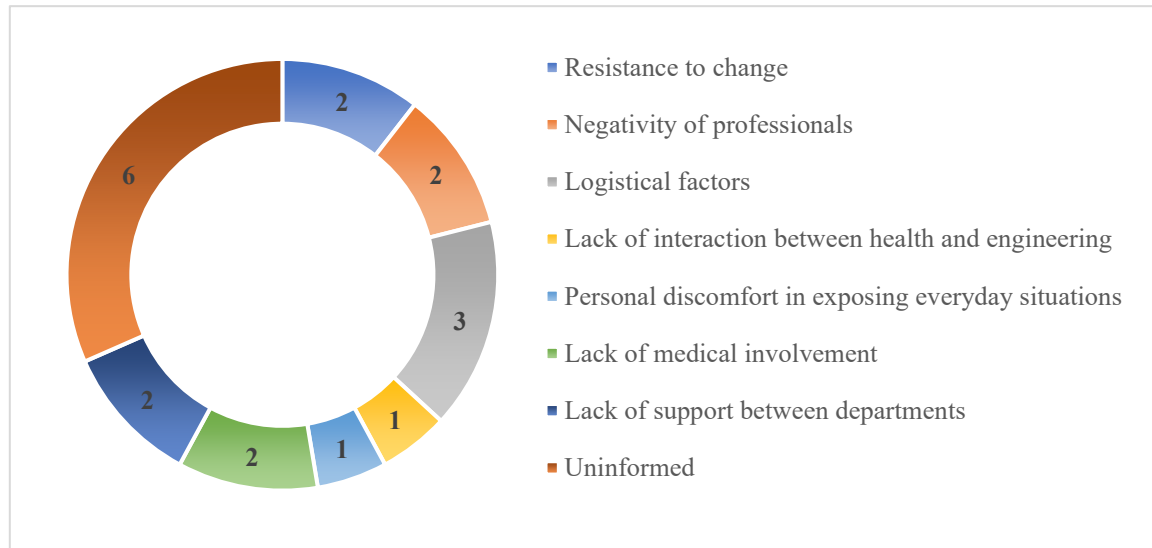


Source: Survey data (2020).

The analysis of the articles also made it possible to find some potential challenges to the implementation

of lean techniques in health services. Considering such barriers or difficulties, it was found that the biggest factor that impacts the implementation of such practices concerns the human factor. Graphic 5 highlights the challenges mentioned in the articles.

Graphic 5. Factors that hindered the implementation of lean techniques



Source: Survey data (2020).

5. Conclusions

This article presents a systematic review of the literature on the topic of lean health and its techniques, demonstrating how and which tools were implemented in the practice of the most diverse health environments, based on the works available on the CAPES Portal.

The results of the study indicate that most studies, considering the period from 2015 to 2019, were published in health journals and that, from the sample, it was possible to observe that the year 2018 had the largest number of published works.

Although productions in Portuguese were not excluded, it was observed that the sample articles were 100% in English, where tools were applied in India - 3 studies, USA and Brazil, with two studies, respectively, in addition to studies applied in the United Kingdom United, Senegal, Lebanon, Kenya, Tanzania, Canada, Norway, Italy and Jordan, with one study each, showing the global relevance of the theme.

It was also observed that among the studies as the main tools used to promote health benefits are MFV, 5S, Standardization, Kaizen and Kanban. However, although they have not been used in many articles, the other techniques mentioned in this study were used in at least one of the selected studies, demonstrating that they are applied considering the specifications of each environment.

The use of multiple lean tools in health brought significant and common results among the articles, such as reduction of waiting times, reduction of operations time, improvement of processes and services provided, detection of restrictions, redesign of works, increased awareness of work team and patients about the importance of the organization, greater patient satisfaction in care, in addition to reducing indirect costs

and costs with human resources.

The study also showed that the human factor still represents a difficulty in implementing lean health techniques, the main problems being reported: resistance to changes, the negativity of professionals in the face of proposals for improvements and the lack of involvement/support from doctors and other servers.

As the study considered only the CAPES Journals as a basis for consultation, it is suggested that future research should deepen the sample in other bases to capture similar studies, as well as continue the examination of the factors limiting the implementation of lean techniques in health.

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Teachers' Assumptions on Teaching English Grammar for Lower-secondary Level Students

(A Case Study of Nepal)

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Abstract

Teaching grammar is one of the aspects of language teaching. From the past, different methods, like teaching from rules, teaching from examples, teaching through texts have been used to teach grammar in Nepal. So, this research was prepared to study the teachers' assumption for teaching English grammar at lower secondary level in Nepal. The issue of teaching prepositions, articles, tense, tags, causative verbs and subject verb agreement are raised in this research. In this research, both the primary and secondary sources of data were used. Questionnaires were used to collect the data for the research. The result shows that most of the teachers use inductive ways to teach grammar lessons or they used student-centered techniques. It also concludes that the level of the learners, context and nature of the text also make the teachers to select the method for teaching.

Key Words: Grammar, inductive teaching, deductive teaching, GT method, CLT

1. Introduction

There are many languages in the world. Among them, English is a language which is widely used all over the world as a means of communication. In the context of our country, English has been given more priority than other international languages such as Chinese, French and Germany. In recent years, it is taught as a compulsory subject from grade one to bachelor's degree as a foreign language (EFL) in Nepal. The introduction of ELT in Nepal was started only in 1971 AD with the implementation of National Education system plan 1971. The High Level National Education Commission (2002 AD) recommended that ELT should be started from grade one of school.

Language is the means of communication as we use it to express our inner feelings, desires, and exchange ideas. The main purpose of language teaching is to make the learner able to communicate appropriately in a given context meaningfully. For that, language should be appropriate in its structure too. The structure of language is called grammar. Thornbury (1999, p. 1) says "A grammar is a description of rules that govern how a language's sentences are formed". It is a connection of words to make an acceptable sentence. Grammar is the rules of language which helps to produce structurally and contextually meaningful

sentences. Without teaching grammar; language teaching cannot be completed. Grammar teaching is necessary to develop linguistic competence.

Celce-Murcia (2001 as cited in Nassaji & Fotos 2011, p. 13) explains “Language teaching was equated with grammar teaching and grammar was used as content as well as organizing principles for developing curriculum and language teaching materials”. For many decades, grammar teaching was the center of language pedagogy and curriculum development. Thornbury (1999, pp. 29-90) posits the 3 ways of teaching grammar as deductive, inductive and text-based method. Every method has advantages and disadvantages in the field of teaching.

1.1 Statement of the Problem

To achieve the pedagogical goal, a successful teacher uses various ways of teaching grammar on the basis of nature of grammar lesson and level of the learner. There are different ways of teaching grammar such as deductive, inductive and text-based which the teachers are practicing inside the language classroom. In Nepal, teaching grammar is really a challenging task for teachers and it is difficult for learners due to the lack of effective teaching method. To know the appropriate ways is the main problem in the grammar classes at secondary level. This study tries to explore how the teachers of lower secondary school of Nepal teach English Grammar and which technique is fruitful in teaching for students.

1.2 Objectives of the Research

The major objectives of the research was to explore how the lower-secondary level teachers of Nepal teach grammar in terms of; teaching prepositions, tense, articles, tags, causative verbs and subject verb agreement. It also suggests which teaching method could be effective to teach grammar.

1.3 Research Questions

The following research questions are addressed in this research:

- a. What are the methods of teaching English grammar at lower secondary level of Nepal are prescribed in the textbook?
- b. How the lower secondary level English teachers are teaching grammar such as article, prepositions, tense, tags, causative verb and subject verb agreement prescribed in the course?

1.4 Significance of the Research

This research is beneficial for those who are involved in English language teaching at lower secondary level. This research will be helpful for the educationist and course designer to design the grammar courses for the EFL learners.

1.5 Delimitations of the Research

This study had following limitations:

- a. The sample size of the research was 20 teachers for responding questionnaire from the five lower secondary schools of Nepalgunj Sub-metropolitan, Banke district of Nepal.

- b. The main focus of this research was to find out the practice and possible ways of grammar teaching.
- c. The research was limited to survey design.
- d. The tools for data collection were questionnaire consisting of both close-ended and open-ended questions.

2. Review of Related Literature

Thornbury (1999, pp. 29-69) posits three ways of teaching grammar which are popularly known as, teaching grammar through rules (deductive method), teaching grammar through examples (inductive method) and teaching grammar through text (text –based method).

- a. Deductive method is a way of teaching grammar where grammatical items are taught through the presentation of rules. Rules are explained before presenting examples. For him the deductive method includes the following steps:
 - i. Presentation of rules
 - ii. Description and explanation of rules
 - iii. Providing some examples
 - iv. Explaining underlying rules mostly by using mother tongue
 - v. Asking students to practice the rules orally or written
 - vi. Contrasting the areas of differences between mother tongue and target language

Inductive method is to teach grammar through examples. Therefore, it is known as rule discovery method of teaching grammar. It is known as modern and scientific method. In this method learners, will be played with sufficient examples where the rule which is expected to teach is practiced. It is a method which emphasizes the use of language rather than presentation of information about the language. The Inductive method to grammar teaching will have the following steps:

- i. Presentation of examples
 - ii. Analysis of examples
 - iii. Rule formulation
 - iv. Generalization of the rules that grow out of the previous activity
 - v. Written or oral practice
- b. Text- based method to teaching grammar is different than previous two types of method as it is solely depending around the text or content rather simply on the rules and examples. The subject matter of language teaching is no grammar or functions or some other language-based unit of organization, but that is content. Without understanding the context, we cannot understand the meaning of the sentences. This method believes that language learning is motivating when students are focusing on something other than language, such as ideas, issues and opinions.

On the basis of degree of activation, we can classify classroom techniques into two categories such as teacher- centered techniques and learner- centered techniques.

- a. Teacher- centered techniques require the teachers to adopt different strategies to deliver and clarify the content and motivate the students. Teacher-centered techniques play dominant role in teaching and learning activities in the context of Nepal. Most commonly, teacher centered techniques include: lecture, explanation, illustration, demonstration, etc.
- b. Learner- centered techniques keep the role of learners at the center of teaching and learning activities. The students may get sufficient opportunities to work and progress in language learning. Learner- centered techniques include: pair work, group work, role play, task performance, project work, discovery techniques, etc.

Several studies have been carried out on the topic grammar and grammar teaching. Shah (2010) carried out a research entitled “Effectiveness of Teaching Grammar through Inductive Method”. The main objective of his research study was to find out the effectiveness of teaching grammar through inductive method. Gautam (2011) carried out a research entitled “Effectiveness of Pair Work in Teaching Grammar.” His main objective was to find out the effectiveness of pair work technique in teaching grammar. Similarly, Sharma (2014) carried out a research on “Techniques Used in Teaching Grammar”. The main objective of his study was to find out the techniques used by secondary level English teacher in teaching grammar.

The Afro-mentioned works are carried on the topic of grammar teaching, but no research studies are carried out on the ways of grammar teaching so this study is needed to carry out.

3. Methods and Procedures of the Study

This study is survey research as I have explored the ways of teaching grammar at secondary level. This study has represented the teachers of Banke district of Nepal and the population sample has been carried out from them

3.1 Population, Sample and Sampling Strategy

To accomplish the targeted objectives of my research, I selected English teachers, teaching in Lower Secondary level of Nepalgunj Sub-metropolitan of Banke district (Nepal) as the population of this study. As the sample of my study I selected 20 teachers to respond the questionnaire.

3.2 Study Area/ Field

The Lower Secondary schools teachers of Banke district were the study area. For the convenience of this study, the researchers selected the schools which are in Nepalgunj Sub-metropolitan area.

3.3 Data Collection Tools

As the tools for data collection I used questionnaires which were prepared for English teachers.

3.4 Data Collection Procedure

I collected the data through questionnaire from Secondary level English teachers. For that, first of all, I prepared questionnaire for teachers. Then, I visited with the head teacher and established rapport with him. I got permission with the concerned teacher. I provided about an hour to respond the questionnaire. When they responded the questionnaire, I took back the responded questionnaire.

3.5 Data Analysis and Interpretation Procedures

Quantitative data are analyzed and interpreted with the help of simple statistical tools like tables and charts.

4. Analysis and Interpretation of Data

The questionnaire was prepared to explore out the ways of teaching grammar. Some specific questions were asked to the informants to attract their attention on the ways of teaching grammar. The relevant data from this phase were found as below:

4.1 Most Effective Methods of Teaching Grammar at Secondary Level

The informants were asked to select the most effective ways for English teachers to teach grammar at secondary level in order to find out the effective teaching method of grammar to be implemented in English classroom. The responses got from the respondents have been exhibited in table no. 1

Table No. 1
Most Effective Method of Teaching Grammar at Lower Secondary Level

S.N.	Focused Teaching Methods	No. of Teachers	Percentage
1	Teaching Grammar from Rules	2	10%
2	Teaching Grammar from Example	12	60%
3	Teaching Grammar through Text	2	10%
4	Teaching Grammar mixing rules and examples	4	20%

From the table above it can be analyzed that out of ten teachers, 10 percent teachers teach grammar from rules. Similarly, 60 percentage of the teacher teach grammar from examples. Likewise, 10 percentage use teaching grammar through texts and 20 percentage of the teacher sometimes teach grammar from rules and sometimes from examples. This data shows that majority of the teachers (i.e. 60%) use inductive method to teach grammar in secondary level.

4.2 Most Effective ways to Teach Articles

The respondents were asked to mention the most effective ways for EFL teachers to teach articles. This question was asked in order to know the most effective ways of teaching articles in secondary level. The result has been presented in table no. 2 below.

Table 2
Effective Ways to Teach Articles

S.N.	Focused Teaching Methods	No. of Teachers	Percentage
1	Teaching Articles from Rules	10	50%
2	Teaching Articles from Example	7	35%
3	Teaching Articles through Text	3	15%

It shows that out of 20 teachers 50% teach articles from rule similarly, 35% teach from examples. Only 15% teachers teach articles through texts in English language classroom. The data shows that teaching from rules, teaching from examples and teaching through texts are the methods for teaching articles. Among them majority of the teachers (i.e. 50%) were found to use rules for teaching articles.

4.3 Most Effective Ways to Teach Prepositions

The informants were asked to mention the most effective ways to teach prepositions to know the effective ways for teaching prepositions. Similarly, they were also asked to specify any other methods except inductive, deductive and text-based. The obtained result has been exhibited in the table 3 below:

Table 3
Effective Ways to Teach Prepositions

S.N.	Way of Practice	No. of Teachers	Percentage
1	Teaching from Rules	-	-
2	Teaching from Example	6	30 %
3	Teaching through Text	4	20%
4	Teaching using other methods (picture etc.)	7	35%
5	Using text and Examples	3	15%

This table presented above shows that out of twenty teachers nobody teaches prepositions from rules. Whereas 30 percent teach prepositions from examples and 35 percent teach prepositions through pictures and realia, similarly, 15 percent use both text and examples to teach prepositions. From the data presented in the table above it is found that teaching from examples, teaching through texts, teaching using pictures and sometimes through text and sometimes from examples are the ways for teaching prepositions.

4.4 Effective Ways to Teach Tags

The respondents were asked to mention the effective ways to teach tags. This question was asked in order to know the effective ways to teach tags at secondary level. The responses elicited from the respondents have been exhibited in the table below:

Table 4
Effective Ways to Teach Tags

S.N.	Way of Practice	No. of Teachers	Percentage
1	Teaching Tag from Rules	6	30%
2	Teaching Tag from Example	10	50 %
3	Teaching Tag through Text	1	5%
4	Using text and Examples	3	15%

The data presented in the table 4 shows that out of twenty teachers 30% teach tags from rules likewise, 50% follows the way of teaching grammar from examples and only 5% teacher teaches tags through texts. But only 15% teachers teach tags using both of the way of teaching grammar i.e. sometimes from examples and sometimes through texts. From the table above it is observed that teaching from rules and examples, teaching through text and teaching sometimes from examples and sometimes through texts are the practice ways of teaching grammar.

4.5 Effective Ways to Teach Tense

The informants were asked to mention the effective ways of teaching tense at secondary level in order to take the data regarding the effective ways of teaching tense. The responses obtained from the respondents are exhibited in table no. 5 below.

Table 5
Effective Ways to Teach Tense

S.N.	Way of Practice	No. of Teachers	Percentage
1	Teaching from Rules	5	25%
2	Teaching from Example	9	45 %
3	Teaching through Text	3	15%
4	Using Example and rules in different times	3	15%

The table 5 mentioned above shows that out of twenty teachers 25% follows teaching grammar from rules to teach tense, similarly, 45% use teaching grammar from examples, likewise, only 15% teachers teach tense through texts. Among them 15% teachers use sometimes examples and sometimes texts to teach tense at secondary level. Teaching from rules, teaching from examples, teaching from examples and through texts are the mostly practices ways of teaching grammar. According to this data majority of the teachers (i.e. 45%) teach tense from examples.

4. 6 Mostly Practiced Techniques of Teaching Grammar at Secondary Level

Teacher uses and designs different techniques to teach grammar lessons within a single method and classroom. As the method and techniques are interrelated each other they both influence teaching learning activities. The informants were asked to specify the techniques that they practice mostly to teach grammar lessons such as prepositions, articles, tense, tags and causative verb at secondary level. This question was asked to the informants in order to find out the practiced techniques to teach grammar as a whole. The data elicited from the questionnaire is exhibited in table no. 6 in the next page.

Table 6
Mostly Practiced Techniques of Teaching Grammar

S.N.	Techniques	No. of Teachers	Percentage
1	Teacher Centered Techniques	3	15%
2	Student-centered Techniques	18	90 %
3	Awareness	2	10%
4	Controlled Drill	3	15%
5	Meaningful Drill	5	25%
6	Guided Practice	7	35%
7	Free Sentence Composition	4	20%
8	Discourse Composition	4	20%
9	Free Discourse Type	3	15%

The table 6 presented above shows that the teachers use different techniques to teach grammar lessons in the classroom. Out of twenty teachers 15% practices teacher- centered techniques such as lecture, explanation, illustration, demonstration etc. Most of the teacher i.e. 90% gives priority to learner-centered techniques such as pair work, group work, role play, task performance, project work, discovery techniques etc. Only 10% use awareness technique, similarly 15% consider controlled drills; likewise, 25% follow meaningful drills and 35% practice guided practice to teach grammar lessons. In the same way, 20% of the teachers practice free sentence composition and discourse composition respectively. And 15% design free discourse activities in the grammar teaching classroom. It is seen that various techniques can be designed to teach grammar at secondary level such as teacher- centered techniques, learner- centered techniques, awareness, controlled drills, meaningful drills, guided practice, free sentence composition, discourse composition and free discourse type. However, the data shows that majority of the teachers (i.e. 90%) design learner- centered techniques to teach grammar lessons at secondary level.

4.7. Teachers Suggestions Regarding the Ways of Teaching Grammar

Finally, the teachers were requested to present their suggestions on the basis of their classroom practices regarding the ways of teaching grammar. This question was designed to draw out the data that the close-ended questions were unable to include. The data obtained from the informants is concluded and presented in the points as below:

- a. The efficiency of teaching grammar depends on the way how it is delivered so a teacher should select the methods on the basis of nature of the course and level of the learners.
- b. The teacher has to create child friendly environment in the tutorial setting which respects the students' level and ability.
- c. Almost 80% informants suggested that there is no specific method which is applicable and can fit for all the grammatical lessons so, we should select and blend different methods in our classroom.
- d. Teacher should play the role of facilitator creating the environment where students can expose different things.
- e. In English as Foreign Language (EFL) context memorization of rules also can't be ignored.
- f. Teachers can invent some ways for delivering grammar lessons as to be suited to the learning environment and context.
- g. We can't teach grammar successfully isolating form and functions.

By the data and opinions given by the respondents it is concluded that, we can select and design the methods of teaching grammar on the basis of the nature of texts and level of the learners.

5. Findings and Conclusion

5.1 Findings

The obtained data and information was analyzed with the help of simple statistical tools and qualitative approach. The findings of this study can be synthesized as follow:

- i. Teaching grammar is one of the aspects of language. Different ways (methods) are found to be practiced while teaching grammar inside the classroom.
- ii. Different methods such as teaching from rules, teaching from examples, teaching from texts are used to teach grammar in secondary level. Among them 60% were found to use teaching from rules.
- iii. The different methods such as inductive, deductive, text-based, sometimes from examples and sometimes from rules, realia are used to teach each grammatical items such as articles, prepositions, tense, tags, causative verbs and subject verb agreement. The ways for teaching these all items are presented below:
- iv. As teaching articles, teaching from rules, from examples and through text were to be used. 50% were found practicing teaching from rules (deductive method) in the classroom.
- v. The ways to teach prepositions were to be found as teaching from rules, teaching from examples, teaching through texts and sometimes from example. The teachers were asked to specify any other ways, 35% suggested realia such as books, bags, pens, marker, charts hung on the wall, flannel board, pictures drawn by the students and downloaded from the internet as the effective ways for teaching prepositions.

- vi. Teaching from rules, teaching from examples, teaching through text and sometimes teaching from examples and sometimes from text were found as the ways of teaching tags. 50% considered teaching from examples as the effective one.
- vii. Different methods, like teaching from rules, teaching from examples, teaching through texts, and sometimes from examples and sometimes through texts were practiced to teach tense. 45% are found to be used inductive methods as the effective method in the classroom.
- viii. As the methods and techniques of teaching grammar are interrelated each other, techniques are designed on the basis of methods practiced. The teachers were asked to suggest mostly practiced techniques of teaching grammar. Some practiced techniques were; teacher- centered techniques, learner- centered techniques, awareness, controlled drills, meaningful drills, guided practice, free sentence composition, discourse composition and free discourse type. 90% of the teachers found practicing student- centered techniques in the classroom. A teacher was found designing different techniques within the single class.
- ix. The teachers were asked to provide any suggestions regarding the ways of teaching grammar. 80% suggested selecting teaching method on the basis of level of the learners, nature of the grammar items and learning contexts. They explained there is no 'hard and fast' way for teaching grammar.
- x. It was found that, teachers used different methods to teach different grammatical item as there is no specific method to teach grammar.
- xi. It was found easier to teach grammar from example for short and comprehensive grammatical items e.g. causative verbs and those grammatical which consists long lists of rules and are vague were found effective to teach from rules and texts.

5.2 Conclusion

From the extensive analysis and interpretation of data and drawn of the result, it is concluded that there is no specific way of teaching grammar. Teacher can select and design any methods to be suited to address the level of learners, nature of the courses and teaching context. Blending of different methods or mixing different methods, makes grammar classroom effective and meaningful. Wise selection and blend of different methods inside the classroom is fruitful to motivate the students and create interest and curiosity to study grammar. It also helps to boost up the learning outcome of students. To develop grammatical competency in the side of the learners and to get expected outcome it is better to design our own methods addressing the needs of classroom rather following the traditional ways of teaching grammar. Practice and selection of different methods makes classroom lively It also reduces monotony of students while learning second language and grammar.

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Impact of Parental Involvement on Pre-Tertiary Learners' Academic Development and Performance in Ghana.

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Abstract

The purpose of this study was to investigate the impact of parental involvement on pre-tertiary learners' academic performance and development in some selected pre-tertiary schools in the Ada East District of Greater Accra Region of Ghana. The study adopted the sequential explanatory mixed method approach. That is, quantitative data were initially gathered through a 3-point Likert Scale response set structured questionnaire followed by a qualitative interview data. The study made use of fifty (50) respondents who were randomly and judgmentally sampled. Both questionnaire and interview guide were developed to collect data on two formulated research questions after which they were descriptively and thematically analysed respectively. The study revealed that learners' academic development and performance move along with parents' financial commitment and other socioeconomic related characteristics, parents' level of training, education and other sociocultural related characteristics as well as parents' relationship and communication with teachers, school community and the community outside. It was concluded therefore that both socioeconomic and sociocultural statuses of parents affect academic development and performance of learners in pre-tertiary schools to a large extent. Conclusion was also drawn on how parents' relationship and communication with the school community, teachers and the community outside contribute to pre-tertiary school learners' development and performance. The study strongly

recommended full parental, community and stakeholders' commitment in all academic related activities of learners.

Keywords: Parental involvement, academic performance, academic development, pre-tertiary school, learners

1. Introduction

Ideally, the sole aim of every parent, teacher, student, institution, stakeholder and country is to see or witness a relatively permanent positive change in academic performance. According to Mauka (2015), the focus of teachers, parents and the school is to improve students' performance in every way particularly in the areas of academics. It is the heartbeat of every teaching and learning process. More so, it is the very desire of every student who finds himself or herself in the school system who is willing and ready to achieve academically. Academic performance is the exact measure or the precise outcome for which instructors look out for after successful completion of classroom instruction.

Academic performance, which obviously is an abstract phenomenon, rallies round on several elements to suffice with learners. This is to say that quite a number of factors play significant roles in influencing the trends of students' academic performance. The presence of some components for example may improve its state whereas the inclusion or exclusion of certain other key constituents may either distort or decline its state. School influence has for instance been identified as one major factor that has been informing academic performance of students (McNeal, 2014). Some schools have programmed teaching and learning to align strictly with existing structures to ensure that learners achieve intended learning outcomes. These structures include basic infrastructure, comprehensive school curricula and curriculum materials such as the school timetable, syllabuses, textbooks, supplementary readers and instructional resources. Ridge (2012) as cited in Gray (2015) assessed the impact of these structures on students' learning by showing how concrete and appealing they present experiences to students hence influencing their academic performance for the better.

Furthermore, studies have pointed out that teacher factor is a crucial element as far as academic performance of students is concerned (Rashid & Zaman, 2018). Scholars believe that learners tend to construct a lot of knowledge through constant interactions with experienced adults (Vygotsky, 1971). This suggests that there is a high possibility for students to mimic series of behaviors from their teachers as they constantly interact with them. They eventually get accustomed to these behaviours of their teachers thereby applying them in every aspect of their lives including academics. Studies have proven that teachers' attitude and perception walk hand in hand with students' learning outcome (Gray, 2015).

Parental influence is yet another phenomenon known among 21st century educationists to have been constantly creating remarkable impacts on academic lives of students (Rafiq, Fatima, Sohail, Saleem & Khan, 2013). Commitment from parents for instance plays sensitive roles in the learning behaviours of children. Students' academic performance, to say, depends largely on the readiness of parents to assist in the upbringing of all the learning faculties of children (Burner, 2006). Children do not need or require the support of the school or teachers entirely to succeed academically but rather participation from parents is

also very vital in this quest. Since children's first language learning and acquisition begins at home (Piaget, 1983), and it is the parents' efforts which make this happen, it is arguably certain that, for students to sail through academically, parents ought to avail themselves in every way.

Successful learning does not happen out of the blue but rather series of factors come in to play to ensure the achievement of such milestone. These factors include learner or student readiness which encompasses psychological, emotional and mental balance of the learner. It is the parent who makes sure that there is serene, stable environment and learning materials ready for children. Parents and guardians are obliged to create the appropriate platform for the academic improvement of their wards. It is their duty to ensure that certain basic needs like clothing, shelter, love, motivation (Maslow, 1941) which move along with learning behaviours of children (students) and academic needs will be met. According to Maslow (1941) certain actions such as meeting or satisfying basic needs such as provision of shelter, food, clothing and other related primary motivationally-anchored treatments from parents and experienced adults inform series of desired learning outcomes of students (Anderson, 2012 cited in Oyedare, Ogunjinmi & Durojaiye, 2016). Similarly, Epstein (1995) defines clearly the crucial roles parents play in the successful academic achievement of their children through her six propositions.

Unfortunately, across the continent of Africa, a little below 84% believe that nurturing academic lives of students is the sole responsibility of teachers and the school alike (Regasa & Taha, 2015). Research has further indicated that more than 60% of parents living in rural communities in sub-Saharan zones do not see the need to fully get involved in the education of their wards let alone paying a considerable attention to academic activities of these children (Regasa & Taha, 2015). Sadly, where there is limited interest in education, the lot is cast to favour some group of persons particularly males at the expense of their counterparts. Similarly, in Ghana, the situation is not far different. Parents' role in students' performance has always been a bone of contention. Scores of parents are pointing fingers at teachers, schools and the government to do the job and make sure that students attain the required academic excellence failing to acknowledge their contributory quota in this campaign.

There have been series of arguments trending major platforms and other media on whether parents have crucial roles to play as far as academic development and achievement of students are concerned. Among these arguments are studies conducted by Agyapong (2012) cited in Apeanti and Danso (2014) who maintains that parental involvement in children's learning behavior results in a quite desirable one. He maintains that students' ability to learn or reach certain academic ladder largely depends on parental commitment. Scholars at one point believe that when parents provide their wards (students) with all the basic needs such as shelter, clothing, food, love, motivation and other related forms of physical, psychological and emotional scaffolds (Vygotsky, 1971), the rate of learning and achievement becomes certain (Kenderich et al, 2013 as cited in Maslow, 1941).

Other research works on the other hand have proven that there is a wide gulf between parental influence and academic achievements of students (Handel, 2007 cited in Sander & Sheldon, 2009). Handel (2007) cited in Sander and Sheldon (2009) opines that successful academic achievement and development does not necessarily rely on either the internal or external manipulation of parents or any form of adult experience but rather learners' level of cognitive, psychological and emotional development go along to informing all intended learning outcomes. In contrast, Bond (2011) argues and concludes in his study that

parents play very little role in the learning behaviors of their children. Bond (2011) believes that children construct knowledge for themselves better with or without the guidance of any experienced adult. Peer learning and other forms of environmental components such as today's trends of technology and certain cognitive abilities of learners are key to successful learning (Bond, 2011).

The multi-million dollar question now is: Do parents really matter in the academic lives of students? Do students need parents and experienced adults to perform well academically? Does the presence of parents actually influence the academic development of students? These and many others have become the very questions trending in the minds of many. Answers to these are still unknown. This debate has remained mixed for some time now, and it is therefore seen to be a big issue which needs to be researched.

Apparently, studies remain scanty in the area of parental roles in students' academic achievements in Ghanaian schools. Aside this, these limited research works also have focused on the role of parents in students' academic development at the tertiary levels (Apeanti & Danso, 2014). Since these studies have placed greater emphasis on tertiary institutions, issues relating to pre-tertiary schools are naturally left unaddressed. As a result, it became necessary that the researchers conducted this study on the role of parents in the academic achievement of pre-tertiary school learners in Ghana. It is against this background that this study sought to investigate the role of parents in the academic achievement of pre-tertiary school learners in the Ada East District in the Greater Accra Region of Ghana from the context of socio-economy, socio-culture and communication. The current study attempted to answer two questions through a survey and follow-up in-depth interview: How do parents' socioeconomic and sociocultural statuses influence academic achievement of pre-tertiary school learners in the Ada East District? What role does communication among parents, teachers, school and the community play in the academic achievement of pre-tertiary school learners in the Ada East District?

2. Literature review

2.1 Epstein' theory of parental involvement and student academic achievement

Epstein's theory of parental involvement is by far among the most vital tools developed by the field thus far for defining parental involvement practices and equating them with certain categories of outcomes. This widely accepted framework mentor educators to design comprehensive family school partnerships (Rafiq, Fatima, Sohail, Saleem & Khan, 2013). Epstein (1995) proposes six types of parental involvement, and they are as follow:

- a) Parenting (helping families with childrearing and parenting skills): Joyce Epstein believes that schools have roles to play in ensuring that families irrespective of the backgrounds build a learning supportive home environment for their children. When children are provided with home environment that supports learning, they get the opportunity to abreast themselves with relevant information on nutrition, children's health, adolescent issues, techniques in parenting and discipline among others.
- b) Communicating (developing effective home-school communication): According to Mauka (2015), communication as a parental involvement practice "refers to how best to design and conduct an effective two-way communication that is school to home and home to school, about school

programmes and their children's progress." Schools ought to seek and adopt different ways of communicating with parents about the progress of their wards in school.

- c) Volunteering (creating ways that families can become involved in activities at the school): As families volunteer to participate in school events and other related school activities, they familiarize themselves with their children's schools and teachers. When parents voluntarily open to school events, their talents and qualities are tapped to enrich school programmes and to facilitate individualized learning.
- d) Learning at home (supporting learning activities in the home that reinforce school curricula): Learning at home pertains to providing ideas and information to parents about how they can best assist their children with homework and curricular related decisions and activities.
- e) Decision-making (including families as decision-makers through school-sites councils, committees): Involving parents in governance, decision-making, and advocacy roles is yet another strategy for fortifying links between schools and parents. As parental participation in decision-making, when it is comprehensive program involving parents in learning support activities as well, is associated with improved student outcomes.
- f) Collaborating with the community (matching community services with family needs and serving the community): Collaborating with the community pertains to identifying and integrating communities' services and resources to support and strengthen schools, students, and their families. (Mauka, 2015; Epstein, 1995).

2.2 Abraham Maslow's theory of needs and student academic achievement

Maslow (1943) hypothesized that within every human being there exists a hierarchy of five needs. These needs are:

1. Physiological: This includes hunger, thirst, shelter, sex and other bodily needs.
2. Safety: This includes security and protection from physical and emotional harm.
3. Social: This includes affection, belongingness, acceptance and friendship.
4. Esteem: This includes internal esteem factors such as self-respect, autonomy and achievement and external esteem factors such as status, recognition and attention.
5. Self- actualization: This is represented by the drive to become what one is capable of becoming; includes growth, achieving one's potential, self- fulfillment etc.

Need levels 1 and 2 are typically called lower order needs and levels 3, 4 and 5 are called higher order needs. The differentiation between the two levels was made on the premise that the higher order needs are satisfied internally to the person, whereas lower order needs are predominantly satisfied externally. The Needs theory stipulates that human behavior or conditioning is determined by a certain definite set of needs. It is preferentially arranged in 'prepotency', which means that, as a person fulfills a lower need, the next higher need becomes important in directing the person's behavior (Venugopalan, 2007).

Applicably, parents have major roles to play to ensure that their wards are well fed both at home and in school. Children are unable to pay much attention to instruction when they are hungry. When this happens the desirable learning outcomes get jeopardized. This implies that, if parents truly wish to bring out the best in their wards academically, there is a greater need for them to make sure that they supply them

adequately with the necessary food supplies. Similarly, parents should provide children with certain basic needs such as school uniforms, shoes, sandals, and other related clothing and protective shelter as well. Kendrick (2011) opines that students perform better when they are assured of their physical, psychological and emotional safety or security. Parents must give their all to ensure that the safety and security of their wards are catered for. They must do well and do away with all possible and impending threats such as physical, emotional and mental abuse that may deter children from developing academically. Again, when a child feels loved and belonged, it goes a long way to informing his/her performance in everything. Parents must show their wards all the positive affections they can give.

2.3 Parents' socioeconomic status and students' academic achievement

The financial strength of families to every degree determines the academic achievement of students. Bond (1994) asserts that children from high socioeconomic backgrounds tend to accomplish more in school than their counterparts from relatively lower ones. He argues that such children have the opportunity to be provided with all the basic needs needed for school and academic activities.

Similarly, upper class and middle class families enroll their wards in the best schools and provide them extra and private tuition in order to develop them academically (Singh, 1992 as cited in Bond, 1994). Studies have shown that the financial muscles of families to a very large extent determines the aspirations, behavior, learning attitudes as well as the academic ethics of children (Mauka, 2015). Mauka (2015), in her studies discovered that children from relatively same higher socioeconomic backgrounds always feel challenged to compete with their peers in school and have the urge to accomplish more in school than children from lower socioeconomic backgrounds.

2.4 Parents' sociocultural level and students' academic achievement

It is believed that families who are educated always have bigger aspirations for their children. They either challenge them to do more to surpass them or do not fall below the status of the family (Mauka, 2015). Parents who were raised from well-educated homes also tend to bring up their children in a similar fashion. Bond (1994) maintains that the level of training a parent has acquired influences the kind of upbringing he/she (a parent) will give to the child.

Families with well-educated background place priceless value on education. According to Ngorosho (2003), children who are often or always monitored in school and home alike are likely to come out from families who prioritize education. In view of Ngorosho (2003), such parents are neither paranoid nor overprotective but rather are very ambitious as far educational development in the family is concerned. Educated parents do well to provide their children with all the relevant education related materials and aids for academic activities. They ensure that their children do not lack at least any appropriate learning materials. Such families also enroll their children in best schools and constantly monitor their level of their academic progress.

2.5 Communication and academic achievement

Recent studies have also shown that communication at home builds intimacy between children and families (Decshen, 2014). Today, communication has taken so many turns and forms. It is either digital or physical

interaction. Oyedare, Ogunjinmi and Durojaiye (2016) explain that parents and teachers are most influential from early period of schooling in child life. Parents normally start to possess education and teachers extend it. He emphasize the importance of home cooperated with school and establish good financial relationship with teachers. This means that, children intellectual potential for successes in school education depends on initial efforts of parents in cultivating this potential so as to prepare conducive learning environment.

Harbison and Hanushek (1992) argued that, studies of educational performance particularly in developed countries invariably indicate that, learning occurring in the home is much more important than that which occurs at school. The quality of education at home is typically reflected in the educational level of parents, their income level and other indicator of social economic status of the family. Parent or family input to education which include the level of both mother and father education exert a positive or negative and generally significant influence on student achievement.

3. Methodology

A survey to assess the impact of parental involvement in learners' academic achievement was designed. The purpose of the survey was to find out the influence of sociocultural and socioeconomic statuses of parents vis-à-vis learners' performance. Again, the survey developed also targeted exploring the role of communication among stakeholders like the school, community, teachers and parents in relation to learners' academic performance. To gain additional information, we also conducted in-depth interviews with some selected parents and school staff members in the Ada East District in the Greater Accra Region of Ghana.

The study purely took a sequential explanatory mixed method approach. This involved using a survey method with a relatively large sample so that the researcher can generalize results to the population following with a qualitative interview for exploratory purposes. Furthermore, for the purposes of describing the phenomena as they naturally exist, the researchers subjected the study to a descriptive design. The two main sampling procedures – probability and non-probability were employed in the selection of participants. Simple random sampling procedure was used to select fifty (50) students whilst judgmental (purposive) sampling technique was involved in choosing nine (9) staff members and six (6) parents respectively. In all, one hundred and sixty-five (65) respondents were sampled for the study.

Instruments used for data collection were mainly through structured questionnaire and semi-structure interview guide. The questionnaire was administered to only learners and all staff members. The researchers, with the help of research assistants, read out the question items to participants and explained them accordingly. Participants were to indicate their responses using a three-point Likert Scale (Yes, No, Somehow). Similarly, the interview guide was used for parents and some selected staff members. Responses given in the interview were recorded in audio format, video format and audio-visual format. Detailed notes were also taken in the course of the interview session. Repeated playbacks of recorded responses were done afterwards to ensure voice clarity and to pave way for transcription as well. Codes were generated and assigned to data gathered from the interview.

The research made use of descriptive analytical tools to analyse all quantitatively gathered data; however, qualitative data like interview responses were subjected to thematic analyses. In ensuring trustworthiness

of the instruments, experts, supervisors, teachers, colleagues and students (participants) were consulted for suggestions, before they were carried out as proposed by Anderson and Morgan (2008). Again, questions were piloted on some selected pre-tertiary learners, teachers and parents to determine content appropriateness and semantic clarity. Wording and format of several questions were modified as a result of the teacher feedback.

4. Results

Findings from the study were presented in accordance with the data type. Tables were used to discuss quantitative results from survey whereas qualitative results from in-depth interviews were also interpreted thematically. The table below shows the role communication among parents, teachers, school and the community play in academic achievement of pre-tertiary schoolers in the Ada East District:

Table 1: Analysis of staff members' responses (Role of communication among parents, staff and community) n = 9

Items	Responses	No. of Staff	Percentage (%)
Parent-teacher face-to-face conversation about children's learning will improve parent's attitudes towards teachers.	Yes	5	55.55
	No	3	33.33
	Somehow	1	11.11
Sending home school progress reports on children's academic achievement will help to improve children's performance	Yes	7	77.77
	No	1	11.11
	Somehow	1	11.11
Parents' contacts with teachers rise awareness on the importance of their children's education	Yes	6	66.66
	No	1	11.11
	Somehow	2	22.22
School parent-day helps parents and teachers for collaboration to improve academic achievement	Yes	8	88.88
	No	1	11.11
	Somehow	0	0
Teachers who visit children's homes can teach the children better	Yes	7	77.77
	No	1	11.11
	Somehow	1	11.11

Source: Field survey (2019)

The responses participants gave in relation to parent-teacher face-to-face conversation revealed that five (5) respondents representing 55.6% said that there is a likelihood of an attitudinal improvement on the part

of parents towards teachers who teach their children in school. Three (3) participants forming 33.3% on the other hand believed that parent-teacher face-to-face interaction will yield no results with respect to parents' attitudes towards teachers. Meanwhile, only one (1) respondent representing 11.1% stated that parents' attitudes towards teachers could or may improve through face-to-face conversation. Considering the responses given by the majority of respondents, there is an obvious indication that parents are more likely to improve their attitudes towards teachers through face-to-face conversation. This will in turn impact academic performance and development of learners greatly since they (learners) will come to acknowledge and understand the serene rapport between teachers and parents.

From the table, it was seen that seven (7) respondents representing 77.8% claimed that there is high possibility of improvement in children's academic performance when the school sends home progress reports on their academic achievement. One (1) respondent representing 11.1% said children's academic performance will still remain same regardless the decision by school and teachers to send progress reports on children's academic achievement home. However, another One (1) respondent forming 11.1% responded that sending home progress reports on children's academic achievement could or may improve their performance in school. The responses gathered from the majority of respondents show that when the school and teachers send home progress reports on children's academic achievement, it will impact positively on their (learners') academic performance and development since they will develop the awareness that their performance are not only being monitored in the school but from home as well.

The table also shows parents' contacts with teachers. The responses participants gave regarding this showed that six (6) respondents representing 66.7% out of the total nine (9) sampled claimed that some parents contact teachers and the school only to find out how their wards are faring and progressing academically, and that shows the value they (parents) place on their wards' education. Meanwhile, one (1) respondent constituting 11.1% said parents' contacts with teachers do not necessarily create or increase awareness on the importance of their children's education. They believed that parents' contacts with parents might have a secondary purpose which may deviate from education. On the other hand, two (2) respondents forming 22.2% responded that parents' contacts with teachers could rise awareness on the importance of their children's education. These responses gathered from the majority of respondents suggest that parents' contacts with teachers increase an awareness on the importance of their children's education. This mean that schools and teachers who tend to recognize the value parents place on their wards' education also tend to put in more effort to address all academic needs thereby improving the academic performance of such children.

The table shows how school-home activities like school-parent day help parents and teachers alike. The responses given by participants in reference to the item in question revealed that eight (8) respondents representing 88.9% out of the total nine (9) sampled believed school-home related activities like school-parent day help parents and teachers alike a lot for collaboration to improve academic achievement. Meanwhile, only one (1) respondent forming 11.1% said school-home related activities like school-parent day do not entirely help parents and teachers to collaborate to improve academic achievement. However, no participant (0) representing 0% neither agreed nor disagreed. These findings obtained from the majority of respondents indicate that school-home related activities like school-parent day and other related celebrations help parents and teachers alike a lot for collaboration to improve academic achievement. This

is because such occasions serve or offer the right platforms or avenues where all manner of academic issues relating to learners and the school in general can be addressed.

The table again indicates responses given concerning teachers' visit to children's home. It was realised that seven (7) respondents representing 77.8% believed that teachers who visit the homes of children understand them and as a result can teach them better. One (1) respondent forming 11.1% however disclosed that there is no relationship between teachers' visits to children's (students) homes and how they teach them. Another one (1) respondent making 11.1% claimed that when teachers visit the homes of children, such occasions somehow help them to understand their needs better and handle them as such in the classroom. The responses gathered from the majority of respondents show that teachers who visit the homes of children understand the needs, interest, personality likewise environmental and home factors such as sociocultural and socioeconomic of these children and as a result teach them well. This implies that when the school and teachers make such visits habitual, it will go a long way to inform academic performance and development of learners in the school. Based on the findings gathered, it can be concluded that the level of communication and relationship that exists amongst parents, teachers, school, and the community undoubtedly have a lot of influence on academic performance and development of pre-tertiary schoolers at Ada East District in the Greater Accra Region, in that the richer and stronger the communication and the relationship, the better the academic performance and vice versa. These findings fall in line with Sanders and Sheldon (2009) who maintain that schools become successful when a strong and positive relationship among students, parents, teachers and the community has been established.

Table 2: Analysis of learners' responses (Socioeconomic and sociocultural impact)

Items	Responses	Respondents	Percentage (%)
<u>Status of parent</u>			
Single parent	Yes	23	46
	No	27	45
	Somehow	0	0
Parents' capacity to provide educational needs	Yes	15	30
	No	22	44
	Somehow	13	26
<u>Educational status of parent</u>			
Primary school leaver		9	18
Middle school leaver		10	20
J.S.S./J.H.S. graduate		6	12
S.S.S./S.H.S. graduate		2	4
Tertiary graduate		4	8
No School		19	38
Parents' enquiry about homework	Yes	15	30
	No	25	50

	Somehow	10	20
Parents' assistance with other school-related activities	Yes	13	26
	No	31	62
	Somehow	6	12

Source: Field survey (2019) **n = 50**

The table shows that twenty-three (23) respondents out of the total fifty (50) sampled forming 46% live with single parents whereas the remaining twenty-seven (27) respondents forming 54% reside with both parents. The responses obtained indicate that majority of learners do have at least more than one family member around them.

Again, socioeconomic and sociocultural impact were assessed through parents' capacity to provide educational needs and parents' educational status respectively. On this, responses gathered from respondents regarding parents' capacity to provide for all educational needs show that fifteen (15) respondents representing 30% out of the total fifty (50) sampled responded that their parents able to provide all their educational needs. However, twenty-two (22) respondents making 44% disclosed that their parents are unable to provide them with all educational their needs. Meanwhile, the remaining section of respondents constituting thirteen (13) representing 26% said their parents are not always able to give them what it takes as far as their educational needs are concerned. The responses given suggest that majority of learners do not get access to all educational needs due to reasons like financial constraints on the part of parents. This explains why some learners always lag behind in academically-related activities in and out of the school environment. This affirms the position of Mauka (2015) who argue that children from relatively higher socioeconomic backgrounds always feel challenged to compete with their peers in school and have the urge to accomplish more in school than children from lower socioeconomic backgrounds.

Furthermore, parents' educational status and academic attainment show that nine (9) respondents representing 18% have parents who have completed primary school; ten (10) participants forming 20% have parents who have attained middle school level; six (6) respondents making 12% are with parents who have completed Junior Secondary School (JSS/JHS) only; two (2) respondents representing 4% have parents who are Senior Secondary School (SSS/SHS); four (4) respondents representing 8% have parents who have attained tertiary level of education whereas nineteen (19) respondents forming 38% have attained no educational level. The responses given imply that majority of learners are living with parents who have attained no or low level of education. This phenomenon arguably accounts for learners' and parents' constant decline in interest in all activities relating to academics hence learners' low academic achievement levels. This aligns with Bond (1994) who maintains that the level of training a parent has acquired influences the kind of upbringing he/she (a parent) will give to the child.

The gathered responses from respondents in relation to homework revealed that fifteen (15) respondents representing 30% out of the total fifty (50) sampled said that their parents do regularly ask them about homework. Twenty-five (25) participants on the other hand making 50% answered that their parents do not inquire about homework at all whilst the remaining section of respondents who constituted ten (10) representing 20% disclosed that their parents do not regularly ask about homework. These responses

gathered clearly suggest that majority of learners do have or live with parents who are negligent of enquiring about wards' homework due to ignorance, lack of time, illiteracy among others. These actions and inactions of parents to some extent determine the fate of learners' academic performance, development and achievement.

Lastly, responses obtained in relation to assistance offered by parents to learners in school-related activities again revealed that thirteen (13) respondents representing 26% out of the total fifty (50) sampled responded that their parents do assist them with their home assignments and other related school activities. Meanwhile, thirty-one (31) respondents forming 62% claimed that their parents do not help them with their homework at all neither do they assist them in any kind of school related activities. The remaining section of respondents on the other hand who comprised six (6) representing 12% said that their parents do help them with their homework and school related activities but such assistance do not come very often. These responses given indicate that majority of students have not been getting the attention or help from parents as far as home works and other school related assignments are concerned due to time factor, level of education, ignorance among others. These findings confirm the assertions of Ngorosho (2003) who posit that children who are often or always monitored in school and home alike are likely to come out from families who prioritize education.

4.1 In-depth interview results

Three global themes were identified from the interaction with parents and staff members: (a) Learners need financial commitment of parents (b) Learners depend on parents' level of training (education) (c) Parent-teacher-school communication is vital for learners' improvement.

Table 3 Parents' and Staff Members' In-depth Interview Themes

Parents' Themes	Staff Members' Theme	Global Themes
Support academics with Your financial resources	Support academics with financial resources	Parents' financial impact
Assist academic lives with Your expertise	Assist academics with experience and expertise	Parents' training impact
Monitor performance via Communication	Monitor performance via Communication	Communication impact

Note: Parents' and staff members' themes integrated

4.1.1 Learners need financial commitment of parents

The parents' theme "Support academics with your financial resources" was same or if to say, closely aligned with the staff members' theme of "Support academics with financial resources." In the interview, both sections of respondents claimed that parents' and guardians' financial commitment is key as far as learners' development and achievement in academics and school-related activities are concerned. This is what one parents had to say:

P3: *“Our children need money for school. I believe the more we spend on them in school, I think the better they are likely to perform in everything they do. I can only speak for myself on this issue. When my son later realised how much I was spending on him.....giving him everything he needed for school and other stuffs, he started buckling up, and I was really happy to see that.”*

Similarly, some of the staff members also gave account of how some parents’ monetary resources commitment have informed students’ performance. This is what a teacher had to say:

SM 5: *“I have encountered countless instances where students’ performance levels have largely depended on how deep parents’ pockets are. You sometimes witness how remarkably a student suddenly begins to perform...You try to find out why, and later you get to realize that their parents have begun to spend on them...they are buying all sort of books for them, paying almost every fees, getting part-time (home) teachers for them and all kind of things.”*

These responses indicate that parents’ financial commitment ought not to be overlooked as a variable if we intend to appropriately address or tackle pre-tertiary learners’ academic performance and achievement in and out of the school setting. This conforms to Mauka (2015) who posits that financial muscles of families to a very large extent determines the aspirations, behavior, learning attitudes as well as the academic ethics of children (Mauka, 2015).

4.1.2 Learners depend on parents’ level of training (education)

The parents’ theme “Assist academic lives with your expertise” was comparable to staff members’ theme “Assist academic lives with experience and expertise.” On this, both section of respondents disclosed the potential influence of parents’ knowledge base, level of training and education likewise experience and expertise on learners’ performance in academic related activities. Some parents stated that:

P1: *“I can say I have always been helpful to my children. After all, I am able to help them do their homework and other home assignments given by their teachers. My children have been grateful for the support and often look up to me anytime they come with school related tasks.”*

P4: *“I have the urge to help my children with academics but I have no idea how to go about it. Unfortunately for me, I didn’t have the chance to go to school so...eerr...hmm...as you can see there is no way I can be of help to them when it comes to homework. I know I’d have been of great help to them and their studies alike if I had received some formal training.”*

In an attempt to attest to the claim that parents’ level of training, education, experience and expertise walk hand in hand with learners’ academic performance, this is what some teachers also had to say:

SM 7: *“I think it is very obvious that high achieving learners in almost every classroom are those whose parents have attained certain level of education. I can say on authority that students who perform well in my school are mostly children of teachers, lecturers, doctors, civil and public servants. You don’t need to ask why because they get all the assistance they need to perform better academically. Some parents even go the extent of teaching their children at home, which I know you can testify to that. Right?”*

SM 2: *“Of course, you see, one can easily tell the educational level of parents and*

guardians of some students in the school. Those who are excelling are largely the ones whose parents have gone through some formal training. It may also interest you to know that some parents teach their children ahead whilst others even introduce them to other curricula. Some even preregister their kids to sit for SAT, IELTS, TOFEL, WASSCE among others."

The responses obtained suggest that parents' knowledge base, level of training and education as well as experience and expertise are highly influential in learners' academic development, achievement and performance at the pre-tertiary level. This confirms the position of Harbison and Hanushek (1992) who argue that parent or family input to education which include the level of both mother and father education exert a positive or negative and generally significant influence on student achievement.

4.1.3 Parent-teacher-school communication is vital for learners' improvement.

The parents' theme "Monitor performance via communication" was same with staff members' theme of "Monitor performance via communication." The purpose was to explore the role communication among stakeholders like the school, parents and teachers play in learners' performance. Regarding this, respondents revealed that the kind of communication and relationship there exist among teachers, parents, the school and the community at large positively inform performance of learners in and out of school. Some parents claimed that:

P2: "My children started to buckle up the very moment they noticed that I had been attending P.T.A. meetings and asking them about some of their teachers. Hahaha...It's funny, you know...hmmm...These kids think you don't have time to communicate with their teachers to find out what's been going on."

P5: "Teachers and school authorities now no longer take us and our children for granted because they have seen that we now tend to ask a lot of questions concerning our wards' studies."

A section of staff members also revealed that:

SM 6: *"Teachers, the school community and learners alike are all sober now because things are not like before. Parents now enquire a lot about the performance of their children in class. Some parents have our contacts; they call you anytime for so many clarifications like errh...approved fees, assignment, authenticity of terminal reports, notes, complaints, and so on. These kids now know that they are being monitored in school from home through parent-teacher contacts."*

SM 1: *"I know some students who started to showed seriousness in academics simply because they started seeing their parents frequently with the headmaster. Some parents even go to the extent of coming to the classroom to discuss with us in front of the children the state of performance in academic related activities."*

The responses gathered show that parent-teacher-school communication is crucial in the academic lives of learners at the pre-tertiary level. This aligns with the assertion of Durojaiye (2016) who explains that parents and teachers are most influential from early period of schooling in child life.

5. Discussion and conclusion

Generally, parental involvement or role is a big issue particularly in the academic lives of learners. However, this phenomenon has constantly been under jeopardy due to the emergence of certain factors like poverty, illiteracy, irresponsibility, presence of social vices among others. From the study, the socioeconomic and sociocultural impact of parents were assessed through their capacity to provide educational materials as well as their educational level. Regarding this, it was realised that parents who show financial commitment in academic related activities tend to positively influence performance and development of their wards through this action and vice versa. Again, it was seen that parents who have attained higher education and possess certain amount of knowledge, expertise, experience and training often assist their wards with school/academic related activities hence informing positively their academic development and performance. Therefore, it has been concluded that sociocultural and socioeconomic statuses of parents affect academic achievement of learners across all pre-tertiary levels in the Ada East District of Greater Accra Region of Ghana. The study revealed that the higher or richer the sociocultural and socioeconomic backgrounds of parents, the higher the academic performance and development of learners of these parents and vice versa. This is because such parents have the ability to provide for their wards almost every essential educational resources and also give them the needed academic assistance via their level of training, experience, knowledge base, expertise and education.

Lastly, the study also revealed the impact of communication on learners' performance. It was noticed that the level of communication and relationship existing among the parents, teachers, school and the community outside help to shape learners' development, performance and achievement in academics. It was seen that communication undoubtedly walked and worked hand in hand with academic development and achievement of learners. It was unveiled that the more effective communication tends to be among parents, teachers and the school the greater the chance for learners to improve academically. The study therefore concludes that the intensity of communication and relationship among parents, teachers, school and the community have promising effects on the academic performance and development of pre-tertiary learners in the Ada East District of Greater Accra Region of Ghana.

6. Research Limitation

The researchers could not meet all pre-tertiary learners in the selected schools and in the district at large due to long distance and limited time. Because of this, the researchers had to use a sample of respondents to represent all learners in pre-tertiary schools in the district and the country at large. Due to this, generalizability of this study becomes very difficult when one considers the mass population of learners in pre-tertiary schools in the district and the country as a whole. Finally yet importantly, during the data collection process, some learners and parents alike felt shy to disclose their socioeconomic and sociocultural backgrounds. Others were also reluctant to respond to some interview questions. Similarly, some section of selected teachers were not compromising in the study. These attitudes made the researchers questioned one another as to the authenticity of the data gathered from these respondents.

7. Recommendations

At home, parents and guardians must show interest in all academic activities of their children. They can do this by assisting their wards with home works, projects and other related school-based tasks. Parents ought to have time for their children and offer them enough study time at home as well if only they wish to ensure a more reliable and an improved academic life for their children. This does not only help students to become academically self-reliant but it also motivates them to thrive for more academic success.

Parents should also make it a point that it is their dire responsibility to make provision for all educational needs as satisfactorily as possible. Academic learning gets more and more difficult for young learners when studies facilities are not readily available. Parents ought to provide their wards with more educative supplementary materials in addition to those already in the school. Most importantly, families should offer their school going children the best psychological advantage as possible. Any form of activity especially marital disputes, family feuds, domestic violence and child labour among others that is likely to dim the interest of children from studying should not be encouraged to revolve around them.

The community also has a role to play by ensuring that they act as reliable agents that support, supplement and complement the efforts of parents. Obviously, parents with low income and limited education cannot do this all alone unless they get helping hands. It is for this reason that communities through the efforts of NGOs and other stakeholders should be entreated to come in and support such disadvantaged parents to help build the academic lives of their children. They can do this by building community libraries to serve all manner of children, organizing extra classes for poor but needy students, giving financial assistance and other forms of scholarship for students from low socioeconomic and sociocultural backgrounds.

The Ministry of Education and the Ghana Education Service should also come up with policies that will compel schools to include parents and communities actively in almost all affairs of the school. Again, the Ministry of Education through the Ghana Education Service, stakeholders of education like NGOs can support parents to realize the dream of achieving academic excellence for their children. They can help by providing free textbooks, supplementary materials, school uniforms, free extra tuition, scholarships, etc. to all manner of children especially those from poor backgrounds.

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Measuring interference with ultrasound and Arduino – How to build an automated ultrasonic scanner

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Abstract

In this paper we describe the construction and application of a simple and inexpensive measurement tool that can be used in the improvement of the demonstration of wave-phenomena, and can help students to understand interference in physics education. Studying or even redesigning of the algorithm controlling the measurement and recording the data can give students an insight into an algorithmic thinking process and helps in implementing programming skills obtained in other classes.

Keywords: Data Streamer; Young's experiment; diffraction; physics; education;

1. Introduction

In many physics teachers opinion, physics education needs some refreshment. One likely way to make physics lessons more interesting, and make students to be interested in physics and science is showing new technologies and development in experiments and using new, innovative devices [1].

The interference patterns of light can be demonstrated using a simple screen, but the behaviour of surface waves is easier to observe, creating them on a sufficiently large water surface. However a special and expensive device, a wave tank is needed to perform such experiments. Examples for the experimental application of ultrasonic waves in the 40 kHz region have already been described in the international literature [2]–[4]. These papers were published shortly after the appearance of the popular and low-cost sensors we also use. One of the first articles presenting basic demonstrational experiments with ultrasonic waves was published in 2003 [5]. PHYWE Systeme GmbH & Co has also begun to produce experimental equipment to study the topic, which also shows the popularity of these new educational methods. In this paper we are showing a way to look into the attributes of ultrasonic waves that are getting more and more widespread in many common areas of life (e.g., medical diagnostics, and vehicles).

We designed a very useful educational equipment made from low-cost components and repurposed parts of outdated electronic devices. Based on this paper, it can be reproduced by anyone having basic electronic knowledge. We tried to develop an automated measuring system capable of spectacularly and obviously

demonstrating the interference shown by ultrasonic waves. The source of the ultrasonic wave was made from the transmitter of a distance measurement ultrasonic sensor. These sources are based on piezoelectricity, the resonance frequency is 40 kHz, thus the wavelength of the ultrasonic wave in air is approximately 8.5 mm. This wavelength makes it possible to observe the intensity of the forming wave front by moving a detector (microphone as an ultrasonic receiver) along a line. Measuring the sign of the moving microphone, we get a graph about the intensity of soundwaves depending on the location. To scan the wave front, we used the machinery of an old, disused document scanner.

2. The structure of the device

The stand of the microphone was attached to the table of the scanner, moved by a toothed belt. The microphone moves along a path of approx. 20 cm. Before attaching the microphone, do not forget to gently remove the glass over the machinery. Discard the useless cards and sensors. The microphone moved by the scanner is measuring the intensity of soundwaves depending on the location. The toothed belt mechanism is run by a T13119635 type unipolar stepper motor. At first we have to solve the control of the motor. We can use any other type old, cast-off scanner, because most of the flatbed types have similar operating principles. If you do not feel like recycling an old document scanner, it can be also used a HPV4 MINI V Linear Actuator Set [6] (Fig. 1.), which is a ready-to-use stepper motor.



Figure 1 HPV4 MINI V Linear Actuator Set [6]

During the development of the measurement tool we intended to build in low-cost ingredients, that can easily be obtained from webshops like Ebay or Aliexpress. The measuring tool is controlled by an Arduino microcontroller, shown in a block diagram in Fig. 2. This controller sends a set of instructions at D2-D5 digital output to the driver board (ULN2003) [7], [8] of the stepper motor (EPOCH T1319635). Furthermore this card completes every other task during the measurement, thus it manages the alternating current (voltage) in the circuit of the digital signal generator (AD9850) [9], [10] of the ultrasonic transmitter.

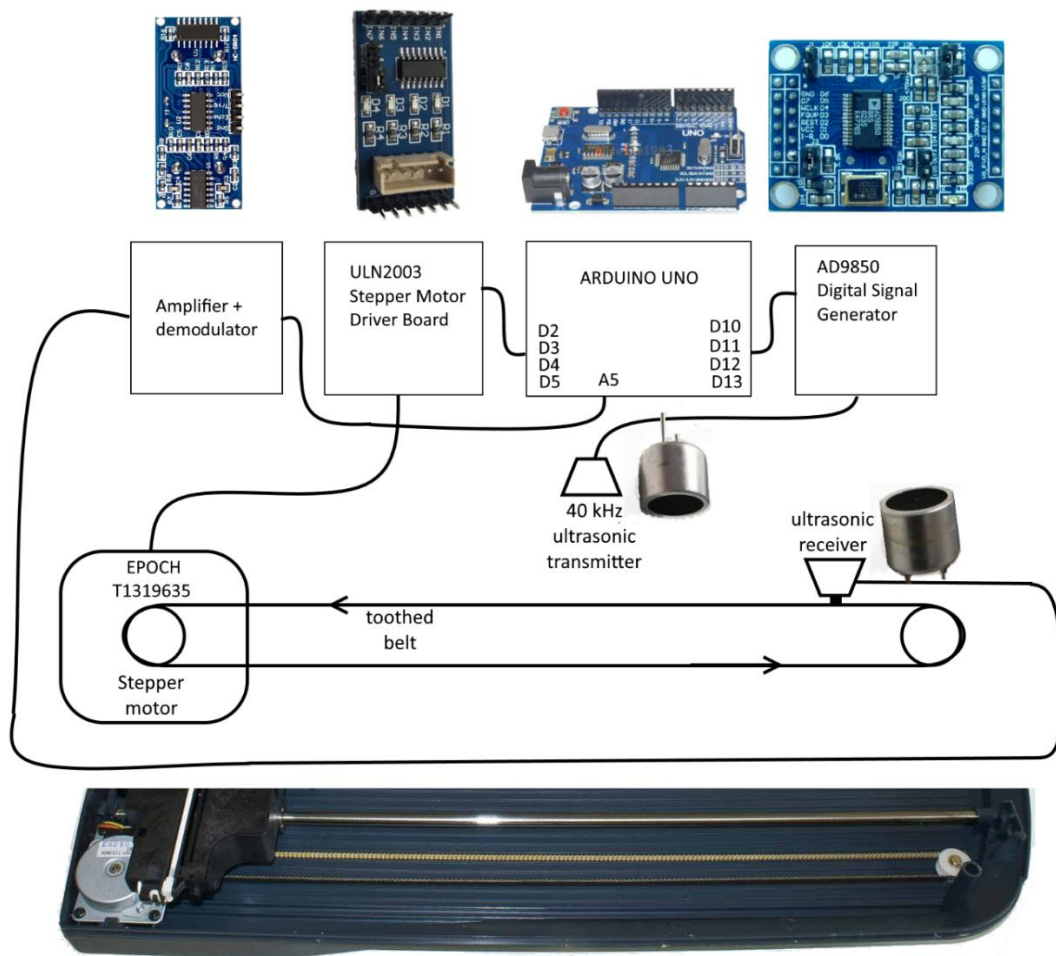


Figure 2 The block diagram of the self-devised automated ultrasonic scanner

A short section of the source code configures the Arduino card via D10-D13 outputs at the beginning of the measurement. On the output, a 40 kHz sinusoidal voltage will be generated, which is directly connected to the ultrasonic transmitter. To measure the intensity of ultrasonic waves, we used a modified ultrasonic distance measuring sensor, type HC-SR04. This device was developed to work with Arduino or other microcontrollers and works on 40 kHz frequency. The sensor is pictured in Fig. 3.



Figure 3 A low-cost ultrasonic distance measuring sensor [11]

The conception of the HC-SR04 sensor is shown in the circuit draw [12] in Figure 4. It is very simple to solder out the T (transmitter) signed “speaker” from this device, and we can modify the other, receiver side

to create a suitable detector. In Figure 3. It can be seen, that the R (Receiver) microphone is connected to a U2D preamplifier, which was created from the 2. operation amplifier of an LM324 integrated circuit. The preamplifier is set to 6 times amplification. The increased sign of the microphone is connected to a 40 kHz bandpass filter, which is followed by another 10 times amplifier device (U2B). The fourth operation amplifier (U2A) of the integrated circuit is a comparator - we do not need this at all. We would like to use the remaining part of the circuit to measure the intensity of ultrasound, thus we have to add some more elements. The extended circuit was shown in Figure. 4. This figure shows the added parts in blue border, which is a simple single-phase rectifier. The main part is an OA 1182 type germanium diode, but a silicon diode (e. g.: 1N4148) is also suitable. The rectified signal is integrated by a C9-R16 filter, and measured by the Arduino connected to A5 analogue input. This voltage is commensurate (proportional) with the intensity of the detected ultrasounds. The PCB of the modified hardware could be redesigned, but the modification of the original one is so simple that it is not worth it to design and manufacture a new PCB when only needing a few examples. It is the most useful to begin with the transformation of the original PCB by removing the 'speaker' marked with T. Let us store the speaker, because later this must be connected to the analogue output of the sound generating card. The amplified signal of the microphone can be taken from the 7th pin (U2B output) of the integrated circuit LM324. Thus, the anode of the diode must be soldered here. Afterwards, the rest of the elements must be connected. The circuit operates from a 5V power supply, so a connector ending in two pins must be prepared from two cables that can be used to connect our modified circuit to the GND and 5V connector pair of the Arduino.

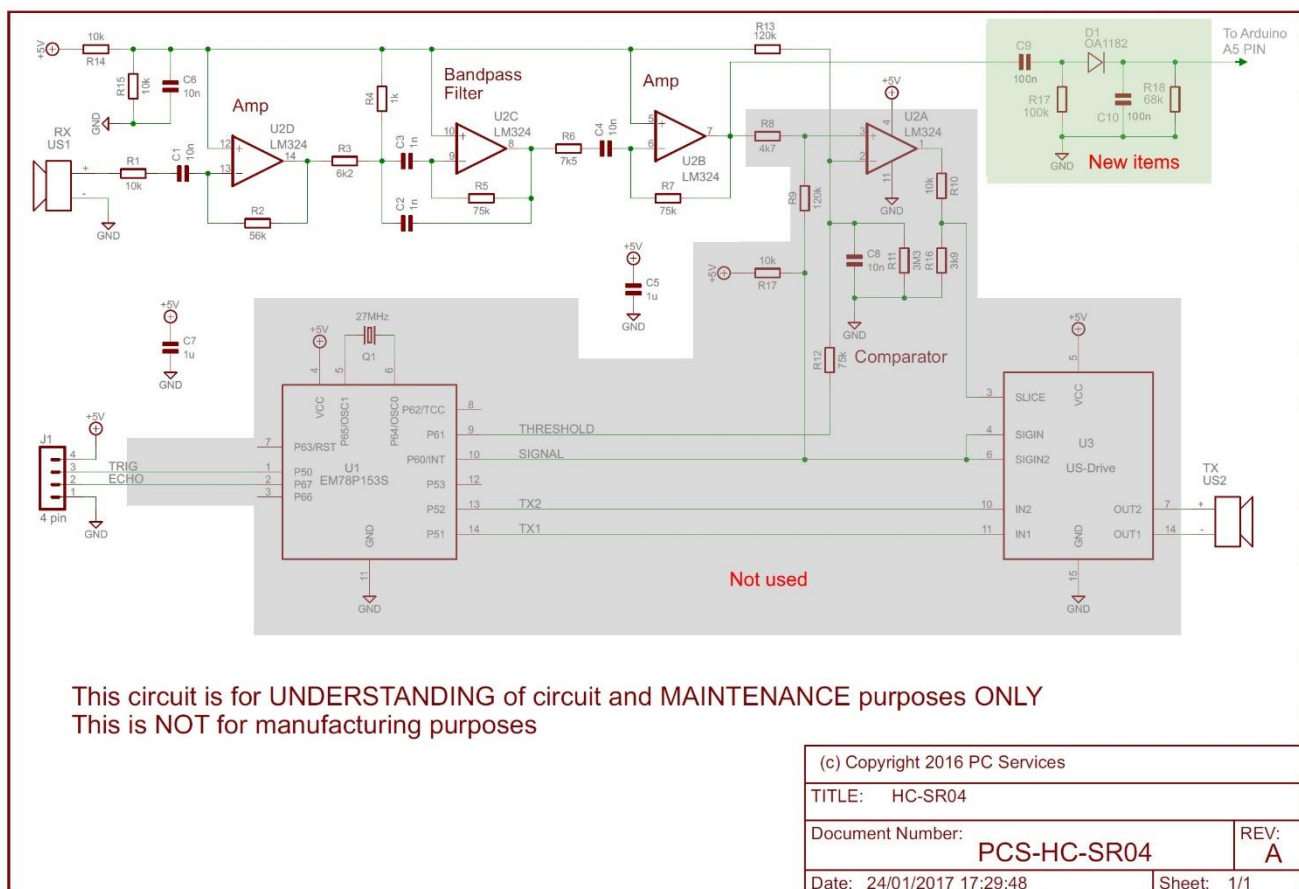


Figure 4 The circuit draw of the conception of the HC-SR04 sensor [12] and an added simple single-phase rectifier

The pins of the ultrasonic speaker (previously removed from the distance measuring sensor) must be connected to the signal generator controlled by the Arduino using a pair of light and flexible cables. At the end of the conversion the receiver sensor (the microphone marked with R, serving the detection of ultrasounds) must also be removed and connected to its original connection points at the demodulator using a flexible piece of shielded cable. This step is necessary to make the microphone mobile. Both the signal generator and the microphone need to get attached to a stand (for example made out of a ruler), with the microphone being fixed to the moving part of the scanner. They need to be placed at the same height. The circuit draw and the schematic of the wiring of the hardware is shown in Figure. 5 and 6.

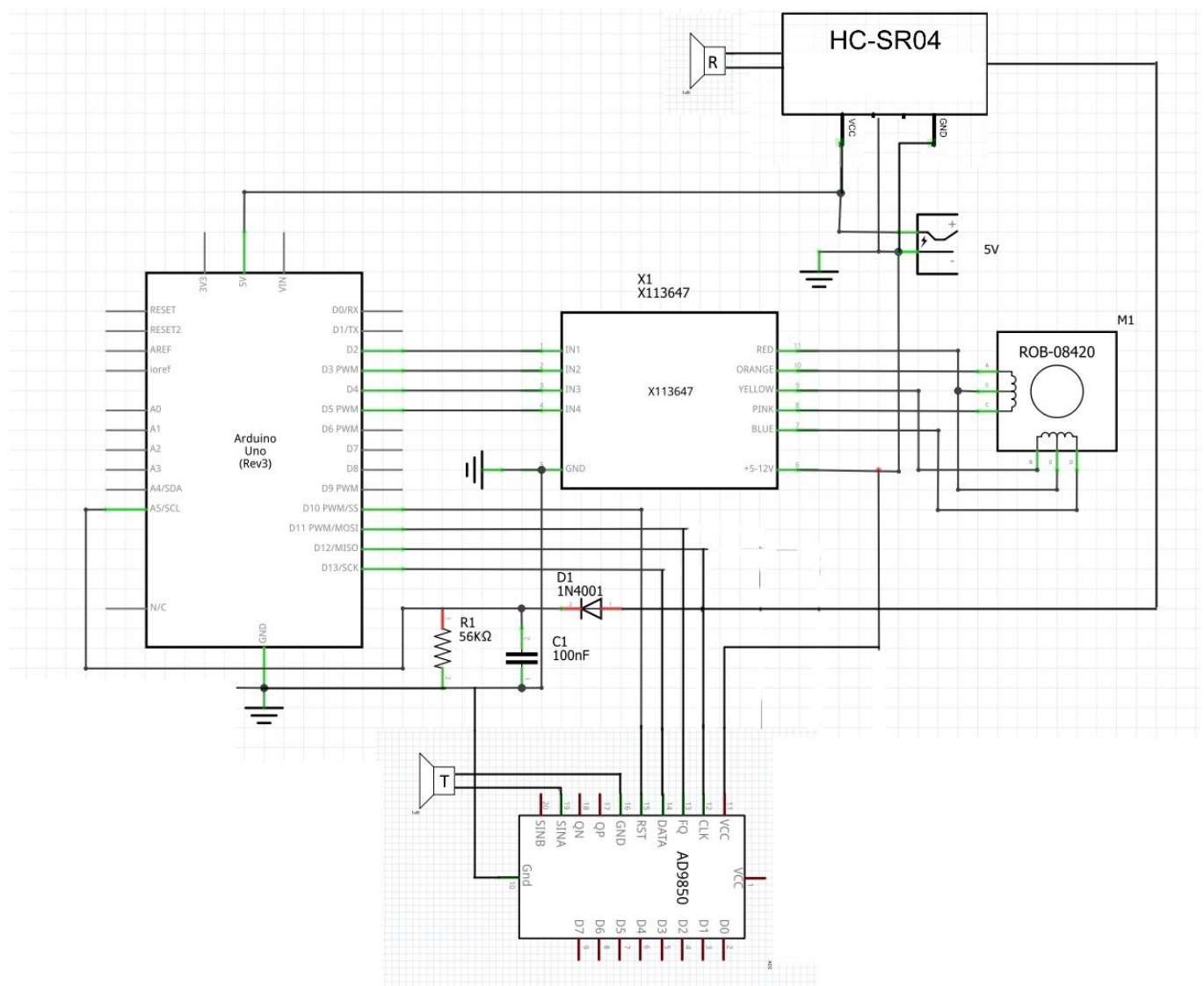


Figure 5 The circuit draw of the hardware

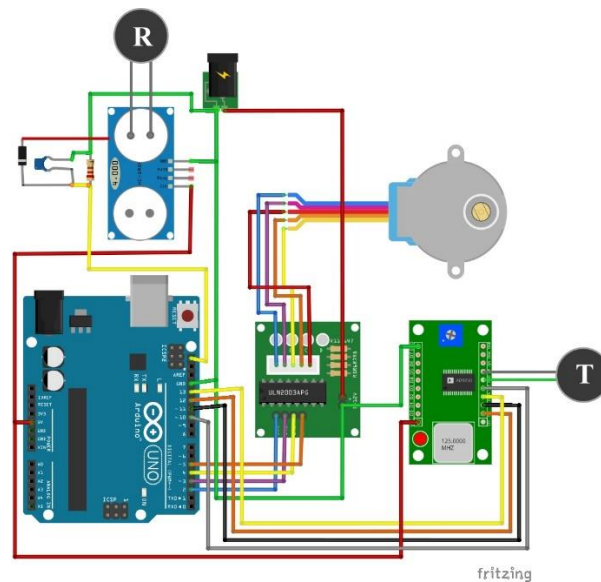


Figure 6 The schematic of the wiring of the hardware

3. The operational principle of the device

Before presenting the code, the operational steps of the apparatus need to be discussed. On switching on the Arduino, the program initializes the important variables and starts operating the hardware. At the beginning of a new measurement it is necessary to record the voltage level measured on the output of the demodulator card corresponding to a zero sound intensity. So, the signal given to the output of the sound generator is switched off, then the signal level of 'silence' is measured and stored. After recording this value called 'Blank', the sound of the wave source is switched on. Afterwards, moving of the microphone through the wave-front. Sound intensity is measured over and over after specified step intervals. The value of 'Blank' is then subtracted and the result is sent to the COM port used to communicate between the Arduino and the PC. The number of steps can be used to calculate when the microphone reaches the end of its course. Then, it is moved back to its original place at the highest possible pace. The microphone will wait for the initiation of a new scanning process in this position.

The program and the detailed explanation of the Arduino-code can be found in the appendix.

4. Collecting measurement data, and results

Measurement data sent to the COM port are collected in an Excel spreadsheet using a Microsoft Data Streamer [13] unit. In the spreadsheet intensity values are plotted against horizontal coordinates. The latter values are obtained by converting step numbers. As the ultrasonic receiver travels 20 cm for every 1000 steps of the motor, one step corresponds to 0.02 cm. Thus performing the measurement in five-step intervals provides a resolution of 1 mm. Figure 7. shows the results of a measurement performed with the apparatus. In this case the obstacle was placed $L = 67$ mm away perpendicularly to the middle of the path of the receiver. Then, an obstacle of 16 cm height and 14.1 mm diameter was placed into the wave-space. Results are shown in the blue curve. The distance of two adjacent peaks are $x = 46$ mm, the wavelength is $\lambda = 8.5$ mm. The diameter of the obstacle can be calculated by the following formula [14]:

$$d = \frac{\lambda}{\sin \alpha},$$

where α can be calculated from the peak distance and the obstacle-detector distance:

$$\tan \alpha = \frac{x}{L}$$

As the distance of the obstacle and the detector is too short, we can not use the $\tan \alpha = \sin \alpha$ approximation as usual.

The calculated diameter of the obstacle is 15.0 mm, which convincingly demonstrate the applicability of our measurement system.

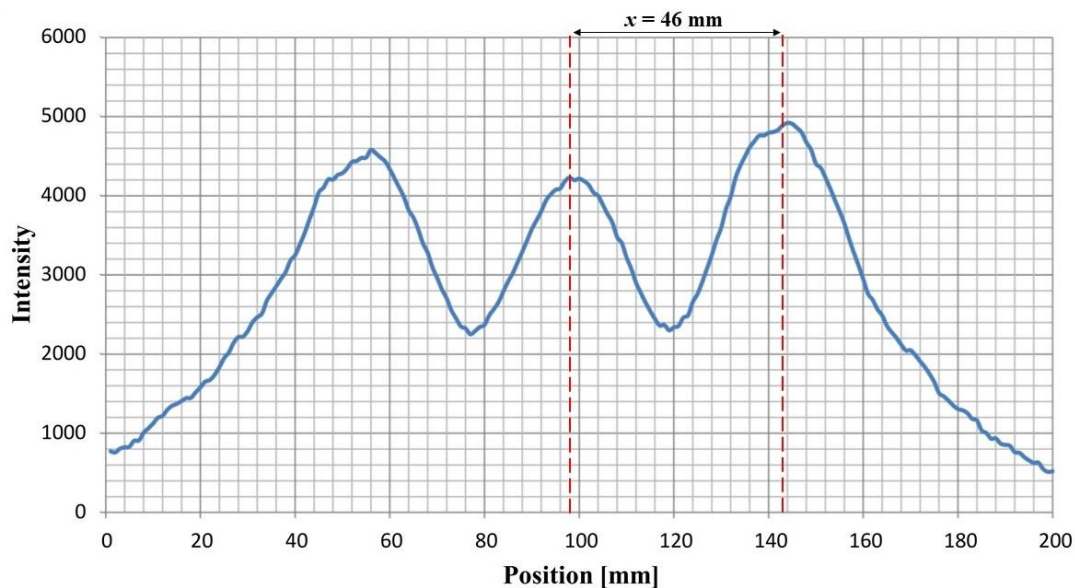


Figure 7 The results of the measurement performed with the apparatus. (The obstacle was 14.1 mm diameter, 16 cm height cylindrical tube 67 mm away to the scanning path)

Figure 8. shows the diffraction pattern obtained in the original, optical variant of the experiment. A human hair was used as the obstacle resulting in a seemingly similar pattern to the one plotted in Figure 7.

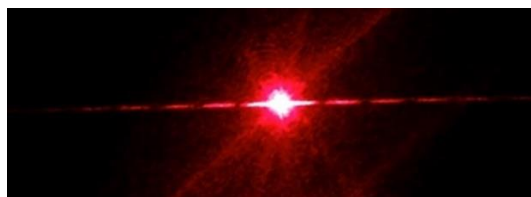


Figure 8 The diffraction pattern of hair obtained in the original, optical variant of the experiment

Figure 9. shows a photo of the complete and functioning experimental setup.

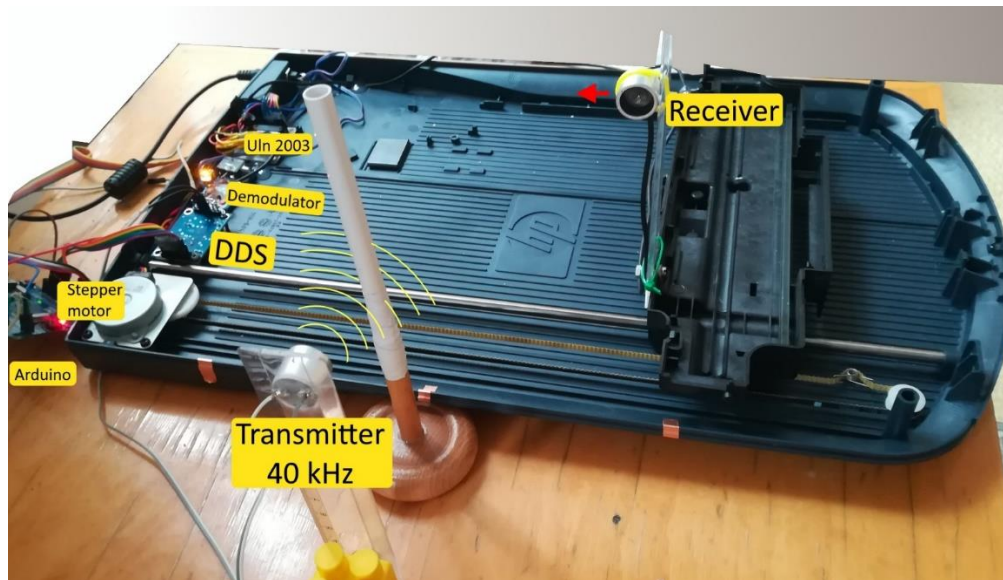


Figure 9 The structure of the automated ultrasonic scanner

5. Further experiments with the device

The automated ultrasonic scanner described in the current paper may also be useful in the conversion of other famous experiments on the interference of light to their sound wave analogies. These can be than simply and spectacularly presented to students. For example using a double slit placed appropriately with the slits being 1 cm away from each other the double slit experiment of Young can be presented convincingly. Placing more slits next to each other evenly would afford a similar diffraction pattern to that of an optical grid. The Lloyd's mirror experiment can also be presented by the experimental setup with small alterations. Basic wave-phenomenon may also be studied with it, like refraction and reflection.

6. Research results

We have already put the device to the touch of 30 students in a few experiments during physics lessons, and made a questionnaire with them about their general physics knowledge and impression about the new experiment. According to the answers, the students showed high interest in the experiments presented by the device. The inquire of the group about physics was medium low, the average scores based on the answers was 3.6 (1 means 'very interested in physics',..., 6 means 'not at all'). In contrast, the points of the answers regarding the presented apparatus implied that it could help students' involvement in physics. The average score based on the interest in the device was 2.3, which is better than the previous result about the usual attitude toward physics.

Figure 10 shows the correspondence between the physics knowledge of the students and their opinion, how much they understood the experiment and the operational principle of the device. However, the average score of physics knowledge was regrettably high, 3.9 (1 means 'very good at physics',..., 6 means 'not good at physics'), the understanding score was 2.3, which is much better result.

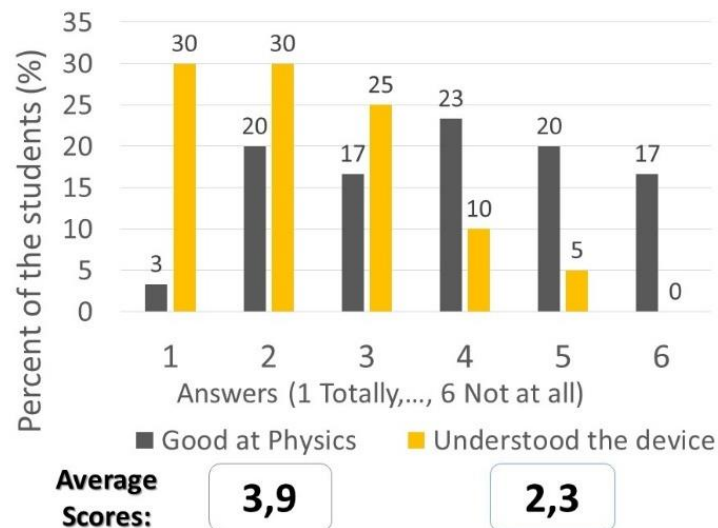


Figure 10 Average score of students based on the answers about usual knowledge of physics and understanding the operation of the device

7. Conclusion

An example on an inexpensive yet robust device is presented for the use in student experiments in physics-classes. The Arduino-automated interferometer is based on repurposed computer-peripheries and is used in the larger-scale demonstration of wave-interference experiments such as the diffraction of waves around an obstacle or the well-known two-slit experiment. Because of using ultrasound instead of light (commonly used in current educational experiments) the objects having a comparable size to the wavelength are larger, making the experiments less sensitive and also more easily perceptible. As programming of the Arduino and the collection and evaluation of the experimental data can be done also by students, a connection between multiple subjects can be established, supporting interdisciplinary education. According to the results of a questionnaire involving 30 students, the device greatly increased their interest in science and modern technologies and improve their attitude about learning physics.

8. Acknowledgement

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Appendix

In this table you can find the Arduino code of the device with explanation. If you feel like rebuilding the device, feel free to use the code in the 2nd column.

	Arduino code	Explanation
1	//*****Stepper motor	
2	int STP1 = 2; //Wiring for stepper motor (blue)	The program (line 2.-5.) defines the digital outputs to send data to the stepper motor. E.g.: int STP2 = 3 means, the 2 nd wire (purple) of the stepper motor is connected to the D3 output of the Arduino (ULN2003 driver board was inserted)
3	int STP2 = 3; //Wiring for stepper motor (purple)	
4	int STP3 = 4; //Wiring for stepper motor (yellow)	
5	int STP4 = 5; //Wiring for stepper motor (orange)	
6	int Speed = 2; //The speed of the stepper motor (1=high, 20=slow)	With the variable “Speed” we can identify the time between two steps of the stepper motor.
7	int N=1000; //The number of steps	In variable N we can store the number of all of the steps along the 20 cm long path.
8	//*****AD9850 DDS signal card	
9	int CLK = 12; // pin 12: AD9850 clock pin	In line 9. -12. We can declare the outputs to control the AD 9850 Analog Signal Generator [9], [10].
10	int FQ = 11; // pin 11: freq update pin	
11	int DAT = 13; // pin 13: D7 DATA pin	
12	int RST = 10; // pin 10: RESET	
13	//*****	
14	String C=""; //Start command	Declaration of the variable to start the program.
15	int LEDPin = 13; //Indicator lamp	The indicator lamp shows us, when a program is running on the Arduino.
16	int Ain_Pin = A5; //ADC input	
17	int Act_Step=0; //Current number of steps	
18	int Blank=0; //Demodulator voltage without signal	
19	int U_in=0; //Demodulator voltage	
20	int Nm; //Number of measurements	

21	int Ns;//Number of steps without measure	
22	void setup() {	
23	pinMode(FQ, OUTPUT);	Program in line 23.-31 is running once during every measurement. We can setup which pins can be used as an output. E.g.: pinMode(STP2, OUTPUT) .
24	pinMode(CLK, OUTPUT);	
25	pinMode(DAT, OUTPUT);	
26	pinMode(RST, OUTPUT);	
27	pinMode(STP1, OUTPUT);	
28	pinMode(STP2, OUTPUT);	
29	pinMode(STP3, OUTPUT);	
30	pinMode(STP4, OUTPUT);	
31	pinMode(LEDPin, OUTPUT);	
32	Nm=60;	We can specify the important constants. Nm=60 is the number of act of measuring. Ns=5 means that we do measurement in every 5 th steps.
33	Ns=5;	
34	DDS_pulse(RST);	In line 34.-36. we set the Analog Signal Generator to default settings [10].
35	DDS_pulse(CLK);	
36	DDS_pulse(FQ);	
37	analogReference(EXTERNAL);//	Between 0V and 5V we can use the voltage AREF pin of Arduino as a voltage reference which make the measurement more accurate.
38	Blank=0;//Measuring a blank signal	Calling subroutin meas_b() (line 90. – 98.) we can measure the level of the signal when the transmitter is tuneless.
39	meas_b();	
40	Serial.begin(9600); // Serial comm setup	Than we can set the boud_rate value of the serial communication.
41	DDS_Output (40000);//Ultrasound signal turns on 40 kHz	
42	C="S";//Ready for first scan	
43	}	
44		
45		
46	//*****Start scan	
47	void loop() {	
48	if (Serial.available() > 0) {	
49	String cln=Serial.readString() ;//Waiting a command from Excel ("S" command = start scanning)	To start the measurement, write an “S” the appointed cell of the Excel.
50	cln.trim();	
51	cln=cln.substring(0,1);	

52	if (cln=="S"){	The scanning process will start as soon as the starter command ("S") arrived.
53	meas_b();//Measuring a blank signal	
54	C="S"; //Ready for a new scan	
55	DDS_Output (40000);//Ultrasound signal turns on 40 kHz	
56	}	
57	}	
58	if (C=="S"){	
59	Act_Step=0;	The program in line 59 resets the actual stepnumber.
60	digitalWrite(LEDPin, HIGH);	The indicator lamp flares up.
61	for (int I = 0; I < N; I++) {	The cycle will be repeated until the stepnumber reaches N (= 1000).
62	Forward();//Just one step forward	
63	U_in =0;	Reset the previous value of voltage.
64	Act_Step++;	The program adds one to the actual stepnumber, than decides, whether it is necessary to do a measurement. If the stepnumber is divisible by Ns (5 in this case), a measuring is done (else, it is not). This is useful to decrease measurement time. The program collects datas 60 times in a single position.
65	int x=0;	
66	x = Act_Step % Ns;//Modulo	
67	if(x==0){	
68	for (int J = 0; J < Nm; J++) {	
69	U_in = U_in + analogRead(Ain_Pin);//Step and measure	Save the new value of voltage.
70	}	(The speed of steps can be affected by the delay(Speed) function as well.)
71	U_in = U_in - Blank;	After measuring the voltage in Ain_Pin, we have to substract the value of Blank voltage to eliminate the background noise.
72	String ln="";	We clear variable String ln="" .
73	ln=ln + String(Act_Step) + "," + String(U_in);//Print a line for Excel	We concatenate the measured values and the number of step to this string variable.
74	Serial.println(ln);	In line 72. the program sends the value of the previous string to the com port
75	}	Data was sent by Arduino with the command Serial.println(ln) are collected by the Excel by the help of the free Data Streamer module [13] The data separated by comma are automatically placed in coulmsns.
76	}	
77	STP_off();	The program turns off the stepper motor and the indictor

78	delay(100);	lamp, than moves the microphone back to the original position by calling the right subroutine. Then, the device turns off permanently.
79	digitalWrite(LEDPin, LOW);	
80	for (int I = 0; I < N; I++) {	
81	Backwards();	
82	}	
83	}	
84	C="X";	
85	STP_off();	
86	}	
87		
88		
89	//*****	
90	void meas_b() {	It is measuring the intensity of the background noise.
91	DDS_Output (40);//Ultrasound signal turns off 40 Hz	We send 40 Hz signal to the output of the signal generator. In case of our microphone – which is optimised to 40 000 Hz – this sound is practically acts like silence.
92	U_in =0;	We reset the value of voltage.
93	delay(500);	
94	for (int J = 0; J < Nm; J++) {	We measure and read the value of the input voltage. We repeat this measurement step Nm=60 times like in case of active measuring.
95	U_in = U_in + analogRead(Ain_Pin);//Average of demodulator voltage without signal	
96	}	
97	Blank=U_in;	We store the value of background noise intensity in the variable Blank.
98	}	
99	//*****	
100	void DDS_pulse(int pin) { digitalWrite(pin, HIGH); digitalWrite(pin, LOW); }	
101		
102	void DDS_Output(float frequency) {	
103	long freq = frequency * pow (2,32) /125000000; // Reference clock	
104	for (int b=0; b<4; b++, freq >>= 8) shiftOut(DAT,CLK,LSBFIRST,freq);	
105	shiftOut(DAT,CLK,LSBFIRST,0);	
106	DDS_pulse(FQ);	

107	}	
108	//*****	
109	void Forward () { //stepper motor one step forward	The code of the stepper motor: https://coleveld.com/arduino-stepper-uln2003a/ (Example 3, 4-step sequence), [7]
110	{digitalWrite(STP1, HIGH);digitalWrite(STP2, HIGH);digitalWrite(STP3, LOW);digitalWrite(STP4, LOW);delay(Speed);}	
111	{digitalWrite(STP1, LOW);digitalWrite(STP2, HIGH);digitalWrite(STP3, HIGH);digitalWrite(STP4, LOW);delay(Speed);}	
112	{digitalWrite(STP1, LOW);digitalWrite(STP2, LOW);digitalWrite(STP3, HIGH);digitalWrite(STP4, HIGH);delay(Speed);}	
113	{digitalWrite(STP1, HIGH);digitalWrite(STP2, LOW);digitalWrite(STP3, LOW);digitalWrite(STP4, HIGH);delay(Speed);}	
114	}	
115	void Backwards () { //Stepper motor one step backwards	The code of the stepper motor to reset the original position. The steps are the same in case of stepping forward, but in reverse order. Moving backwards can be fast, thus we can decrease the time between steps (Speed).
116	{digitalWrite(STP1, HIGH);digitalWrite(STP2, LOW);digitalWrite(STP3, LOW);digitalWrite(STP4, HIGH);delay(Speed);}	
117	{digitalWrite(STP1, LOW);digitalWrite(STP2, LOW);digitalWrite(STP3,	

	HIGH);digitalWrite(STP4, HIGH);delay(Speed);}	
118	{digitalWrite(STP1, LOW);digitalWrite(STP2, HIGH);digitalWrite(STP3, HIGH);digitalWrite(STP4, LOW);delay(Speed);}	
119	{digitalWrite(STP1, HIGH);digitalWrite(STP2, HIGH);digitalWrite(STP3, LOW);digitalWrite(STP4, LOW);delay(Speed);}	
120	}	
121	void STP_off() { //stepper motor turn off	
122	{digitalWrite(STP1, LOW);digitalWrite(STP2, LOW);digitalWrite(STP3, LOW);digitalWrite(STP4, LOW);delay(Speed);}	
123	}	

The role of Knowledge Media in Network Education

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Abstract

An efficient model of education is always closely related to a vision of society. The conception of network society places as a priority a network education model. The general objective of this article is to establish the foundations of network education and its relationship with the knowledge media. The methodology used in this research will be qualitative, descriptive with theoretical approach. The first section will establish the foundations of network education, based on the vision of network society, and its difference from distance education models based on the use of information and communication technologies. In the second section the concepts of "knowledge media" will be analysed and discussed. The third section will address the relationship between network education and the knowledge media. The fourth section will establish the possibilities and limits of network education within the scope of knowledge communication. The result of the theoretical reflection points to a network education model in the digital age based on the network society, within the scope of knowledge communication, aiming to establish the knowledge dialogue through knowledge media.

Keywords: network education; knowledge communication; knowledge media; knowledge dialogue.

1. Introduction

An efficient model of education is always closely related to a vision of society. The concept of a network society (Castells, 2010) places a model of network education as a priority. Networks can take many forms represented in a basic typology such as centralized, decentralized, and distributed. Network education can initially take any of these forms. Network education is not the same as democratic education, although they may coincide, depending on the structure of the educational network. Therefore, it is necessary to abandon an ideological or idealized view of network education so that it can reach its full educational potential. If a distributed and democratic network education is desirable (Uys, 2002), then it needs to be planned and built.

A democratic network education requires network literacy. There is the need for a network literacy in a network society (Cramer, Porter, Sayama, Sheetz, & Uzzo, 2015). If you want to understand your educational process in a network, it is necessary to advance in the understanding of nature, structure, and possibilities of this educational network. Someone can understand educational connections and interactions at various fractal levels through network literacy. If network education has as one of its characteristics the flexibility of connection and interaction patterns, understanding these patterns become students able to

informed change them. Network literacy seeks to raise awareness of the value of network science in education and offers a new lens for seeing the world: the lens of connectivity (Cramer, Porter, Sayama, Sheetz, & Uzzo, 2018).

Network education emerges strongly associated with knowledge media. Daniel (1996, p. 2) identifies “knowledge media” with the new generation of technologies that emerged at the end of the 20th century. Knowledge media emerged with the third generation of distance education. With the advancement of the internet and the virtualization of the world, new trends in distance education have been emerging and updating the understanding of knowledge media. However, network education is not reduced to Distance Education, but broadens it, bringing the science of networks to the media of knowledge. There are several types of knowledge media and several ways to use them, so the use of knowledge media does not imply that it must take any particular educational perspective (Inglis, Ling, & Joosten, 2003, p. 166). A democratic network education aims to increase the autonomy and educational, technical and contextual skills of teachers and students. In this perspective, knowledge media can offer the opportunity to emphasize the educational process on the person and learning (Lynch, 2004, p. 16).

Network education can favor the improvement of technical skills such as the use of devices and applications to carry out educational tasks (Lin, Lin, Jiang, & Lee, 2007). Network sciences and knowledge media become the educational process without limit of time or space (Lin, Lin, Jiang, & Lee, 2007; Guan, 2012). Democratic network education offering to students greater flexibility and promoting lifelong learning (Lin, Lin, Jiang, & Lee, 2007). The beginning of the 21st century is depicted by an immense volume of information that is offered to people. Along with this immense volume of information is Fake News. Democratic network education aims to provide the development of the competence to manage this information, fostering research, the selection, and organization of documents and making informed decisions (Lin, Lin, Jiang, & Lee, 2007). Network education in times of fake news should promote information literacy and ethics of information (Müller & Souza, 2018). Democratic network education should favor more personalized learning that enables the student to understand the relationship between regional and global problems.

Some of the challenges of network education are the unfamiliarity with network sciences (Cramer, Porter, Sayama, Sheetz, & Uzzo, 2018), the lack of knowledge and misuse of technology, the lack of adequate equipment for students, the lack of self-discipline on the part of students (Lin, Lin, Jiang, & Lee, 2007) and the lack of preparation of teachers. New skills for this educational modality need to be massively developed. A much larger number of students have been reached than traditional universities would ever be able to through information and communication technologies (Burke, 2012).

There seems to be a process of the mediatization in the society that is facing the COVID-19 pandemic. The mediatization of society which is the result of the interaction process between the media and human relations and social practices (Hjarvard, 2013). The dependence on the media increases during the mediation process and as a result of this chronic and acute interaction, many of the social practices are redefined. This may be the result of the intensive interaction with the media (traditional, social, or digital) that is being experienced during the COVID-19 pandemic in 2020. Mediation is interfering with the way human relations occur. Mediatization is not characterized by the use of the media or the power of influence of the media, but by human interaction which becomes mediated (Hjarvard, 2013). Mediatization arises

from the relational space between the media and human relations and social practices. The phenomenon can be found almost everywhere because of the ubiquity of the media in many forms of devices. This leads to the question: what is the impact of the knowledge media in this intense mediation process?

The general objective of this article is to understand the nature of the relationship between network education and knowledge media. The article intends to answer the following question: what is the locus of network education?

In the first section, the foundations of network education, based on the vision of network society, will be established, and their difference from distance education models, based on the use of information and communication technologies. In the second section, the concepts of “knowledge media” will be analysed and discussed. In the third section, the relationship between network education and knowledge media will be addressed. In the fourth section, the possibilities and limits of network education within the scope of knowledge communication will be established. The result of the theoretical reflection points to a model of network education in the digital age based on the network society, within the scope of knowledge communication, aiming to establish the knowledge dialogue through the knowledge media.

1. From Distance Education to Network Education

A fundamental characteristic of distance education is that teachers, tutors, and students are, at least in part, separated in time and space, physically and geographically, and, being in this condition, the use of Information and Communication Technologies (ICT) is necessary (Diana, 2019, p. 27). The foundation of distance education is precisely the use of ICT to fill the space-time gap between those involved in didactic-pedagogical mediation. The technology-mediated connection between student and teacher is a necessary condition of distance education (Diana, 2019, p. 34). Teaching necessarily takes place, at least in part, at a different time and/or place from learning, through ICT and some special institutional infrastructure (Moore & Kearsley, 2013, p. 2). Although several active methodologies are used today in distance education, it is not based on the pedagogical approach. Although the teacher's skills as a mediator of knowledge have been growing within the distance education scenario (Alarcon & Spanhol, 2015), it is not based on the teacher's dialogical mediation. Although one can speak of a new generation of distance education, such as network learning (Silva & Spanhol, 2018), placing networks and their structures at the service of distance education, the mediation of digital information and communication tools play a necessary role. In distance education modality, online social networks are essential.

The term “network education” is driven by the works of Margarita Gómez based on the conjunction of Paulo Freire's pedagogical proposal, aiming at a liberating education, and the development of the expression of networked, rhizomatic and creative thinking in a globalized world (Gómez, 2005). Margarita Gómez (1999) develops the model of liberating education (freireana) to the network scenario and uses the term “network education” to indicate the “point of intersection of the educational activity”. The term “network education”, used by Gomez, appears motivated by an application of Freire's pedagogy to telematic networks (Gómez, 1999).

Margarita Gomes offers a clear and well-founded view of the nature of network education in her book, *Educación en red*, published in 2005. According to Gómez (2005) Network education (a) requires

connectivity, communication and solidarity, placing the educational focus on the learning process (p. 16); (b) it makes it possible to open the school to the world, involving the entire school community, promoting transculturality (p. 17-26); (c) it has its foundation and purpose in line with the educational thought of Paulo Freire, which proposes an education for human solidarity (p. 27); (d) it promotes human relations in its context, both local and global, as well as the relationship with other areas of knowledge, especially epistemology, which could help in reaching a more accurate understanding of the process of acquiring knowledge in learning networks (p. 165); (e) it is characterized by the relationship of solidarity between the human, epistemological and technological dimensions, making it possible for the educator to find in the virtual sphere a space for speech, deliberation and realization (p. 189) and for the transdisciplinary relationship (p. 198).

Therefore, Margarita Gomez's vision of Network Education (2005) assumes a liberating and solidary education as a starting point and an ending point, using Information and Communication Technologies (ICT) as an aid given an emancipatory appropriation of knowledge (Nunes, Rosa, Souza, & Spanhol, 2016). In this perspective, the use of ICT in network education is neither necessary nor sufficient. It is just convenient and instrumental to achieve that liberating and rhizomatic way of thinking in a globalized world. ICT can expand and enhance network education. However, network education is based on qualified human relationality as solidarity. It focuses on learning, aiming at an integral education of the human being integrated into his community. With ICT, open-access materials and tools and the possibility of building collaborative networks, network education can expand its reach, making education much more inclusive. Another perspective on network education has been developed by the research group Media and Knowledge from the Federal University of Santa Catarina (Brazil), in which the foundation is in a model of a network society. There is no way to think about a non-network education within a network society. The network society changes the productive, cultural, and educational processes (Castells, 2010; Souza M. V., 2015, p. 37; Nunes, Rosa, Souza, & Spanhol, 2016).

On the other hand, "network education emerges in a knowledge society, whose reach is expanded by digital technologies" (Rosa, Silva, Müller, Spanhol, & Souza, 2018). In this perspective, network education is an education extended across the entire network, being this physical and/or virtual, using for this purpose the resources of interactive digital media (Souza M. V., 2015, p. 23). Network education is a "comprehensive, holistic, complex education" that involves seeking to promote a space (physical or virtual) for dialogue and interactivity (Souza M. V., 2015, p. 26). In this model of network education, pedagogical views, methodologies, technologies, and agents involved in the educational process work on the network to promote a knowledge dialogue, inclusive education, and improvement of the cognitive, technical and contextual skills necessary to achieve a qualified education (Spanhol, Farias, & Souza, 2018, p. 20).

Network education is a process of socialization and development for autonomy that aims at social integration and involves the acquisition of knowledge, skills, and values. Education is a broad process, aimed at social inclusion and integration. Network education is deeply related to a complex and network society. In a globalized, networked, and ever-changing society, network education will use all the means offered by ICT to expand its power of inclusion, integration, and updating, serving as an effective means to accompany cultural changes both in small communities and the global community.

Considering the fundamental characteristic features of distance education and network education in their

two perspectives, a comparative framework can be established between these two types of education on four aspects. The first aspect is the foundation and distinctive feature of each modality. It was considered that the distinctive feature of Distance Education is the necessary use, at least in part, of ICT for didactic-pedagogical mediation, due to its foundation being in the space-time gap between teacher and student, and between teaching and learning. On the other hand, the distinctive feature of Network Education is precisely the relationship in offline and/or online networks, given that the foundation of the first perspective is liberating education, based on the pedagogical vision of Paulo Freire and the foundation of the second perspective is the network society model.

The second aspect to consider is the purpose. The mode of distance education aims to give access to education to those people who are, at least partially, prevented from participating in person in the educational institution, being deprived of carrying out or completing their studies on time. On the other hand, the Network Education modality aims at a participative, dialogued, and inclusive education.

The third aspect to consider is the network relationship. In the distance education modality, the online network structure mediated by ICT is a necessary condition. Usually, both online and offline networks are contemplated. However, there is no distance education without the presence of online networks at least part of the time. On the other hand, the network education modality can only take place through offline network structures, since ICT is not necessary, although useful and convenient. Generally, the two modalities are considered, online and offline.

The fourth aspect to consider is the use of digital information and communication tools. Both modalities, distance education, and network education make use of the great technological potential of these tools, aiming to enhance the quality and decrease the time of the teaching-learning process.

For these reasons, it can be inferred that distance education and network education are not the same phenomenon or reducible to each other, since they share only the technological means, distinguishing themselves in their foundations, their purpose, and their structure.

2. Knowledge Media

The term “knowledge media” was used for the first time by Mark Stefik (1986) to depict consequences of linking Artificial Intelligence to the internet (Eisenstadt & Vincent, 1998/2000, p. 4). The knowledge media emerges as a new discipline (Eisenstadt & Vincent, 1998/2000, p. 4), from the convergence between computing, telecommunications, cognitive sciences or learning sciences (Eisenstadt, 1995; Daniel, 1996, p. 2; 101; Lynch, 2004, p. 15). The emergence of knowledge media offers a new vision in the area of education connecting the rise of ICT to social and educational contexts.

There are three major projects that follow from the proposal of Stefik (1986). They were based at (1) Stanford University (USA), (2) University of Toronto (CAN), and (3) Open University (UK).

Mark Stefik's knowledge media proposal (1986) was first implemented, around the 1990s, at Stanford University (USA), through The Knowledge Sharing Effort of DARPA (Defense Advanced Research Projects Agency) which was a consortium with aim to “sharing and reusing knowledge bases and knowledge-based systems”, underpinning the knowledge media on ontologies (common vocabularies) (Grütter, 2002, p. viii). The purpose of The Knowledge Sharing Effort was “the development of techniques,

methodologies and software tools for sharing and reusing knowledge” (Stanoevska-Slabeva, 2002, p. 6) “providing the basis for the next evolution of the web - the web semantics” (Hendler & McGuinness, 2000). Grütter (2002, p. viii) comments that the approaches to knowledge media at the (i) Knowledge Media Design Institute of the University of Toronto (CAN) and (ii) Knowledge Media Institute at the Open University (UK) are not directly based on Stefik's (1986) original view, but reflect some basic features of that view.

The Knowledge Media Design Institute, from the University of Toronto (CAN), conceived of the knowledge media as “building blocks of a learning society” (Stanoevska-Slabeva, 2002, p. 10).

On the other hand, the project based at the Knowledge Media Institute, of the Open University (UK), idealized that the knowledge media capture, store, transmit, share, access and create knowledge (see Eisenstadt, 1995), to continue education (lifelong learning) (Stanoevska-Slabeva, 2002, p. 11). At the KMI (Knowledge Media Institute) the scope of knowledge media encompasses “enhanced collaboration media on the Internet, multimedia environments for students with disabilities, intelligent agents, organizational memories, digital documents, scientific visualization and simulation tools, informal and formal representations of the knowledge” (Eisenstadt & Vincent, 1998/2000, p. 9).

The term “knowledge media” has an origin and history. However, There is neither space nor purpose of this article to develop the history of knowledge media. However, it is of fundamental importance for the arguments offered here to understand the origin and nature of the term. There is no hegemonic definition of the term “knowledge media” or a common understanding of the nature of knowledge media. In the following, the definitions found in the literature will be presented in chronological order.

First, it is necessary to warn of the use of the term in the singular “Knowledge medium” and in the plural “knowledge media”. Second, to signal that the term was coined by Mark Stefik, in his article “The Next Knowledge Medium” published in 1986 (Baecker, 1997; Grütter, 2002, p. viii). Stefik (1986) defines the term for the first time, in the singular, “knowledge medium” as “as an information network with semi-automated services for the generation, distribution, and consumption of knowledge”. Stanoevska-Slabeva (2002, p. 11) notes that Stefik's (1986) concept of knowledge media is characterized by the standardized language of communication and by the representation of knowledge in an interactive digital media.

In the 1990s, with the emergence of major projects for the development of knowledge media, a more intense reflection emerges in the academic community, generating some new definition proposals for the term. Among them is the proposal by Gruber, Tenenbaum and Weber (1992), defining the term, also in the singular, as “a computational environment in which explicitly represented knowledge serves as a communication medium among people and their program”; the proposal de Eisenstadt (1995) summarized by Lynch (2004, p. 15), defining the term, in the plural, “knowledge media” as “capturing, storing, imparting, sharing, accessing and creating of knowledge” (Lynch also comments that Eisenstadt coined the term “knowledge media” to describe the convergence between telecommunications, computing and cognitive or learning sciences), the proposal by Baecker (1997), defining the term, already in the plural, “knowledge media” as “documents, artifacts, technologies, and systems intended to enhance human creativity, learning, and knowledge building”; Schmid's proposal (1997), summarized here by Stanoevska-Slabeva (2002, p. 8), defining the term “knowledge media” as “as a platform providing a sphere for the management and exchange of knowledge within a confined community of human and artificial agents”; in

close relationship with the previous one, is the proposal of Schmid and Stanoevska-Slabeva (1998), defining the term “knowledge media” as “information spaces, which based on innovative ICT support information exchange within a community consisting of human and artificial agents” (and signaling in his article that the concept of knowledge media is instantiated from the generic concept of computational media, which provides a basis for the development of interactive and multi-agent ICT); Eisenstadt and Vincent's proposal (1998/2000, p. 4), defining the term “knowledge media” as “the process of generating, understanding and sharing knowledge using several different media, as well as understanding how the use of different media shape these processes”; and the proposal of Eppler, Seifried and Röpnack (1999), defining "knowledge media" as "as a technical and organizational platform of a community for the purpose of knowledge exchange between its agents".

From the 2000s, three definitions for the term were found. Among them is the proposal by Stanoevska-Slabeva (2002, p. 3), defining “knowledge media” in a broad sense as “as extensions of ourselves capable of storing and transmitting explicit knowledge over space and time”, but explains that in restricted the term should be understood as “spaces of communication for the exchange of knowledge (“Ba”) that arise with digital media”; Eppler's proposal (2011, p. 525), defining "knowledge media" as "Information technology-based infrastructures that enable knowledge codification and transfer"; and Souza's proposal (2019, p. 107), defining “knowledge media” as “any mediating system: mechanical, electrical, electronic and electronic-digital, with some autonomy, which produces new information and simulates the knowledge process”, emphasizing (p. 15) the “procedural autonomy in the production of knowledge” and “its destination to the user in the context of social action” as distinctive conditions. Following, table 1 with the respective definitions follows:

Table 1. Definitions of the term “knowledge media”

Author/Date	Definition
(Stefik, 1986)	“as an information network with semi-automated services for the generation, distribution, and consumption of knowledge”.
(Gruber, Tenenbaum, & Weber, 1992)	“a computational environment in which explicitly represented knowledge serves as a communication medium among people and their program”.
(Eisenstadt, 1995)	summarized by (Lynch, 2004, p. 15) “capturing, storing, imparting, sharing, accessing and creating of knowledge”.
(Baecker, 1997)	“documents, artifacts, technologies, and systems intended to enhance human creativity, learning, and knowledge building”.
(Schmid, 1997) summarized by (Stanoevska-Slabeva, 2002, p. 8)	“as a platform providing a sphere for the management and exchange of knowledge within a confined community of human and artificial agents”.
(Schmid & Stanoevska-Slabeva, 1998)	“as information spaces, which based on innovative ICT support information exchange within a community

	consisting of human and artificial agents”.
(Eisenstadt & Vincent, 1998/2000, p. 4)	“the process of generating, understanding and sharing knowledge using several different media, as well as understanding how the use of different media shape these processes”.
(Eppler, Seifried, & Röpn, 1999)	“as a technical and organizational platform of a community for the purpose of knowledge exchange between its agents”.
(Stanoevska-Slabeva, 2002, p. 3)	“as extensions of ourselves capable of storing and transmitting explicit knowledge over space and time”.
(Eppler, 2011, p. 525)	“Information technology-based infrastructures that enable knowledge codification and transfer”.
(Souza R. P., 2019, p. 107)	“any mediating system: mechanical, electrical, electronic and electronic-digital, with some autonomy, which produces added information and simulates the knowledge process”.

Source: Authors

Knowledge media have the potential to capture, store, transmit, share, access, and create knowledge (Eisenstadt & Vincent, 1998/2000, p. 5). However, terminology in the field of knowledge media is still being established (Inglis, Ling, & Joosten, 2003, p. xiii). Knowledge media “can be differentiated in terms of its target community, such as scientific knowledge media, public knowledge media, professional knowledge media, and so on” (Eppler, 2011, p. 516).

However, not all digital media are knowledge media (Baecker, 1997). The knowledge media can arrange the incoming information in order to offer new arrangements of information (Baecker, 1997), characterized by “autonomy in carrying out processes”, since “they alter information and produce knowledge”, resulting in “informative syntheses” (Souza R. P., 2019, p. 10).

Stefik's knowledge media concept (1986) is grounded in the “interactive and *intelligent* digital medium” (Stanoevska-Slabeva, 2002, p. 11). In this perspective, knowledge media can be understood as autonomous non-biological mediating systems (Souza R. P., 2019, p. 10). However, the most interesting and relevant knowledge media are those that “incorporate interactive computing and communication technologies” (Baecker, 1997). Knowledge media are the integration of “human and artificial agents connected through a semantic space” that facilitates the production, conservation, offer or exchange of knowledge (Schmid & Stanoevska-Slabeva, 1998; Souza R. P., 2019, pp. 10-11).

Knowledge media enable the exchange of ideas, experiences, and methods (Eppler, 2011, p. 525) and transfer and aggregation of knowledge through information and communication technologies (Eppler, 2011, p. 516). We can think, communicate, and learn using knowledge media (Baecker, 1997).

In broad sense, we are following the definition of knowledge media from Stanoevska-Slabeva (2002), but we understand “as extensions of ourselves” as extended mind. The extended mind thesis explains that some cognitive processes extend beyond the organism's mind/brain (Clark & Chalmers, 1998). Tools and instruments assimilated by the organism can function as an extension of the capacity of some perceptual,

mnemonic, inferential, communicative or even social cognitive process (Carvalho, 2018). Tools and instruments are no longer understood as objects and are assimilated as an extension of the person's cognitive abilities in their knowledge acquisition, retention and sharing processes. Knowledge media express above all the integration of the organism with tools and instruments, expanding the potential of epistemic-communicative functions.

In narrow sense, we assume a disjunctive view about the structural nature of knowledge media which include understand that knowledge media is more than “information network”, “computational environment”, “systems”, “platforms”, or “information technology-based infrastructures” Knowledge media is primarily a system or network based on Information and Communication Technologies (ICT). Knowledge media can be as a system as a network. If it was a system based on ICT, it will underline the interdependence between ICT and agents. If it was a network based on ICT, it will highlight the various possible relational structures between ICT and agents.

In broad and narrow sense, we assume that knowledge media generate, distribute, and feed on knowledge through the integration of human and artificial agents. We disagree that knowledge media just produce added information and simulates the knowledge process. Luciano Floridi (2019, p. 71) explains the distinction between information and knowledge: “information is well-formed, meaningful, and truthful data” and knowledge is correctly accounted information. Knowledge requires “the capacity for answering relevant questions about p” (Floridi, 2019, p. 74). In this meaning, “scientific textbook or a website like Wikipedia” contains knowledge (Floridi, 2011, p. 286), not just information. The analysis informational of knowledge depict a pragmatic trait of knowledge by connecting propositional knowledge to practical knowledge (Floridi, 2011, p. 287). Therefore, knowledge media produce genuine knowledge in its process. In broad and narrow sense, we assume that knowledge media is typically characterized by integration of human and artificial agents. The key feature of the production of knowledge by a group composed of human and artificial agents is that the task is beat-up into small components and distributed to different members of the group (Bird, 2014, p. 45). The distributed cognition approach can be characterized as a system that producing knowledge in which each member of the group has a particular function within the overall system (Hutchins, 1995). Consequently, knowledge media requires distributed cognition between human and artificial agents or between human agents and technological devices.

We define knowledge Media as a system or network based on Information and Communication Technologies (ICT) that generate, distribute, and feed on knowledge through the integration of human and artificial agents. As a result knowledge media change the fundamentals of the relationship between person and knowledge by integrating technologies and agents (Eisenstadt, 1995; Daniel, 1996, p. 2; Lynch, 2004, p. 16). Qualifying a media as knowledge means that it will be different not only in degree but in kind (Daniel, 1996, p. 101) because it puts “knowledge first” (Eisenstadt & Vincent, 1998/2000, p. 8).

3. Knowledge Media and Network Education

In this section, it will approach the relation between Knowledge Media and Network Education. Initially knowledge media can contribute to various segments of the knowledge society (Eisenstadt & Vincent, 1998/2000, p. 1). Its potential lies in the productive use of technology (Daniel, 1996, p. 2), promoting the

continuous improvement of the user experience in the learning process (Eisenstadt & Vincent, 1998/2000, p. 13).

Knowledge media add new perspectives and tools to the process of knowledge dissemination and sharing (Eisenstadt & Vincent, 1998/2000, p. 13) to meet the demands and cognitive tasks of its users (Baecker, 1997). Knowledge media foster potential for aggregation and collaboration in the network, through knowledge sharing and reuse (Eisenstadt & Vincent, 1998/2000, p. 13). Accessibility, the degree of interactivity, and the use of the interface with knowledge media (Lynch, 2004, p. 16) will drive a faster and more effective learning process. However, this effectiveness will also depend on how it is used (Inglis, Ling, & Joosten, 2003, p. 51), since poorly executed applications of knowledge media can create obstacles to learning and may even be inferior to education. paper-based traditional (Eisenstadt & Vincent, 1998/2000, p. 12).

Eisenstadt and Vincent (1998/2000, p. 7) signal that the knowledge society leads to four fundamental changes in the area of education: (i) 'knowing how' to do something will be more important than 'knowing that' something is like this; (ii) the knowledge shared between people will be worth more than someone's personal library; (iii) people will choose what content and information they want to consider and consume; and (iv) presentations and lectures will take the form of shared experience (Eisenstadt & Vincent, 1998/2000, p. 7).

However, neither the definitions of knowledge media listed above nor the purposes of the foundational projects of the three universities (Stanford University, University of Toronto, and Open University) seem to identify with the foundation of distance education or even have such a limited purpose and nature.

There are several types of knowledge media and several ways of using them, so “the use of knowledge media to facilitate learning does not imply that it takes any particular form” (Inglis, Ling, & Joosten, 2003, p. 166). According to Lynch (2004, p. 16), knowledge media “offer the opportunity to shift the emphasis from the classroom and teaching to the individual and learning”.

Knowledge media should not be seen only addressing learning based on explicit knowledge, but also and above all addressing learning based on associated practice and implicit knowledge in order for the proposed courses to be effective (Inglis, Ling, & Joosten, 2003, p. 51). Based on this characterization, knowledge media can be modeled to be used for broader educational purposes such as Network Education.

If knowledge media can also promote implicit and tacit knowledge, then they can be used in offline educational networks, favoring the qualitative development of socio-emotional competences and more efficient educational interactions.

However, the nature of network education goes beyond technology, aiming to promote open, creative, and network education through the dialogue of knowledge. From this perspective, it can be said that the nature and purpose of network education are broader than those of knowledge media. Network Education does not belong to the conceptual and theoretical framework of knowledge media, but the opposite. It has a broader scope in which knowledge media find space to develop and collaborate.

Network education highlights educational connections. A theory of learning that could offer support by educational processes in a network society is connectivism (Siemens, 2004). Connectivism aims to respond to the influence that technology has on socio-cognitive processes underlining the importance of the characteristics of the social environment in which cognitive interactions are established (Silva, Müller,

Souza, & Spanhol, 2019, p. 94). Connectivism may offer a base to socio-cognitive adaptation in a world in constant change and technological influence. Although network education is not committed to any specific learning theory, connectivism appears as another useful theoretical resource for network education in the era of digital transformation in which knowledge media play an crucial role.

On the one hand, if there is a strong process of digital transformation in the early 21st century and the popularization of ICT, accelerated by the effects of the Covid-19 pandemic, on the other hand, there is a need to enhance the horizontalization of digital literacy due to the great interest in digital media and great expansion of online learning (Mendes, Spanhol, & Souza, 2018, p. 37). Digital literacy presents itself as an ethical-political horizon that calls for social inclusion and the development of the subject's autonomy in relation to the learning path throughout his life. An analysis of education based on the relationship between social networks and knowledge media points not only towards digital literacy, but also towards informational and network literacy.

A democratic network education requires the strengthening of cyber citizenship, using digital and knowledge media in a transformative and critical way, aiming at the social good (Souza M. V., 2015, p. 16). It is characterized by the effort of social inclusion, development of autonomy and exercise of cyber citizenship. A democratic network education should be understood as a space for dialogue, interactivity, re-elaboration of information, transforming knowledge into an instrument of cyber citizenship (Souza M. V., 2015, p. 40). On the other hand, we must be aware of other network education projects that can assume any form of distribution between nodes, highlighting other connections and expressing more or less hierarchy, etc. In a broad sense, network education is looking at education through networks. In this way, the use of knowledge media can take on any role within network education from the most central to the most peripheral. Therefore, the value of knowledge media is directly related to the network education projects being developed.

Social networks occupy a significant space within the network education scenario. Social networks enable various forms of human organization and articulation between groups and institutions. Network education is also driven by the various forms of relationship allowed by social networks (Giglio, Souza, & Spanhol, 2015, p. 110). In this way, network education can make education much more interactive. Network education can use the best of both worlds, face-to-face and virtual empowering individuals and groups (Giglio, Souza, & Spanhol, 2015, p. 116). However, it is necessary to investigate how ICT and the digital transformation process can better contribute to a more qualified and inclusive network education.

4. The locus of Network Education

In this section, it will approach possibilities and limits of network education within the scope of knowledge communication. One proposal is to align network education with the scope of knowledge communication. Martin J. Eppler (2011, p. 525) defines knowledge communication as “the (deliberate) activity of transmitting and interactively building ideas, assessments, experiences, or skills by verbal and non-verbal means”. Knowledge communication has a large scope involving human and technological, informational and communicational, and epistemological and social factors. Eppler (2011, p. 525) explains that knowledge communication “designates the successful transfer of know-how (e.g., how to perform a task),

know-why (e.g., the cause-effect relationships of a complex phenomenon), know-what (for example, the results of a test) and know-who (e.g., experiences with others) through face-to-face (co-located) or media-based (virtual) interactions”.

According to Eppler (2011, p. 516), knowledge communication can occur in two ways: (a) knowledge dialogue and (b) knowledge media. The knowledge dialogue is synchronous, and the knowledge media is asynchronous. The scope of knowledge communication is quite broad, covering the most varied items and knowledge processes, it can take place both face-to-face and virtual and both synchronously and asynchronously. In addition, it expresses in a qualified way its two aspects: the knowledge dialog and the knowledge media. If network education is characterized by a communication network, which must express and enhance the generation, sharing and retention of knowledge items and processes, offline and/or online, aiming at establishing knowledge dialogues throughout the network, using the media of knowledge, then the communication of knowledge is the comprehensive locus and compatible with network education, capable of offering you a new scope of research and better-defined practice. Network education can, therefore, be a strong expression of knowledge communication.

One of the most legitimate expressions of Network Education is dialogue, more precisely, the dialogue of knowledge. The dialogues of knowledge vary according to their objectives and according to different patterns of behavior, interaction, and support measures (Eppler, 2011, p. 516). Knowledge dialogues can be divided into four types, given their interactive and collaborative style: (a) *Crealogues* - aimed at creating new ideas and knowledge; (b) *Sharealogues* - aimed at transferring and sharing knowledge; (c) *Assessalogues* - aimed at evaluating new ideas and knowledge; and (d) *Doalogues* - which aim to transform understanding into committed action, using knowledge (Eppler, 2011, p. 516). The participants in the knowledge dialogues are in a process of knowledge mediation, which occurs when agents cooperate in a communicative process, combining knowledge (Sterling, 2011, p. 16).

Network education should interconnect distance education, face-to-face education and hybrid education in the network knowledge society” (Nunes, Rosa, Souza, & Spanhol, 2016). A democratic network education can follow through a dialogical education (Socratic-Freirean) with the purpose of building a teaching-learning process through dialogue and the exchange of experiences between the agents involved in the educational process (Nunes, Rosa, Souza, & Spanhol, 2016). Network knowledge communication in an educational environment will only fulfill its epistemological role insofar as it uses its two strategic resources, the knowledge media and the knowledge dialogue.

As a trend, network education has engaged ICT and active methodologies in an educational innovation process. However, the articulation between them will depend on the type of network education project that will be developed. Innovative educational methodologies are described as challenging and active methodologies in which they harmonize processes for the acquisition of theoretical and practical knowledge (Rosa, Spanhol, & Souza, 2018, p. 188). ICTs can be explored in a collaborative way for network education, enabling the mediation of knowledge (Rosa, Spanhol, & Souza, 2018, p. 187).

Democratic network education tends to be innovative and responsible, promoting transdisciplinary relationships of interdependence and social inclusion. Educational innovation should promote improvements in the teaching-learning process, taking into account the following measurement criteria: impact, contextualization, efficiency, applicability, engagement, intentionality (Souza, Teixeira, & Souza,

2018, p. 22). In an educational network, all agents involved, not just teachers, are challenged to be agents of innovation. In addition, knowledge communication is an essential ingredient to disseminate and share innovation processes and products and problem-solving in network education.

Responsible Research and Innovation (RRI) aims to expand and deepen the dialogue between the scientific community and civil society by establishing forums for cooperative dialogue between scientists and citizens (Okada & Rodrigues, 2018, p. 44). Scientists and citizens collaborate throughout the research and innovation process, seeking to reconcile values and expectations. In this way, “open education with open science and open schooling are essential to prepare individuals and communities for critical-collaborative participation with knowledge, skills and attitudes” (Okada & Rodrigues, 2018, p. 49). Networked open education based on the dialogue of knowledge can offer a new horizon of knowledge and skills to face changing social, political and economic scenarios. Besides, an open science based on RRI can offer promising future scenarios to the challenges posed by the Covid-19 pandemic.

5. Conclusion

After considering the fundamental characteristics of distance education and network education, it was understood that the fundamentals and the main characteristic of these two modalities are different; that the purpose of network education is much broader than the purpose of distance education; that the vision of network learning is different between them; and that both use knowledge media for their purposes. Thus, it was inferred that distance education and network education are not reducible to each other.

It was understood that there is no hegemonic definition of knowledge media. However, its impact, especially on education, is large, indicating developments that are relevant to several areas. Concerning the relationship between Network Education and Knowledge Media it was understood that the nature and purpose of Network Education are broader than those of Knowledge Media. Network education does not belong to the conceptual and theoretical framework of knowledge media.

Finally, knowledge communication and network education seem to have a broad and compatible scope. Knowledge communication can be the locus of network education, capable of offering a new scope of research and practice based on knowledge media and knowledge dialogues. Network education can therefore be a strong expression of knowledge communication.

The theoretical reflection pointed to a model of network education in the digital age based on the network society, within the scope of knowledge communication, aiming to establish the dialogue of knowledge using the knowledge media. Network Education finds a new locus, no longer in the wake of Distance Education, subjugated by the Knowledge Media, but open to dialogue under the aegis of knowledge communication.

6. References

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The Use of Deep Learning in Verifying the Functioning of LEDs

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Abstract

This article aims to bring an alternative to carrying out manual tests of devices mounted on a production line. One of the tests done by the operator is to find out if the LEDs are present on the device being turned on and working correctly. Image processing techniques were applied in the elaboration of the dataset and the use of Convolutional Neural Networks for the classification of the colors presented by the LEDs and the recognition of their operation. An accuracy of 99.25% was obtained with a low percentage of false positives and true negatives. There were no difficulties in porting the model built to a small computer.

Keywords: Computer Vision; Deep Learning; Industry 4.0; LED Recognition.

1. Introduction

The current market has forced companies to work more quickly, evolving their production systems. Thus, they have sought to maintain their share of the market and, at the same time, do their utmost to constantly increase this share. For this, they have used the available methodologies to optimize their productive capacity and improve their competitiveness in relation to competitors (Cardoso and Lopes 2018, Brighenti 2006).

Thus, it is clear that today people live on the threshold of a fourth industrial revolution, called Industry 4.0, which is characterized by the intensive use of digital technologies, in order to manufacture new products quickly, with an agile response to demand and real-time optimization of production and supply chain. Among these technologies, the Internet of Things (IoT), Internet of Services (IoS), 3D Printing, Advanced Robotics, Artificial Intelligence, Big Data, Cloud Computing and Nanotechnology (Lima and Pinto 2019) stand out.

Coelho, mentioned by Lima and Pinto (2019), mentions that the impact of Industry 4.0 goes beyond simple digitization, passing through a complex form of innovation, which will force companies to rethink the way they manage their business and processes, such as position themselves in the value chain, how they think about developing new products and how they place them on the market, adjusting marketing and distribution (Lima and Pinto 2019). The impacts that this revolution has on productivity, cost reduction, control over the production process, customization of production, among others, point to a profound transformation in manufacturing plants (ABDI 2020).

Therefore, there is a growing demand for the elaboration and implementation of solutions responsible for optimizing manufacturing processes, such as the use of algorithms for the replacement of human labor, in repetitive jobs or that require precision, thus avoiding possible human failures and enabling that such workers are relocated to more complex tasks. In this way, the present work aims to bring an automatic way to check and test the functioning of LEDs of an electronic device, in order to optimize the process through the use of Industry 4.0 techniques, especially Artificial Intelligence. Automatic verification seeks to reduce the time needed to perform the manual test performed by the human operator, since it needs supervision throughout its entire process, which added to the number of tests carried out in parallel, results in slowness and stops the production line.

2. Theoretical Foundation

2.1 Computer Vision

The Computer Vision area aims at the automatic extraction of information given an image, which aims to resemble computers to human vision (Solem 2012, Khan et al. 2018). To achieve this result, Computer Vision techniques use statistical, geometric approaches and ways that mimic human vision, to obtain three-dimensional information from two-dimensional images (Khan et al. 2018).

With the growth in the volume of data, especially images and videos, the Computer Vision area has gained increasing notoriety and importance, given its variety of applications, such as closed-circuit camera images, or even the navigation of autonomous vehicles (Solem 2012). The Computer Vision area has as main applications tasks of classification, location, detection and segmentation of objects in images. The classification tasks aim to indicate a group to which an image belongs (Khan et al. 2018).

The location tasks aim to find a specific characteristic within an image. Object detection, on the other hand, identifies all groups that exist in an image. Finally, the segmentation of objects indicates the exact location where the groups of objects are in the image, even if partially covered (Khan et al. 2018).

2.2 Artificial Intelligence

Artificial Intelligence is one of the most recent fields in science and engineering (Russell and Norvig 2013). According to Winston (1992), it can be defined as the study of computing that makes perception, reasoning and action possible (Simões 2000). Artificial Intelligence aims not only to understand, but also to build

intelligent entities (Russell and Norvig 2013).

Currently, Artificial Intelligence covers a large number of subfields, from learning and perception to more specific tasks such as chess games, demonstrations of mathematical theorems, creating poetry, driving a car on a busy road and diagnosing diseases (Russell and Norvig 2013). Faceli et al. (2011) shows us that Artificial Intelligence comes to assist in the resolution of tasks that could be solved by human beings, but due to its volume of data and its complexity, they become difficult to be performed correctly. Artificial Intelligence techniques, in particular Machine Learning, have been used successfully in a large number of real problems, including those previously mentioned (Faceli et al. 2011).

2.3 Machine Learning

In the last decades, with the increasing complexity of the problems to be treated computationally and the volume of data generated by different sectors, it became clear the need for more sophisticated computational tools, which were more autonomous, reducing the need for human intervention and dependence on specialists (Faceli et al. 2011). Machine Learning is an area of Artificial Intelligence whose purpose is the development of computational techniques on learning, as well as the construction of systems capable of acquiring knowledge automatically (Monard and Baranauskas 2003).

This learning system uses successful experiences from previous problems to make new decisions (Monard and Baranauskas 2003). According to Flach (2000), previously cited by Monard and Baranauskas (2003), research carried out in the Machine Learning area can provide improvements to current techniques and a basis for the development of alternative approaches to knowledge acquisition (Monard and Baranauskas 2003).

Machine Learning algorithms are used in several tasks, which use different criteria to be organized, such as the learning paradigm. These learning tasks can be divided into descriptive, where the objective is to explore or describe a set of data, and predictive, whose objective is to find a function from the training data to predict a label or value that characterizes a new example, with based on input attributes (Faceli et al. 2011).

Machine Learning methods induce predictive models and follow the supervised learning paradigm, which indicates the presence of a supervisor who knows the desired output for each example. We can say that there is a hierarchy where, at the top, inductive learning appears, which indicates that generalizations are made from the data. Below, we have the types of predictive or supervised and descriptive or unsupervised learning. After that, we have that the supervised types can be distinguished by the type of the label being discrete in the case of classification, and continuous in the case of regression (Faceli et al. 2011).

The unsupervised types can be divided into: grouping, according to the similarity of the data, summarization, whose objective is to find a simple and compact description for a dataset and association, which seeks frequent patterns of association between the attributes of a set of data (Faceli et al. 2011). In

addition to these, we have other well-known paradigms, like reinforcement learning, which is a particular case of supervised learning, and competition learning, which is a particular case of unsupervised learning (de Pádua Braga et al. 2007).

2.4 Artificial Neural Networks

Artificial Neural Networks are Artificial Intelligence techniques inspired by the functioning of neurons in the human brain (Mergulhão et al. 2019). As neural computation is not based on rules or programs, it is an alternative to conventional algorithmic computation (de Pádua Braga et al. 2007).

Such networks are adaptive systems composed of interconnected processing units, called neurons, distributed in different layers working together to solve a problem (Mergulhão et al. 2019). These units calculate certain mathematical functions, generally non-linear and are arranged in one or more layers and are interconnected by a large number of connections, which are normally unidirectional (de Pádua Braga et al. 2007).

The architecture of Artificial Neural Networks is usually defined through parameters such as the number of network layers, number of nodes in each layer, type of connection between the nodes and network topology. They can be classified according to their connectivity, being a partially connected network or a fully connected network (de Pádua Braga et al. 2007).

The great advantage in the use of artificial neural networks to solve complex problems comes mainly from its learning capacity through generalization of the response acquired during the training of the network, through the use of examples that have already occurred in the past (Mergulhão et al. 2019).

We also have Convolutional Neural Networks, which can be defined as Artificial Neural Networks that employ convolution operations in at least one of their levels. These models stand out for their success in practical applications, being widely used in data processing with a well-defined grid topology, such as images and time series (Goodfellow et al. 2016).

2.5 Deep Learning

Deep Learning, from the English Deep Learning is a subfield of Machine Learning responsible for the construction of conventional Artificial Neural Networks, however with multiple intermediate layers, capable of building even more sophisticated models, since with the greatest number of layers, they are capable of better abstract the problems addressed, with applications in image classification tasks, speech recognition and hand made transcriptions, having reached almost human levels in these tasks (Chollet 2018, Gulli and Pal 2017).

Therefore, Deep Learning is a subarea within Machine Learning, which in turn is an Artificial Intelligence subarea, as we can see in Figure 1.

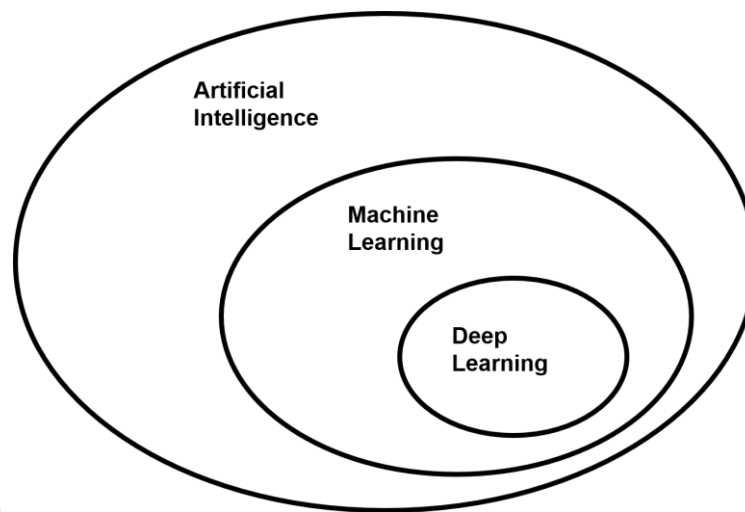


Figure 1. Artificial Intelligence, Machine Learning and Deep Learning (Chollet 2018).

Consequently, the field of Deep Learning has been widely used in Computer Vision tasks, more specifically, in the classification and detection of objects in images. In addition, Deep Learning is also used in recommendation systems, which are used to list consumer items and potential customers, in order to maximize profits through targeted advertising (Goodfellow et al. 2016).

3. Related works

Tsai et al. it brings an automated color inspection, using an optical sensor to assess the color emitted by the LED (Tsai et al. 2011). Before the sensor perform this inspection, color matching functions corrected by the least squares approach method were used. The LED was placed in a dark place to avoid light pollution from the environment, which could interfere with color detection. Two red LEDs, one green and one blue, were analyzed. With the method proposed by the authors, a significant improvement was obtained in the average color difference of each LED after compensation, while the average luminance reduced to less than 3.5%.

Banik's work brings a way of detecting colors from an LED using a smartphone camera (Banik et al. 2017). Multivariate regression analysis was used to detect color in LEDs. As the methodology used, for the LED image, the region of interest was identified, image processing was performed together with the K-means algorithm to generate the possible colors of the LED and the regression model was applied to predict the color emitted by the LED. Red, green and blue LEDs were used, with R-square results of 91.4%, 94.8% and 96.2%, respectively.

Polzer et al. features an integrated sensor without a filter for determining the color of LEDs (Polzer et al. 2011). This sensor was manufactured in the BiCMOS process, which allows the sensor to be integrated with other circuits on a chip without modifying the process. It determines the central wavelength of an LED and uses the silicon penetration depth of the incident light to find the resulting RGB output from the LED. The results obtained show an accuracy of approximately 10 nm, which the authors claim is suitable in

environments with an external light source.

The work of Dias et al. it consists in the development of a color detection system for people with low visual acuity (Dias et al. 2016). The authors used the Arduino platform and the App Inventor to have a low-cost solution. During the test phase, the authors found that the change in lighting in the environment affected the reading value in the voltage of the light sensors, influencing the identification of colors, which made it necessary to use algorithms for lighting compensation. After that, 31 different colors were measured in 3 different environments, obtaining a result of 100% accuracy.

Thus, it is observed that most studies use physical methods for the detection of colors, which are conducive to the variation of tension that can influence the results obtained. In addition, it is possible to observe that, in the work that used Computer Vision techniques, the approach used less robust methods for the detection and prediction of the colors of each LED.

4. Methodology

For the implementation of the proposed solution, images were collected for the construction of the dataset. Then, a model more suitable for the image classification activity was chosen and built, considering its size and performance. After that, this model was submitted to the dataset and trained, having its weights saved at the end of the training. The weights along with the model were embedded on the small computer. The following subsections better demonstrate the steps mentioned.

4.1 Proposed Solution

The proposal developed consists, in principle, of a camera that captures images and performs the classification of colors emitted by LEDs of an electronic device assembled and tested by a production line. This camera is associated with a small computer in order to optimize the space used in the production line. The dataset built for training was divided into parts for training and testing.

On the computer, there is the Artificial Intelligence model and an algorithm that assists in the necessary procedures for prediction such as redefining photos, exchanging information with other test equipment, among other activities. A multilayer Artificial Neural Network was used, responsible for the task of supervised learning, performing the classification of the LEDs in three classes, representing the LED turned on in red, green, or the LED off. This model and the algorithm were implemented in the Python programming language, using the Keras Neural Networks library and the OpenCV library for image manipulation.

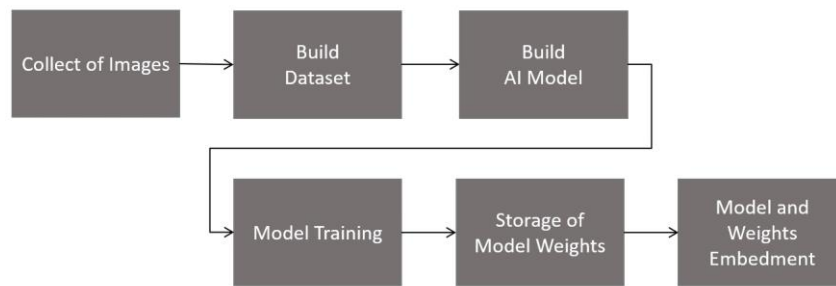


Figure 2. Block diagram that represents the sequence of steps performed in the process.

4.2 Dataset

The data for training and testing of the built model were collected directly from the electronic device, captured by the camera itself connected to the reduced size computer. The camera used had night vision technology, since the place where this prototype would be placed would have a discreet amount of light. A total of 450 images were captured, with 150 images of the green LED on, 150 images of the red LED on and 150 images of the LEDs off. Figure 3 contains some examples found in the dataset.

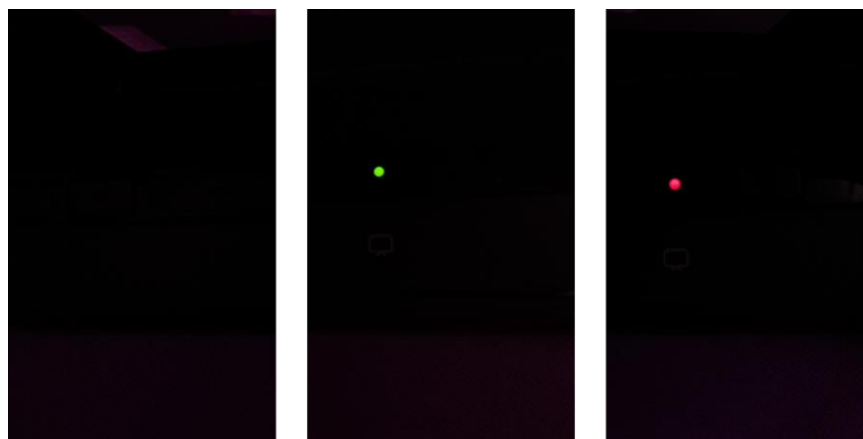


Figure 3. Example of images found in the dataset representing the LED in off mode and the colors green and red, respectively, used in training the model.

The captured images were organized in folders identified according to the color of the corresponding LED, and renamed in order to be in sequence. The labels of the folders were selected in order to allow the later use by the implemented model. The partition adopted for the dataset was of the hold-out type, in the proportion of 70/30, with 70% of the dataset being designated for the training phase and 30% for testing.

In addition to the separation of data for training and testing, it is also important to note that each class had balanced amounts of images of each possible scenario for the problem, such as different amounts of light or the presence of specific objects, so where the model was trained and evaluated within the broadest possible scenarios. After dividing the dataset, the images were manipulated in order to be redefined from

their original size of 640 x 480 pixels, to the size of 150 x 150 pixels, in order to adapt to the data entry expected by the implemented model, with the necessary manipulations also being made at the implementation level.

4.3 Developed Model

As previously seen, Deep Learning has good applicability in Computer Vision problems. Thus, for the addressed problem, techniques from this area were used, through the use of Convolutional Neural Networks, since they provide good results regarding the task of image recognition.

For this, a model was elaborated according to the following architecture: an input layer of 150 x 150 pixels, to contemplate the images of the dataset, followed by three layers stages, the first two being composed of 32 convolutional layers and the last one composed of 64 convolutional layers. As an activation function for these convolutional layers, the rectifier linear unit, or ReLU, with 3 x 3 size filters was used. After each step of convolutional layers, a 2 x 2 Max Pooling layer was added.

After the convolutional layers, a fully connected layer with 64 neurons was added followed by another fully connected layer with 3 neurons, or three outputs, in order to cover the three possible classes for forecasting, as already mentioned. After assembling the final model, we have a total of 1,212,643 parameters, 1,212,643 of which are trainable and 0 non-trainable. Figure 4 shows how the final architecture of the model was assembled.

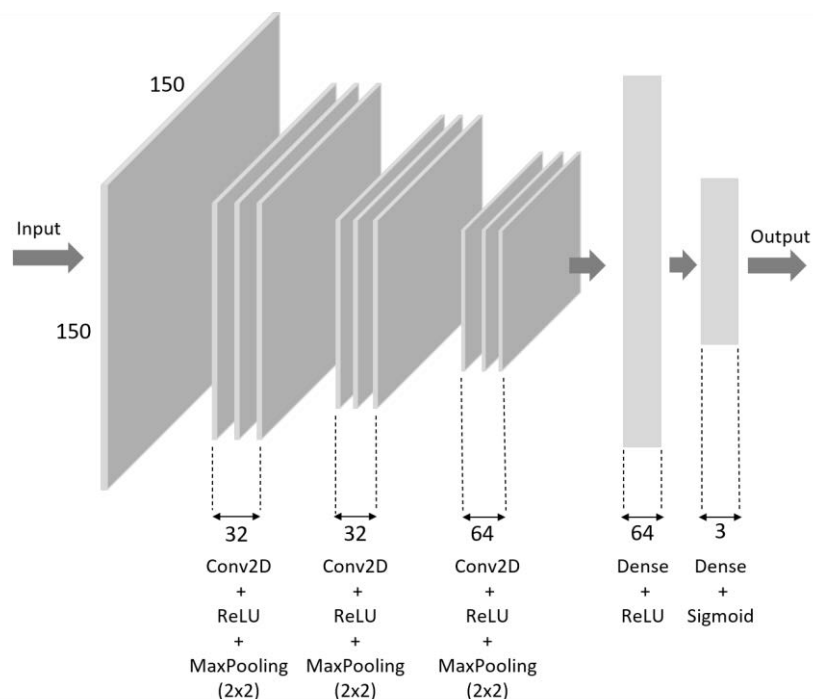


Figure 4. Illustration of the model architecture. It is possible to observe the number of layers used for each stage of the model, represented by the values at the bottom of the image.

5. Results and Discussion

5.1 Results Obtained

To measure the performance of the built model, two main performance metrics were adopted, namely, accuracy and F-Score. Accuracy can be defined as the metric that returns the number of correct answers taking into account all attempts of the model. This metric reveals the percentage of correct answers that the model has. The F-Score is defined as the harmonic average between precision and recall of the model, where precision indicates the true positives among those that were predicted as positive and shows the number of false positives and the recall indicates the percentage of true examples that were classified as true and the positive examples that the model did not classify (Marques 2017). Figure 5 describes the performance of the model in its confusion matrix.

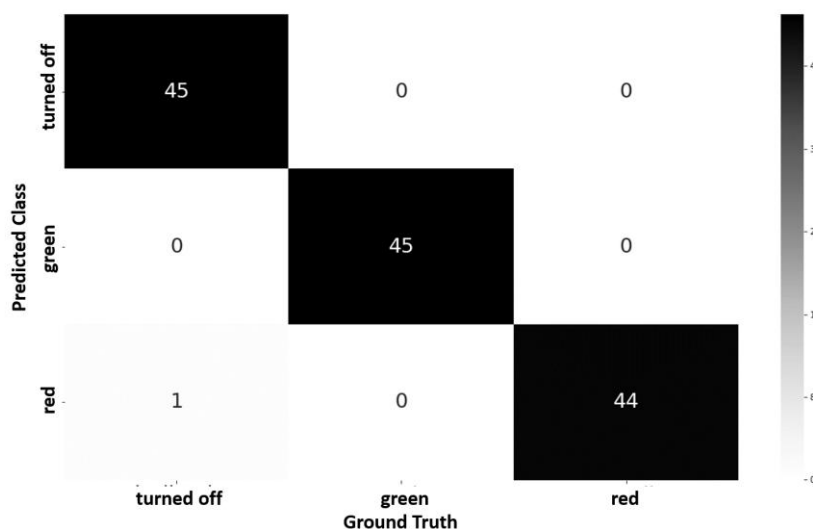


Figure 5. Confusion matrix of the results obtained, where the performance of the model is observed.

In this way, after the training period has passed, the model then had its performance measured according to the test data, obtaining the metrics of 99.25% accuracy, with 0.9925 F-Score, showing the good performance of the built model, given the problem addressed. It is also worth mentioning that the results obtained were achieved without any additional Image Processing technique, fine adjustments to the built model, or grid searches, relying only on the methodology previously described.

4.2 Discussion of Results

With the results obtained, the remarkable performance of the model built for the addressed problem is observed. It is also noticed that in the examples in which the proposed model incoherently inferred, such an error can be attributed to the fact that the camera used is made for night vision, in order to interpret the clarity of the images with a reddish tone, which may have confused the model in its test stage. However, even if such an error has been verified, it is important to emphasize the accuracy achieved in the other classes, where for the green color, for example, the model did not present errors.

With regard to the possibility of portability of the model built to the reduced size computer, no problems were found, since due to the size of the model, there were no major impacts on computer processing. It is also noted that the model developed has about half of the trainable parameters of architectures already popular for the same task, such as MobileNet V3, ideal for embedded environments (Howard et al. 2019).

In comparison with the related works, it is not possible to make a direct comparison with the results of the mentioned works, since they are in different contexts. However, in relation to the detection of LEDs, it is clear that the model built obtained better results for the classification, when compared to the work of Banik, where the K-means algorithm was used, emphasizing that in such work, a camera was used smartphone to obtain images (Banik et al. 2017). Compared to the works in which physical methods were used, such as sensors, it is observed that the same model obtained similar results, after considering the compensations and Image Processing techniques used in the related works.

6. Final Considerations

The work developed showed a good result, both in the construction and training of the model, as well as in the process of embedding the model trained in the reduced size computer. An accuracy of 99.25% was obtained with a low percentage of true negatives and false positives. For the next works we can mention the construction of a dataset of LED images in environments with different incidence of light and the change of the technology of the camera, without night vision, to evaluate the behavior of the model with these changes.

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Helping a Student with Learning Disabilities Develop Automaticity with Multiplication Facts

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Abstract

An eighth-grade student, was able to memorize multiplication facts (0 to 10) for the zeroes to fives with 100% accuracy. In a previous study [1] the student used skip counting and her hands to recall all the facts for the ones to fives. The overall goal of the current study was to improve the student's automaticity of multiplication facts (0-10) for the ones through fives, such as $4 \times 6 = 24$. The student had been taught multiplication concepts in her elementary years and she did have a basic understanding of the meaning of multiplication facts as shown in the previous study. She understood that 4×6 is a representation of four sets of six or $6 + 6 + 6 + 6 = 24$. The student had used skip counting and flash cards with illustrations of the multiplication facts to memorize the multiplication facts. In the current study a multiple baseline design was used to measure the acquisition of fluency of multiplication facts over time. The student was able to develop automaticity with 80% accuracy by giving the solution within 3 seconds for all of the facts (0-10) for the ones through fives.

Keywords: autism, learning disabilities, multiplication facts, automaticity

1. Introduction

The student was in the eighth grade and this investigation was conducted during the school year. The student was in a special education classroom at a middle school. She received all of her academic instruction in the special education classroom and went to other classrooms for electives such as art and physical education. The student was diagnosed with mild learning disabilities and autism. She was performing at the third or fourth grade level in reading, writing and mathematics.

According to the student's classroom teacher, the student was having difficulty with several mathematics concepts including fractions. The researcher had previously been working with the student on renaming and simplifying fractions. The student was able to understand fraction concepts as long as explanations were given and concrete models were used. The student was not able to rename or simplify fractions abstractly as she did not know the basic multiplication facts by memory. She could not rename fractions such as thirds and fourths to twelfths nor simplify fractions such as $\frac{4}{12}$ without specific instructions and the use of manipulatives. Therefore, the researcher changed the focus of the lessons from learning fraction concepts to memorizing multiplication facts. Once the multiplication facts zero to five were memorized, the researcher then worked on developing automaticity with the multiplication facts.

2. Literature Review

The National Council of Teachers of Mathematics (NCTM) has set the following as one of the standards for grades 3 through 5: “develop fluency with basic number combinations for multiplication and division” [2]. The NCTM recommends using multiple models such as skip-counting, area models, and relating known facts with those that are not known. According to the NCTM, if the basic facts are not known by the end of the fourth grade, the student “must either develop strategies so that they are fluent with these combinations or memorize the remaining harder combinations” [2]. The Common Core State Standards for Mathematics for Grade 3 states that, “By the end of Grade 3, know from memory all products of two one-digit numbers” [3].

2.1. Rationale

It is important that students be able to recall basic multiplication facts because they are necessary in mastering more complex concepts in mathematics [4], [5], [6], [7], [8], [9]. The multiplication facts are especially important in learning fraction concepts such as equivalent fractions, simplifying fractions, and finding common denominators of fractions. Students without learning difficulties usually master memorizing multiplication facts by grades 3 to 4, while it usually takes children with learning difficulties longer [4], [10], [11], [12].

2.2. Conceptual Understanding Stages

A conceptual understanding of basic addition and multiplication facts is essential before students are expected to progress to more complex mathematical topics [13], [14], [15]. Students may progress through three stages in learning the meaning of addition and multiplication: concrete, semi-concrete, and abstract stages. In the concrete stage of learning, students use different types of manipulatives to represent sets and counters in sets to understand addition and multiplication concepts. In the semi-concrete stage, drawings are used to represent sets and counters in sets for example circles for sets and dots in the circles as counters. In the abstract stage, students understand addition and multiplication concepts without using manipulatives or drawings [16], [17], [18], [19] [20].

2.3. Stages in Memorizing Basic Facts

Students should first have a conceptual understanding of multiplication facts such as “ $3 \times 4 = 12$ ” means “3 sets of 4 counters” and is equivalent to the sum, “ $4 + 4 + 4 = 12$ ”. Next, it is important that students memorize the basic multiplication facts such during their elementary school years [7]. Having used multiple models for multiplication such as groups, arrays, area models, jumps on a number line, etc, most student will memorize some of the basic facts such as $2 \times 3 = 6$ and the doubles such as $4 \times 4 = 16$. Memorization techniques should be used to teach the students how to memorize the remaining facts [2]. Memorizing basic math facts will help students in learning other mathematical concepts such as fractions in the middle grades and algebra beyond the middle grades.

Three phases that children usually progress in memorizing basic multiplication facts are described in the research. Phase one involves using counting strategies such as counting blocks, tallies, fingers, etc. Phase

two involves using reasoning strategies such as using patterns, logic, relationships in numbers, etc. Phase three is fast and accurate mastery of the multiplication facts [5], [6], [7], [8], [9]. In the third phase, students have memorized the multiplication facts and can recall the product with speed and accuracy. In the first two phases cognition is conscience, deliberate and slow, while in phase 3 cognition is non-conscience, automatic, and fast [5]. Automaticity is the ability to automatically recall the facts without using counting or reasoning strategies [7], [8], [9].

In learning the multiplication facts, students learn relationships between number facts such as multiplying with the numbers zero and one, and multiplying “twin numbers” together such as 2×2 , 3×3 , 4×4 , etc. An example using the commutative property of multiplication is learning the relationship between “ $6 \times 3 = 18$ ” and “ $3 \times 6 = 18$ ” [4], [5], [7], [8]. Learning the commutative property allows students to realize that they only need to memorize half of the facts on a multiplication chart [5], [6].

In phase two, mental reasoning strategies are used to find relationships in the numbers. For example, when multiplying 7×8 the student may know that $7 \times 7 = 49$ so therefore 7×8 would be seven greater or $7 \times 7 + 7 = 56$. In reality the student is using the distributive property of multiplication over addition: $7 \times 8 = 7(7+1) = (7 \times 7) + (7 \times 1) = 49 + 7 = 56$ [4], [7], [8]. Connections between the arithmetic and algebra should be made by teachers teaching algebra.

2.4. Two Views on Memorizing Basic Facts

Rote memorization results in routine expertise where knowledge can be applied to familiar tasks but not with new tasks. Meaningful memorization results in adaptive expertise which can be applied to familiar as well as new tasks. There are two views as to how children learn basic facts. The passive storage view [5] or conventional wisdom view [6] describe how multiplication facts are memorized by rote through repeated practice and reinforcement. The active construction view [5] or number-sense view [6] describe how the facts are memorized meaningfully.

With the passive storage view or the conventional wisdom view, the association between problem and solution does not consider conceptual understanding nor developmental readiness of the child. The learning may be accomplished without counting or reasoning. Positive and negative reinforcements may be used to motivate the students to learn the facts. The fact recall part of the brain does not involve the conceptual and reasoning part of the brain [6]. Phase 1 and 2 can help; but are not necessary for phase 3. Memorizing the multiplication facts can be achieved through extensive practice such as using flash cards and timed drills alone [5].

With the active construction view or number-sense view, phase 1 and 2 are necessary for phase 3. Meaningful memorization of the multiplication facts is achieved by creating a rich network of factual, relational, and strategic knowledge. For example, multiplication by “zero” and “one” become rules that lead to automaticity. Multiplication of “doubles” leads to reasoning that helps the students memorize other multiplication facts [5]. Mastery of computational fluency happens by discovering the numerous patterns and relationships that interconnect the basic combinations [6]. Students learn better by learning patterns and relationships rather than by rote memorization. Knowledge that is connected to prior learning is stored in long term memory better than isolated facts [6].

With the passive storage view or the conventional wisdom view, phase 3 instruction is achieved by well-designed and extensive drill. The key to memorization of basic multiplication facts is practice. With the active construction view or number-sense view, instruction in all three phases should include discovery of patterns and relations connecting the basic multiplication facts. The emphasis is on relating new knowledge to previous knowledge. A focus on the structure, rather than memorizing individual facts by rote memory, is more likely to lead to retention of facts [5].

According to the passive storage view or conventional wisdom theory, learning difficulties are due to deficits in the learner [5], [6]. These children are labeled as “learning disabled” and often characterized as inattentive, forgetful, often confused and unable to apply knowledge. Children labeled as learning disabled rely heavily on counting strategies, may be taught reasoning strategies; but will not invent them on their own, difficulty in learning number facts especially those with numbers higher than 5, and have a high error rate in recalling basic number facts [6].

According to the active construction view or number-sense view, learning difficulties are due to defects in traditional instruction [5], [6]. Although children with learning disabilities do have cognitive impairments, they are capable of learning basic multiplication facts. One reason that learning disabled children have difficulties is because they lack the informal knowledge to develop successful problem solving and reasoning skills. For example, they may lack the informal knowledge to develop an understanding of composition and decomposition which are foundations for learning many mathematical concepts. A second reason is that if the students have been taught with a focus on memorization, they have not developed skills such as looking for patterns and relationships, reasoning skills, nor developed an appreciation for mathematics [6]. Students who have been taught with a focus on memorization may confuse rules such as multiplication by “zero” and “one”. They may lose count if they are skip counting and give the wrong answer. Students taught by rote memorization do not think about the reasonableness of an answer and may give an answer that is unreasonable. These strategies make them prone to errors [6].

With the passive storage view or conventional wisdom theory, massive drill and practice is not recommended. It is recommended that students are introduced to one set of basic facts and that the students learn those facts before advancing to another set [6].

With the active construction view or number-sense view, the memorization of basic facts should be integrated with conceptual understanding, problem-solving and reasoning strategies. Students should be encouraged to develop number sense and invent informal strategies. Students should develop meaningful mastery of facts by being encouraged to focus on looking for patterns and relationships among numbers [6].

2.5. Studies on Developing Automaticity

Parmar et al. indicate that students with learning disabilities have different needs in the mathematics classroom [21]. Thorton and Toohey [22] describe basic guidelines when planning the learning of basic facts with learning disabled students. Factors to consider include prerequisite knowledge, monitoring and assessing, the sequence that facts are presented, teaching strategies prior to drill, learning styles of the student, pacing, verbal prompts, and self-monitoring skills.

Low achieving students and students with learning disabilities have difficulty in developing automaticity. Student with learning disabilities are more likely to use counting strategies rather than instant recall of multiplication facts [8], [9].

Students with learning disabilities may have difficulties expressing themselves verbally or in writing. They may have difficulties following a set of verbal or written instructions. They may have cognitive difficulties with memory, attention and language. Teachers can make adjustments so that the child with learning disabilities can master the concepts and knowledge. Teachers can use explicit and systematic, provide additional support and instruction, adjust the environment, re-explain and model and describe the outcomes desired [23].

Morin and Miller [20] taught three seventh grade students with mild intellectual disabilities to memorize multiplication facts. Students were taught using the concrete-representational-abstract teaching method and students did improve on a pretest-posttest measure.

Wood et al. placed the 100 multiplication facts (0-9) into six sets [24]. Facts with zero (19 cards), facts with one (17 cards), two (15 cards), five (13 cards), nines (11 cards) and other facts (25 cards). The results showed that fourth and fifth grade students improved their fluency on multiplication facts after instruction and on to a follow up measure. The weakest effects occurred with the last set of cards or those labeled as facts other than zero, one, two, five or nine.

Bouck et al. investigated the use of Pentop computers to improve multiplication of three middle school students with mild intellectual disabilities [10]. Each student was being educated in a special education classroom with pull-out classes for art, music, and physical education. The three 12-year old students were performing at a fourth grade level in mathematics. The FLYTM Pen was used to improve the students' fluency with multiplication. Students were first taught multiplication facts for two weeks. Base line scores were acquired and pre-training on use of the FLYTM Pen was given to the students. The intervention took place for a period of three weeks. Assessment scores were taken during the intervention phase. One week after the intervention, students completed a maintenance assessment on the multiplication facts. The results showed that the students did improve on percentage of multiplication problems solved correctly from the base line to maintenance phases [10].

The constant time delay teaching strategy has been used in many studies. This strategy involves using multiplication fact flash cards. If the student replies incorrectly or takes more than a set number of seconds (usually 2s-4s) to respond, the teacher repeats the problem and correct answer. The card is placed 2-3 cards back in the stack of cards [7].

Giving the answer to the student after the designated time period is important so the student focusses on immediate recall instead of taking time to derive the answer [7]. If the student does not recall the answer within 3-4 seconds, he or she is immediately told the answer and asked to repeat it [7]. Small sets of multiplication facts learned to high levels of mastery before adding more facts is important to achieving automaticity [7].

Baker and Cuevas [9] investigated the use of strategies in recalling multiplication facts. Their subjects were 3rd, 5th, and 8th grade students. The findings corroborated previous research that shows students struggle with recall of single digit multiplication facts. This is alarming because the lack of fluency with multiplication facts puts their future success in the mathematics classroom in jeopardy.

Automaticity should be achievable for most students. There are different strategies that students use to recall multiplication facts such as skip counting, using their fingers to count up, and the hand trick for multiplication by 9. Baker and Cuevas [9] found that 13.1% of the participants in their study used a strategy and that strategies were used on the most difficult problems. The results showed the percentage of automaticity was 52.4% for 3rd grade students, 75.7% for 5th, and 65.7% for 8th grade students. The percentage of automaticity was higher for easier problems than for harder problems such as multiplication facts of 6, 7, 8, and 9.

Instructional strategies that can be used for students with different academic levels include explicit timing and cover-copy-compare strategies [25]. Coddington et al. found that students who are at a frustration level with math fact fluency did better with a cover-copy-compare strategy and students at a normal range of math fact fluency did better with explicit timing. The cover-copy-compare (CCC) strategy involves 5 steps: 1) look at problem and answer, 2) cover the problem and answer, 3) record the answer, 4) uncover the problem and answer, and 5) compare answers [25] [26]. A recent study [27] found no significant difference between Math Cover, Copy, Compare intervention procedures for children with Autism Spectrum Disorder (ASD).

Burns investigated the use of Incremental Rehearsal (IR) to increase fluency of single-digit multiplication facts [28]. A gradual increase of known to unknown facts was used with the final stage being 90% to 10%. Three third-grade elementary students with learning disabilities and low fluency with multiplication facts were the subjects. Base line data was collected using single worksheets with 35 randomly selected single-digit multiplication facts. The experimental treatment was administered twice per week for 10-15 minute periods. The 100 (0 to 9) single-digits facts were written on index cards and identified as “known”, if the child correctly stated the answer within 2 seconds and identified as “unknown” if the child was not successful. The treatment was an IR sequence where 1 card presented was “unknown” and 9 cards presented were “known”. The Incremental Rehearsal method was successful in increasing fluency of single-digit multiplication facts [28].

Lessons presented with direct instruction methods are presented systematically. Direct Instruction (DI) was used with flash cards and model-lead-test correction procedures with elementary students with learning disabilities [29], [30], [31].

Cravalho et al. investigated the use of DI flashcards to teach elementary students with learning disabilities their addition facts [29]. A baseline score was obtained followed by direct instruction and correction models of teaching. The student was shown a flash card with an addition fact and the problem was read by the researcher. Following the student's response, the researcher would respond with “Yes”, or “No” followed by the correct answer. If the student responded with an incorrect response, the researcher used a model, lead, test, and retest correction procedure. The missed card was then placed two cards back in the stack. The results showed that all students made progress using DI flashcards in learning addition facts [29].

Lund et al. investigated the use of DI flashcards in teaching multiplication facts to sixth grade students with learning disabilities [30]. The researchers in this study required the students to state the problem themselves rather than the researcher. A correct response was considered a correct answer within 5 seconds. Mattingly and Bott [31] also used a 5 second constant time delay procedure in teaching multiplication facts

to fifth and sixth grade students. The DI lesson was followed by a math racetrack game. The racetrack was a board game with 28 spaces for multiplication facts. The student was timed for speed and accuracy. The problem was read by the student. The researcher responded with either “Yes” or “No” followed by the problems with the correct answer. If the student’s response was correct, they were allowed to go on to the next square. If the student’s response was incorrect, the student had to repeat the problem after the researcher’s correction. The DI and math racetrack intervention was effective in increasing the students’ accuracy and fluency on basic multiplication facts [30].

Glover et al. also investigated the use of DI flashcards to teach multiplication facts to adolescents with learning disabilities [32]. The researchers were successful in teaching basic multiplication facts to 11 and 12 year old students using DI flashcards with back three cards for errors strategy [32].

3. Methodology

The single-subject study served to (a) identify the unique needs of the student, (b) guide the selection of instructional content and materials, (c) create an individualized education plan (IEP), (d) monitor student progress, and (e) evaluate learning [33]. Adequate representation of content, appropriate scope and sequence of the content and developmentally appropriate content were addressed to insure accurate measures.

A single-subject multiple baseline design [34], [35], [36] across sets of multiplication facts for ones to fives with Direct Instruction (DI) flashcards [28], [29], [30], [31] were used. Multiple baseline designs are useful for measuring the acquisition of fluency of skills over time [20], [28], [29], [30], [31], [32].

The researcher had worked with the student in four previous studies [1], [38], [39], [40]. The student’s previous knowledge and history were used to develop an individualized education plan to help her memorize multiplication facts (0-10) for the ones through fives [1]. The study showed that the student had a conceptual understanding of basic multiplication facts; but did not have them memorized. The researcher began by engaging the student in skip counting exercises. The student’s hands were used and each finger represented the basic facts from 1 to 10. The interventions were using flash cards with illustrations of the multiplication facts and skip counting. The student was able to skip count using her fingers with accuracy but not with speed. The posttest showed that she could provide the solution to a given multiplication fact, name the multiplication fact of a given an illustration of a fact and provide an illustration for a given multiplication fact with 100% accuracy. The student was able to memorizing multiplication facts (0-10) for the ones to fives over a two month period [1]. The purpose of the current study was to provide automaticity for of the (0-10) facts for the ones to fives.

In the current study, the student first recited the multiplication facts for the ones to fives using her fingers at the beginning of each of the weekly sessions. There were 55 flash cards randomly divided into 5 sets of 11 cards. The goal was to go through each set of cards, by the researcher stating the multiplication fact on the card and allowing the student 3-seconds to respond with the correct answer. The researcher recorded a “+” or “-” for each of the 11 cards to record mastery or non-mastery respectively. One session was conducted per week and consisted of three attempts to finish the set of 11 cards with at least 80% accuracy. A record of at least 9 out of 11 correct was a successful attempt. Once the student was able to achieve at

least 80% accuracy on three consecutive attempts, the student proceeded to the next set of 11 cards. Whenever a new set was started, the researcher used two instead of three attempts to introduce the student to the new set of cards and gave the student 5-seconds to respond instead of 3-seconds.

3.1. Subject

The student was in the eighth grade when this investigation was conducted. The student is in a special education classroom at a middle school for grades 6-8. She goes to regular classes for physical education and art. The student was diagnosed with mild learning disabilities and was performing at the third-fourth grade level in math, reading and writing. The student was also diagnosed with mild learning disabilities and autism. She was performing at the third to fourth grade level in reading, writing, and mathematics.

3.2. Materials

The student had been taught to skip count for the multiplication facts, ones to fives, using the fingers. At the beginning of each session, the student used her fingers to review the one to five multiplication facts. Flash cards for the ones to fives were used in this study. There were eleven multiplication flash cards for the one to five facts. For example, for the multiplication by three facts the following cards were used: 3×0 , 3×1 , 3×2 , 3×3 , 3×4 , 3×5 , 3×6 , 3×7 , 3×8 , 3×9 , 3×10 . The facts were written in vertical form on the card rather than horizontal form. In all there were 55 cards covering the multiplication facts for the ones to fives.

4. Results

A single-subject multiple baseline design [34], [35], [36] across sets of multiplication facts for ones to fives with Direct Instruction (DI) flashcards [28], [29], [30], [31] were used. Multiple baseline designs are useful for measuring the acquisition of fluency of skills over time [20], [28], [29], [30], [31], [32].

The first set of 11 cards took four weeks to master. At the first session or first week, the student answered 3 in the first attempt then 6 in the second attempt of the 11 flash cards correct by responding within 5-seconds. At the week two session, the student had 8 of the 11 cards correct in 3-seconds, then 6 and 7 of the 11 cards correct during the second and third attempts. At week three, the student had 8, 10 and then 10 cards correct out of the 11 cards in the first, second, and third attempts respectively. During session four or week four, the student mastered the set of cards by getting 11, 10, and 10 cards correct in the three attempts. Since the student answered 9 or more cards correct, mastery was at least 80% on all three attempts; therefore, the student progressed to the second set of cards at week 5. Table 1 contains the results for the first set of 11 cards (See Table 1) and Figure 1 is a graph of the data (See Figure 1).

Table 1. Developing automaticity set 1 results

Session	Attempt 1	Attempt 2	Attempt 3
Week 1—A	3	6	
Week 2—B	8	6	7
Week 3—C	8	10	10
Week 4—D	11	10	10

The student achieved automaticity on set 1 after four weeks.

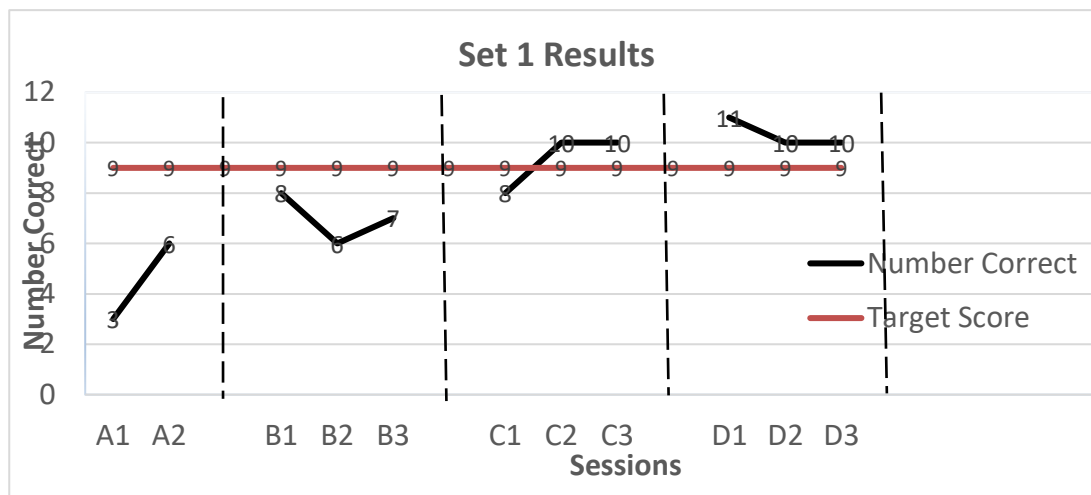


Figure 1. Developing automaticity set 1 results.

The student achieved at least 80% automaticity on three attempts after four weeks.

The second set of 11 cards took three weeks to master. At the fifth session or fifth week, the student answered 9 in the first attempt then 8 in the second attempt of the 11 flash cards correct by responding within 5-seconds. At the week six session, the student had 8, 7 and then 9 flash cards correct by responding within 3-seconds in the first, second, and third attempts respectively. During session seven or week seven, the student mastered the set of cards by getting 11, 9, and 10 cards correct in the three attempts. Since the student answered 9 or more cards correct, mastery was at least 80% on all three attempts; therefore, the student progressed to the third set of cards at week 8. Table 2 contains the results for the second set of 11 cards (See Table 2) and Figure 2 is a base-line graph of the data (See Figure 2).

Table 2. Developing automaticity set 2 results

Session	Attempt 1	Attempt 2	Attempt 3
Week 5—A	9	8	
Week 6—B	8	7	9
Week 7—C	11	9	10

The student achieved automaticity on set 2 after three weeks.

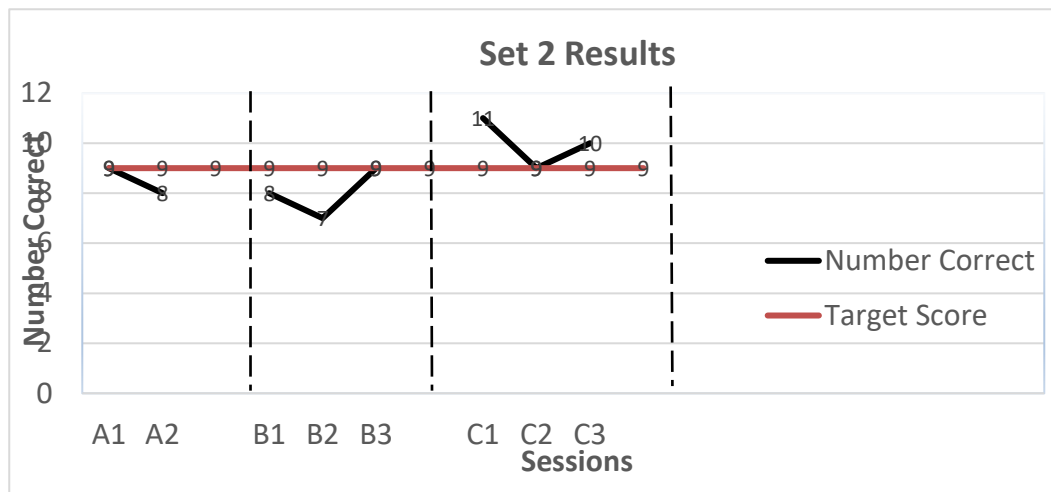


Figure 2. Developing automaticity set 2 results.

The student achieved at least 80% automaticity on three attempts after three weeks.

The third set of 11 cards took five weeks to master. At the eighth session or eighth week, the student answered 7 then 8 of the 11 flash cards correct by responding within 5-seconds during the first and second attempts, respectively. At the week nine session, the student had 8 of the 11 cards correct in 3-seconds, then 7 and 10 of the 11 cards correct during the second and third attempts. At week ten, the student had 9, 8 and then 9 cards correct out of the 11 cards in the first, second, and third attempts respectively. At week eleven, the student had 9, 8 and then 11 cards correct out of the 11 cards in the first, second, and third attempts respectively. During session twelve or week twelve, the student mastered the set of cards by getting 10, 10, and 10 cards correct in the three attempts. Since the student answered 9 or more cards correct, mastery was at least 80% on all three attempts; therefore, the student progressed to the fourth set of cards at week thirteen. Table 3 contains the results for the third sets of 11 cards (See Table 3) and Figure 3 is a base-line graph of the data (See Figure 3).

Table 3. Developing automaticity set 3 results

Session	Attempt 1	Attempt 2	Attempt 3
Week 8—A	7	8	
Week 9—B	8	7	10
Week 10—C	9	8	9
Week 11—D	9	8	11
Week 12—E	10	10	10

The student achieved automaticity on set 3 after five weeks.

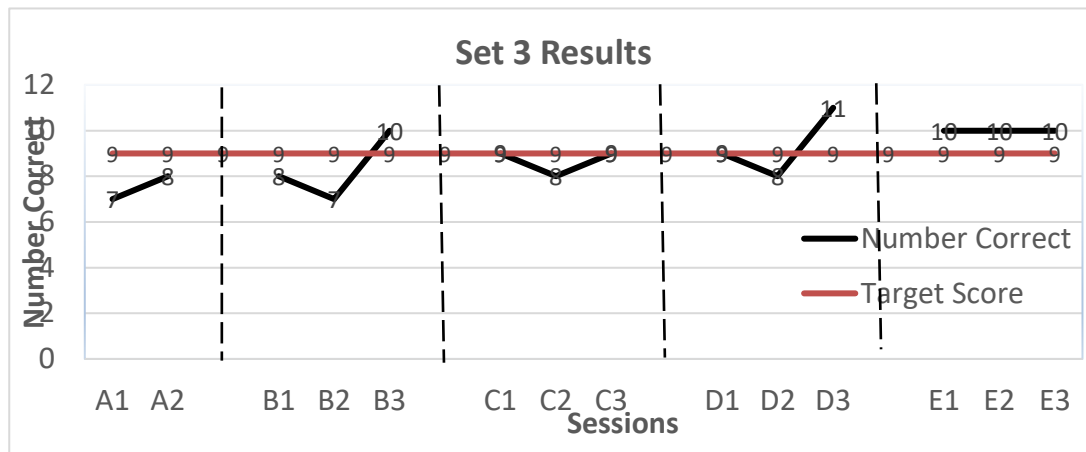


Figure 3. Developing automaticity set 3 results.

The student achieved at least 80% automaticity on three attempts after five weeks.

The fourth set of 11 cards took four weeks to master. At the thirteenth session or thirteenth week, the student answered 6 in the first attempt then 5 in the second attempt of the 11 flash cards correct by responding within 5-seconds. At the week fourteen session, the student had 5 of the 11 cards correct in 3-seconds, then 9 and 11 of the 11 cards correct during the second and third attempts. At week fifteen, the student had 7, 8 and then 8 cards correct out of the 11 cards in the first, second, and third attempts respectively. During session sixteenth or week sixteen, the student mastered the set of cards by getting 10, 10, and 10 cards correct in the three attempts. Since the student answered 9 or more cards correct, mastery was at least 80% on all three attempts; therefore, the student progressed to the second set of cards at week seventeen. Table 4 contains the results for the fourth set of 11 cards (See Table 4) and Figure 4 is a graph of the data (See Figure 4).

Table 4. Developing automaticity set 4 results

Session	Attempt 1	Attempt 2	Attempt 3
Week 13—A	6	5	
Week 14—B	5	9	11
Week 15—C	7	8	8
Week 16—D	10	10	10

The student achieved automaticity on set 4 after four weeks.

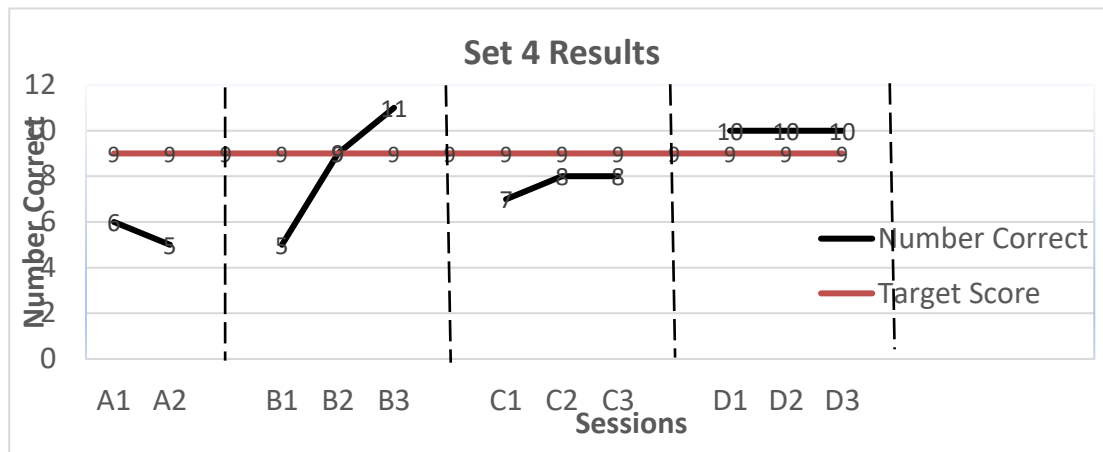


Figure 4. Developing automaticity set 4 results.

The student achieved at least 80% automaticity on three attempts after four weeks.

The fifth set of 11 cards took four weeks to master. At the seventeenth session or seventeenth week, the student answered 5 in the first attempt then 7 in the second attempt of the 11 flash cards correct by responding within 5-seconds. At the week eighteen session, the student had 5 of the 11 cards correct in 3-seconds, then 7 and 8 of the 11 cards correct during the second and third attempts. At week nineteen, the student had 8, 10 and then 10 cards correct out of the 11 cards in the first, second, and third attempts respectively. During session twenty or week twenty, the student mastered the set of cards by getting 10, 10, and 10 cards correct in the three attempts. Since the student had 9 or more cards correct, mastery was at least 80% on all three attempts (See Table 5) and Figure 5 is a graph of the data (See Figure 5).

Table 5. Developing automaticity set 5 results

Session	Attempt 1	Attempt 2	Attempt 3
Week 17—A	5	7	
Week 18—B	5	7	8
Week 19—C	8	10	11
Week 20—D	10	10	10

The student achieved automaticity on set 5 after four weeks.

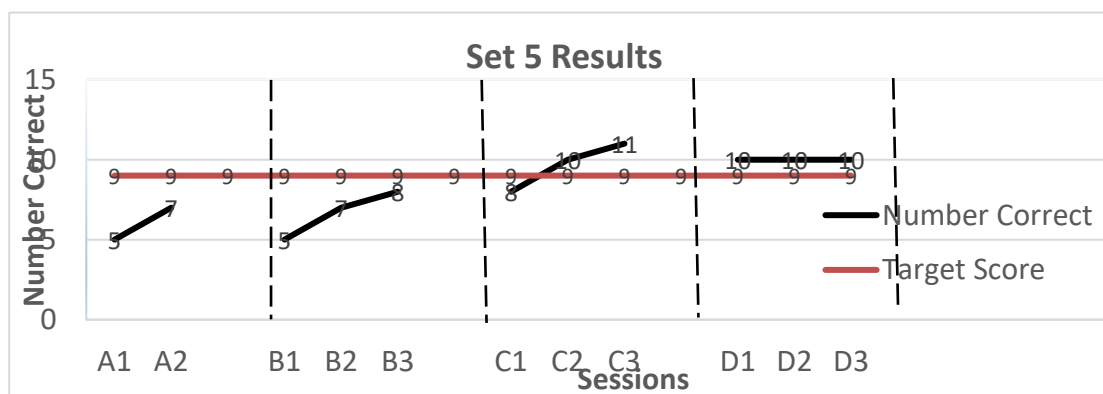


Figure 5. Developing automaticity set 5 results.

The student achieved at least 80% automaticity on three attempts after four weeks.

The student mastered all five sets of 11 cards by responding correctly within 3-seconds for each multiplication fact. The student successfully developed automaticity in twenty weeks with all the multiplication facts for the ones to fives.

5. Conclusions

According to the Individuals with Disabilities Education Act of 2004, “specific learning disability means a disorder in 1 or more of the basic psychological processes involved in understanding or in using language, spoken or written, which disorder may manifest itself in the imperfect ability to listen, think, speak, read, write, spell, or do mathematical calculations” [37]. The student in this study was diagnosed with mild disabilities. She was performing at about the fourth grade level in reading, writing and mathematics. The student was also enrolled in speech services at the public school which she attended.

Students continue to struggle with multiplication facts in the elementary grades. Students who do not develop automaticity with the multiplication facts in the elementary grades, struggle with mathematics in the middle school and are even further behind in high school mathematics. Basic multiplication facts are a building block for understanding higher mathematical concepts; so it is very important that elementary students achieve automaticity [7], [8], [9]. Low achieving students and students with learning disabilities have difficulty in developing automaticity. Student with learning disabilities are more likely to use counting strategies rather than instant recall of multiplication facts [8], [9].

It took several months for the subject in this study to memorize the multiplication facts for the ones to fives. The student was quite successful at reciting the multiplication facts for the ones to fives, using skip counting on her fingers [1].

Automaticity is developed by practicing a small set of multiplication facts and mastering that set before proceeding to another set of facts. The recall time should be immediately, within a couple of seconds, rather than taking time to derive the answer [7]. The student in this study was able to develop automaticity for the one to five multiplication facts. She was able to respond with the correct answer within 3-seconds of hearing a problem stated by the researcher. The student was able to respond to all of the facts for the ones to fives divided into five sets of 11 cards with at least 80% accuracy.

The use of calculators and computers may be a reason that students are not motivated to memorize the basic multiplication facts [9]. Summer or other vacation time from school is a perfect time for older students or adults to help elementary aged students memorize basic addition or multiplication facts. Counters and drawings may be used initially, followed by flash cards with pictures. Next, flash cards with the problem only may be used. Finally, the student is expected to give a verbal response from memory. Some students may need more time and practice to memorize all the multiplication facts. Memorization is the most basic level of learning and can be achieved by most students.

The researcher will continue to work with this student, so she may master the multiplication facts for the sixes to tens. Skip counting using the hands seems to be a successful technique with the student, so this method will be used. After the multiplication facts for the sixes to tens are memorized, automaticity lessons will follow.

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The Didactic Contract from the Perspective of the Theory of Didactical Situations: An Integrative Review

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Abstract

The phenomena related to the mathematical teaching and learning process have a significant and direct influence on the construction of knowledge and studying these issues is of interest to the theory developed by Guy Brousseau, called Theory of Didactical Situations. When dealing with the relations established between student, knowledge and teacher, Brousseau presents those that are specific, explicitly and implicitly, of the relationship between teacher and students, as well as their influences on the teaching and learning process, defining, for this, the Didactic Contract, which consists of the set of behaviors that the teacher expects from the student and the student from the teacher. With this, the following question arose for this work: What is the relevance of the Didactic Contract when designing teaching sequences with input in the Theory of Didactical Situations? The objective was, then, to carry out an integrative review in order to systematize information present in scientific articles about the Didactic Contract in the

perspective of the Theory of Didactical Situations. A search for works was carried out in the databases Scielo, Google Scholar and Portal de Periódicos CAPES/MEC through the descriptors "Didactic Contract" and "Theory of Didactical Situations", with the following exclusion criteria: works not related to the theme and book, theses, dissertations and monographs. That is, only papers of the scientific article type were chosen. A total of one hundred and seventy-seven works were obtained as an initial result, of which thirteen were repeated. After reading the abstracts and adopting the exclusion criteria, sixteen articles remained, of which nine responded to the elaborated question. With the research, it was found, in the period consulted, a limitation of publications that deal specifically with the Didactic Contract and, in spite of that, it was concluded that the Didactic Contract is a very important element in a teaching and learning situation, because it can favor or cause an obstacle in the acquisition of new knowledge by the student.

Keywords: Didactic Contract; Theory of Didactical Situations; Science teaching.

1. Introduction

The Theory of Didactical Situations was developed by the French Guy Brousseau (1986), a researcher at the University of Bordeaux and one of the main pioneers of Didactics of French Mathematics in order to study the phenomena that are linked to the teaching and learning process of mathematics. It sought to introduce this theoretical model of interaction between the student, the knowledge and the teacher, arguing that it is these phenomena, added to the characteristics of teaching situations, that favor the acquisition of knowledge.

When idealizing this theory, Brousseau proposed didactic situations that could be reproduced at different times, in order to establish a general model for the teaching and learning of mathematical concepts, considering the particularity of each subject studied. With this theory, the aforementioned researcher did not intend to only use reproducible situations, but also to study and understand the relationships established between the teacher, mathematical knowledge and the student.

Reproducible situations would promote a change in the behavior of students who would start to acquire a set of knowledge resulting from significant learning. The change in student behavior would happen, because the teacher makes it possible, with the Theory of Didactical Situations, for the apprentice to assume the position of a researcher, acting actively in the construction of knowledge, reflecting on the studied subject, making conjectures and building concepts concerning the new knowledge at stake. In this pedagogical relationship established with the Theory of Didactical Situations, the teacher assumes the position of mediator of the new scientific knowledge.

For the construction of knowledge by the student, Brousseau also proposes the construction, analysis and experimentation of “didactic situations” – a term that gives name to the relationships established between student, knowledge and teacher. And to analyze the specific relationships that are established, explicitly and implicitly, between the teacher and his students, as well as to analyze the influences of these relationships in the teaching and learning process, the author defines the Didactic Contract, which consists of the set of behaviors that the teacher is expected by the student and the student by the teacher (ALMOULOU, 2007).

For Pais (2008) the concept of Didactic Contract is already widespread beyond Mathematics and the interest in this study comes from the possibilities of understanding certain conflicts in pedagogical practice. The Didactic Contract is what allows, and can guarantee, the significance of a problem or concept for the student, according to the way in which it was established. In other words, a poorly managed Didactic Contract can cause difficulties for the student, creating obstacles for the learning of new mathematical concepts. This contract should highlight the importance of student autonomy, since being the teacher responsible for its administration, it is up to him to respect the student's role and the capacity of his cognitive development.

It is clear in this panorama that the Didactic Contract assumes a role of great relevance for a didactic situation with contribution to the Theory of Didactical Situations, however, there is a considerable shortage of research in the area of mathematics teaching, which deal with the Didactic Contract. In this way, we chose the subject in evidence for this research, seeking to understand the influence of the Didactic Contract when establishing the relationships between teacher, student and knowledge in the classroom and its different effects on the teaching-learning of mathematical content. In this sense, this investigation aimed to carry out an integrative review in order to systematize information in scientific articles about the Didactic Contract in the perspective of the Theory of Didactical Situations.

2. Methodology

An integrative literature review was carried out in order to systematize the information on the Didactic Contract from the perspective of Theory of Didactical Situations. The integrative review allows a broad understanding of theories, since when combining the data from theoretical and empirical literature, it forms a broad panorama, either of defining concepts or reviewing theories and evidence, in a very consistent way (SOUZA; SILVA; CARVALHO, 2010). That is, in order to synthesize results obtained in research, it integrates and analyzes, in a comprehensive and systematic way, a body of scientific knowledge already produced (ERCOLE; MELO; ALCOFORADO, 2014). The Integrative Review technique goes through six (06) phases, namely: (1) elaboration of the guiding question; (2) searching or sampling in the literature; (3) data collection; (4) critical analysis of the included studies; (5) discussion of results and (6) presentation of the integrative review.

In the first stage, which consists in the elaboration of the guiding question, the topic of interest for study was identified and the question was selected to carry out the integrative review. The Didactic Contract was chosen as a research theme from the perspective of Theory of Didactical Situations, seeking to answer the following guiding question: What is the relevance of the didactic contract when designing teaching sequences with a contribution to Theory of Didactical Situations? And what are the effects of their rupture? After the theme and the guiding question of the investigation were chosen, the second stage of the work went on, which was the search for related studies for review in the databases: Google Scholar, Scielo and the Portal de Periódicos CAPES/MEC. For this purpose, the following descriptors were established: Didactic Contract and Theory of Didactical Situations. The established search was based on the research period from 2015 to 2019, using the following vernaculars: English, French and Spanish.

The inclusion criteria were those articles that presented the theme of Theory of Didactical Situations with

a deliberate interest in the Didactic Contract or that brought a conceptual description of this element. Regarding the exclusion criteria of the publications found, the work that did not deal with the Didactic Contract in its established theme, as well as the duplicated articles in the databases consulted, were adopted as the elimination criterion. Table 1 presents a summary of the information from the consultation.

Table 1. Number of articles found in the databases

Database	Year	Number of scientific articles	Percentage (%)
Google Scholar	2015 – 2019	170	96,04%
Portal de Periódicos CAPES/MEC	2015 – 2019	06	3,39%
Scielo	2015 – 2019	01	0,56%
Total		177	100%

Source: Prepared by the authors.

In the data collection and critical analysis of the included studies, the selection of the paper related to the researched theme was made, based on the inclusion criterion initially established, in the reading of the abstracts of the publications, as well as considering the refinement of the research period in the years from 2015 to 2019. Of the total of 177 articles found, only 16 were selected, 14 of which were from Google scholar; 01 article found in the Portal de Periódicos CAPES/MEC and 01 in Scielo. The 161 publications were not related to the theme chosen for the present research, or they were books, theses, dissertations and course completion works, that is, they were not aligned with the chosen criterion for inclusion of works. It is worth mentioning that 13 articles among the 161 excluded publications dealt with duplicate works. It is also noteworthy that after reading the 16 selected works in full, only 09 remained for the discussion of the integrative review, due to the fact that 07 articles talk about the Didactic Contract, but do not focus on the theme of the guiding question of this research. Figure 1, called the Prisma Flow Diagram, presents more detailed information regarding the selection, inclusion and exclusion of works researched in the databases.

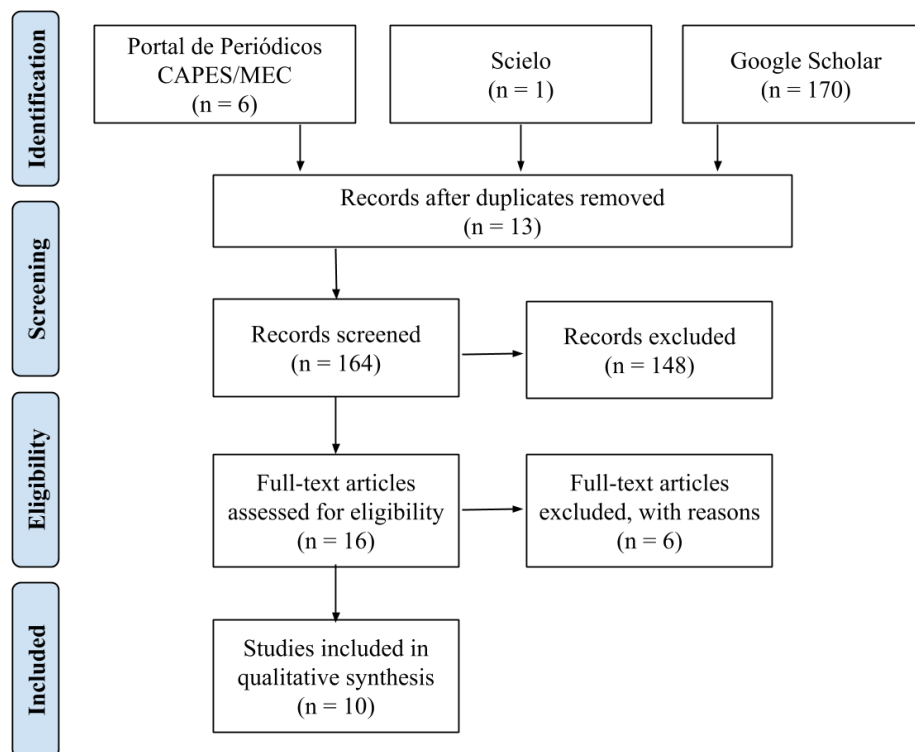


Figure 1. Prisma Flow diagram.

Source: <http://prisma-statement.org/PRISMAStatement/FlowDiagram>

After selecting the articles, considering the objective of answering the guiding question of the investigation, we sought to extract the information from the chosen publications, considering some criteria for collection, namely: objectives of the work, studied sample and results found. Finally, the discussion of the results found with the data collection was exposed and the integrative review was presented.

3. Results and Discussion

Table 2. Main references of articles included in the integrative review

Authors (year)	Goals	Main results	Conclusions	Cientific magazine
Oliveira; Mastroianni, 2015.	To investigate the conceptions of polyvalent teachers of the initial years regarding the theme Problem Solving.	It was identified that there is a choice of exercises instead of problems by the teacher. There is also a revelation of the prevalence of a Didactic Contract based on explicit or implicit procedures in relation to the tasks and occurrence of some of its effects.	The subjects of this research understand the relevance of their problematizing role in mathematics classes, but it is still difficult for them to organize an antagonist milieu, which causes imbalances and	Ensaio de pesquisa em educação científica

			adaptations in the students.	
Batista; Siqueira, 2019.	To highlight didactic aspects that a playful activity of Nuclear Instability provides for the teaching of concepts of Modern and Contemporary Physics.	It was observed that taking into account the implicit is one of the necessary conditions for students to be directed to the contents. Moreover, as the students were provoked to speak the elements of the Didactic Contract, these elements became explicit.	Nuclear Instability showed didactic aspects of playful character, when submitted to the concept of Didactic Contract.	Góndola, Enseñanza y Aprendizaje de las Ciencias
Souza <i>et al.</i> , 2017.	Conduct a bibliographic survey to identify and analyze research on Didactic Contract involving the approach of physical and chemical knowledge in Brazil.	The abusive use of analogies should be avoided, the effect of the Didactic Contract, as this can trivialize teaching and prevent learning from occurring. Thus, the researchers, in many moments, had to explain it, seeking a renegotiation. It was also observed that the effects of the Didactic Contract may emerge more than once in teaching situations.	There was a plurality of research involving the Didactic Contract. This shows that your investigation can be done in any classroom, including training in hospital settings.	Revista de Educação, Ciências e Matemática
Brick; Ferreira; Sena, 2016.	Explain the relationship between Didactic Contract and school evaluation	He pointed out that both the evaluation and the Didactic Contract reflect a certain educational and epistemological intention. In addition, the rules of the Didactic Contract, together with the traditional evaluation, condition the innovations of teaching practices.	Modifications in the assessment give rise to changes in the Didactic Contract and vice versa. Also, the moment of the evaluation can make some elements of the Didactic Contract explicit, besides being an indicator of its type.	Ensino de Ciências e Tecnologia em Revista
Souza <i>et al.</i> , 2017.	Analyze the Didactic Contract based on the criteria: expectations for the other, negotiations,	The action of casting questions to the class without giving time to answer is a strong indicator of occurrence of topaze effect. In addition, the negotiations, in the	The study of the Didactic Contract enabled the knowledge of the behaviors expected	Educação Química em Ponto de Vista

	ruptures, renegotiations and effects.	establishment of a Didactic Contract, go beyond the negotiation of papers, although it directly involves the establishment of these parts of the responsibility	by teachers and students, in addition to assisting in the analysis of the relationships between teacher, student and knowledge.	
Teixeira, 2017.	Reflect on issues related to teaching and learning mathematics through the Problem Solving methodology, having as theoretical reference the Theory of Didactical Situations.	A mathematics teaching, in which mathematical concepts are defined from the outset, followed by application exercises, does not allow the student to develop skills to think, reflect, question and/or raise hypotheses. Evaluations with questions similar to those presented do not mobilize the search for strategies, procedures and representations necessary to solve problem situations.	The study of didactic situations allows to reveal and use the role of non-explicit or even not valid knowledge for the establishment and learning of mathematical knowledge.	Temas e Conexões
Nascimento; Menezes, 2018.	Investigate the evaluation and its influences on didactic phenomena, didactic transposition and the Didactic Contract in the mathematics classroom.	The approach taken by the teacher is systematic, because there is a report that mathematics is accurate, which can cause a barrier in the teacher-student-knowledge relationship; evaluation is not an occasion but a process; the student decorates for the test because it focuses on the result of the evaluation and not on the learning, resulting from a Didactic Contract established by the teacher.	The teacher reinforces implicitly in the Didactic Contract that knowledge will be measured in the test, reinforcing a traditional teaching method.	Revista Ciências e Ideias
Mastroianni; Oliveira, 2019.	Investigate teachers' beliefs and conceptions regarding didactic strategies related to	Because she did not know the class, the problem situation presented by the teacher was below the possibilities of the students, hindering mediation	Teachers understand that it is important to take the position of mediator in the teaching of	Revista de Educação Matemática

	Problem Solving and their application in class.	and making it impossible for students to evolve, caused by lack of planning. The teacher did not internalize the posture required by Theory Didactical Situations and induced the students to respond expected by her, causing the topaze effect of the Didactic Contract.	mathematics, however, they find it difficult to apply a methodology that leads to an investigative posture. In addition, they prefer to be led by the teacher.	
Giordano, 2016.	Study the possible contributions of the Descriptive Statistics approach through research projects.	The teaching material was not adequate, requiring the teaching intervention. The knowledge required transcended the sphere of mathematics. The breaking of the Didactic Contract proved necessary for the maturation of the groups and the development of investigative autonomy.	The project-based approach provides greater motivation and student involvement.	Revista Metáfora Educacional
Rodrigues; Menezes; Santos, 2017.	Propose the Course of Study and Research as a teaching methodology in undergraduate courses in Mathematics based on the concept of functions.	Higher education institutions have a dominant epistemology that does not allow itself to be studied and questioned by didactics. Thus, it is difficult to enter the academic environment with new methodological proposals. However, the teacher must do this in a reflexive way through tools that enable him to make an analysis of the actions adopted.	The use of the Study and Research Pathway as a teaching methodology causes changes in the attitude of the teacher and consequently of the students and to analyze these changes we have the option of the Didactic Contract.	Amazônia Revista de Educação em Ciências e Matemática

Source: Prepared by the authors.

Oliveira and Mastroianni (2015) carried out a study with multipurpose mathematics teachers from the early years, seeking to investigate, among other aspects, the validity and influence of the Didactic Contract in the use of the Problem Solving teaching methodology. During the observation of the teachers' practice, the topaze effect was identified, since “clues” were provided to students in search of the quick appearance of the correct answer. In addition, there was the practice called “metacognitive slip”, which was the teacher's indication that mathematical operation would be the key to problem solving, often bringing it as the focus

of the study object rather than the real one knowledge to be developed. There was also the incidence of the “journain effect or well-founded misunderstanding”, characterized by the professor's efforts to value the student's reasoning and, at the same time, to be concerned with the use of correct models.

It is emphasized that the effects of the Didactic Contract can compromise the learning objective in a didactic teaching situation, since through them, the teacher prevents the student from actively participating in the construction of his knowledge. By proposing ways for the student to overcome the difficulty more quickly, without committing much personal effort, the teacher neglects the student's intellectual development, while not favoring creating hypotheses, conjectures and elaborating concepts. This practice causes a negative factor to the student's learning and the teacher must be aware of this issue, since he must let the student play his role in the teaching-learning process, respecting his cognitive development.

Batista and Siqueira (2019), in the analysis of recordings of a Physics class on the content of Radioactivity, observed that the Didactic Contract promoted the intellectual involvement of students, by observing the rules to be obeyed for the performance of the activity, providing the teacher necessary tools to coordinate the situation. The teacher's warning about the purpose of the activity highlighted the implicit acceptance of its compliance by the students, that is, of the rules to be followed by them. In addition, a breach of the contract was identified when there was a change in the type of material used in class, even though it did not influence the performance of the activity, which ended up contributing to causing transgressive attitudes in students. As a result, there was a process of renegotiation of the Didactic Contract, in which the teacher reread the rules and continued to establish them, despite the fact that, throughout the activities, some commitments were not accepted by all students.

It can be seen here that the Didactic Contract was favorable to the teaching and learning situation and that its rupture served as a positive factor to overcome an obstacle in learning, causing an improvement in the students' performance. It is also noted that there was a renegotiation of the rules established implicitly between teacher and students. However, the new agreement favored the acquisition of content and was not characterized as a negative factor for the development of students. In this sense, it is worth emphasizing the need to renegotiate the Didactic Contract whenever a rupture or one of its effects occurs.

Brick, Ferreira and Sena (2016), based on a systematic literature review in the area of Education in Sciences, seek to explain the relationship between Didactic Contract and school evaluation, stating that the conception and evaluation practice adopted by the teacher permeates this contract, even if it is to maintain it, change it or break it. In addition, the rules established in it can be influenced by experiences lived by the teacher and students throughout their school lives. They also point out that evaluating students in a different way than what they are used to is enough to be characterized as a breach of the Didactic Contract, having to be renegotiated.

The study points out an important consideration about the implicit rules present in the Didactic Contract that can be easily identified at the moment that students are used to the way a teacher teaches a class or to evaluate students and there is a change. For example, when the teacher usually evaluates through the traditional test and then decides to evaluate through seminars. This generates reactions in the students and explains the rupture of the contract. In this perspective, Nascimento and Menezes (2018) also corroborate by presenting an experience in which the teacher draws the students' attention through warnings about the importance of those contents for the test. Given this, it ends up reinforcing the idea that assessment is an

occasion where students' knowledge will be measured. The student therefore tries to prepare for that moment, focusing on the result of the evaluation and not on the process that arrives until its date of completion. Thus, the teacher may not notice this implicit agreement established.

Souza et al. (2017), through a bibliographic search, carries out studies on works evolving the Didactic Contract in the teaching of Physics and Chemistry contents in Brazil, revealing low scientific production in the area. However, he considers that the analyzed works are significant, as they show that the Didactic Contract can manage paradoxes found in the classroom, for example, such as including unexpected situations in problems presented to students in order to contribute to their reorientation and make it most significant. However, if this behavior is used constantly, it will be included in the implicit rules of the contract.

These types of paradoxes are found in different contexts, as is the case of the teacher-student-knowledge relationship during a training situation in a hospital area, in which there is a lack of identification of this space as a school environment by the students themselves. Through these situations, we saw that the teacher must be prepared to face the paradoxes that are present in the classroom, especially those that present themselves through the rupture of the Didactic Contract and, at the same time, it is up to him to be creative and open to new forms of didactic relationships, so that teaching situations can continue with investment in those that may be new.

Giordano (2016) presents the influences of breaches of the Didactic Contract during the process of statistical literacy, affirming the existence of a didactic intention in the individual who goes through contradictions and imbalances, sometimes provoked by the teacher. The teacher also needs to strengthen relationships with students, creating an environment conducive to learning, offering help to them, but in the right measure, since too much help can make the student lose the opportunity to experience the potential investigative of an activity.

When proposing the application of the Study and Research Course as a didactic device, Rodrigues, Menezes and Santos (2017) state that if the teacher makes this option, he will break the Didactic Contract that was in effect until then. This implies a change in teaching methods on the part of the teacher and a different participation in the class by the student, causing difficulties for both teachers and students. However, the fact that the Study and Research Course is based on a generative issue, this will favor the expansion of creativity in problem solving by learners through the mediation of the teacher. In order to understand this new reality of the teacher-knowledge-student relationship, the authors propose the use of the Didactic Contract, considering that this concept seeks to understand the behaviors expected by both parties in a didactic session, highlighting the importance of the Didactic Contract for understanding teaching and learning relationship.

It can be seen that for a change in the attitude of students and teachers, it is necessary to break the previous norms that determined the behavior of both. For the understanding and establishment of these new implicit and explicit rules the Didactic Contract is a tool that enables this reflection action. Collaborating with the hypothesis of Rodrigues, Menezes and Santos (2017), we have the results found by Souza et al. (2017) that point to the importance of understanding the elements that arise in the teacher-knowledge-student relationship. In this study, the authors concluded that the study of the Didactic Contract enabled knowledge of the behaviors expected by teachers and students, in addition to assisting in the analysis of the

relationships between teacher, student and knowledge.

According to Mastroianni and Oliveira (2019), teachers in the initial grades of elementary school understand that it is important to assume the position of mediator in the teaching of mathematics, but they experience difficulties in applying a methodology that leads the student to become unbalanced and adapt. In addition, students give up taking an investigative stance and prefer to be led by the teacher. Therefore, the effects of the Didactic Contract explain these difficulties and categorize the teachers' mistakes when changing their posture, concluding that the study of relationships in the classroom contributes to the reflexive action of the teacher.

4. Conclusion

In this research, we sought to synthesize, through an integrative literature review, information related to the Didactic Contract and, through the researches studied in the review, it is concluded that the Didactic Contract is a very important element in a teaching and learning situation, since it can favour or cause an obstacle in the acquisition of a new knowledge by the student. Because, if conducted in the wrong way, it generates difficulties in the assimilation of concepts and, if well managed, will promote a meaningful learning of content by the student.

Given the relevance of this element in a classroom context, where the didactic triangle established by the relations between teacher-knowledge-student is instituted, one must take a close look at the issue of the effects on learning caused by the rupture of the Didactic Contract. Students often find it difficult to adapt to learning situations when such a break occurs. Thus, to remedy the situation, the contract renegotiation is recurrent. However, the teacher must be aware of the fact that the continuous negotiation of the Didactic Contract can negatively compromise the learning objectives. Because, aiming for his students to be successful in assimilating the contents, he can facilitate the apprentice's work, putting into practice some of the effects of the Didactic Contract, such as: topaze effect, jourdain effect, metacognitive slide and abusive use of analogy. This teaching attitude makes it impossible for the student to overcome difficulties through personal engagement and, consequently, deprives the apprentice to make conjectures, create hypotheses and take an active role in the construction of knowledge.

Through these considerations, the relevance of the theme addressed in this research is reinforced, paying attention to the limitations found in the research path, which was to find a profusion of publications that specifically dealt with the Didactic Contract in teaching sequences with input in the Theory of Didactical Situations and, also, in the question of the effects on learning generated by the rupture of the referred contract. To this end, it is expected that this research promotes reflection on the part of teachers about the importance of the Didactic Contract in teaching situations and that it will add information on the topic studied to the list of existing research in the area of science and mathematics education.

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The Environmental Dynamic Efficiency Of Onshore Oil Fields Located At The Brazilian Coastal Basin

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ABSTRACT

One of the main environmental concerns associated with the exploration and production of oil fields is related to the generation of produced water, this is a strategic challenge for companies since is responsible for the largest share of waste generated by the oil industry. This theme is presented as multidisciplinary since it is a study with dynamic models in an environmental area linked to the oil industry. Thus, the present work aims to evaluate the performance of dynamic environmental sustainability, from the generation of produced water from onshore oil fields located at the coastal basins of Brazil with higher oil production. The data were made available by the ANP (National Petroleum Agency) from its website, totalizing 67 fields during the years 2014, 2015 and 2016. In addition, dynamic Data Envelopment Analysis was used to determine dynamic efficiency. The results showed a positive effect of the variables directional wells, vertical wells and age, the first two variable showed a fundamental role in determining environmental efficiencies. Therefore, the results allowed to state that there is a poor management of the technological resources in onshore fields of the Brazilian coastal basins, generating excessive amounts of produced water.

Keywords: Environmental sustainability. Oil fields. Environmental efficiency. Produced water.

1. INTRODUCTION

Nowadays, oil can be considered the most important source of energy, since it produces multiple derivatives (gasoline, kerosene, bitumen, etc.) in order to meet an ever increasing demand from society. According to data from the IEA (International Energy Agency), it is estimated that in 2018, the daily demand for oil reached the level of 146.2 million barrels per day worldwide. Despite this latent growth in oil production, there is an important trade-off in this production system between the development of the oil sector and the increase of waste generation inherent to the process, representing threats to the environment and environmental sustainability of this industry.

The oil and gas production processes produce large volumes of liquid waste, among which stands out the generation of produced water. This term is used to describe a water that is produced along with oil and gas during production, that is often injected into wells in order to increase oil recovery (Venkatesan & Wankat, 2017)

This undesirable fluid is an inextricable part of the hydrocarbon recovery process. As the fields develop, they tend to produce increasing amounts of water (Khatib & Verbeek, 2003), and can reach values close to 100% of the well's production as it reaches the end of its productive life. Thus, in view of the problem exposed it is evident the damage caused to the environment due to the repeated and constant generations of water produced by the oil and gas industry, promoting damage to the environmental sustainability of the industry, generating challenges for researchs for efficiency.

One of the most used techniques to measure the efficiency of a set of decision units is Data Envelop Analysis (DEA), whose application has spread through several areas, assisting in decision-making for greater efficiency (Liu, Lu, Lu & Lin, 2013). The DEA uses a non-parametric method, whose objective is to determine the efficiency curve from a mathematical optimization schedule, allowing to analyse the relative performance of similar production units (Cook & Seiford, 2009).

Considering the relevance of this theme, it was identified the scarcity of quantitative studies related to the evaluation of productive efficiency in the oil and gas industry, especially with the consideration that the production system has an undesirable output, the "produced water". Through the importance and impact of environmental issues on the oil industry, this study continues the considerations of Song, Zhang & Wang, 2015, Sueyoshi & Goto, 2012 and Sueyoshi & Goto, 2012a.

However, this is a distinct analysis, since it aims to investigate the dynamic aspects of production through an adequate modeling (DDEA), in order to monitor the environmental performance of productive fields of the Brazilian coastal basins for both productive and environmental issues, showing the multidisciplinary of this theme. This transversality of knowledge brings to the end the need to research about the themes that use multiple sciences for their development, as can be attested in the case of the environment area.

Therefore, this work aims to evaluate the dynamic environmental efficiency of oil fields located at the Brazilian coastal basins, considering the years 2014, 2015 and 2016, through Data Envelopment Analysis (DEA). This evaluation was structured in the considerations of Golany & Roll (1989), characterized by constant returns of scale and product orientation. Moreover, this study seek to promote a significant contribution to specialized literature regarding the oil and the environment area, since it deals with an environmental efficiency model capable of measuring the performance of an oil field focusing on the output of an undesirable product: produced water. In addition to the contribution related to the environmental area, the study contributes to the literature of DEA, since studies using it in the oil sector are still insipid, especially with the use of dynamic models.

2. EFFICIENCY MODELS APPLIED TO THE OIL INDUSTRY

Industrial development is important to all nations when evaluating their economic prosperity. However, this development causes trade-offs among which stand out: air pollution, water and other types

of contamination, that result in health problems to the population and climate change. Thus, it is necessary to consider how to reach a balance between economic success and pollution mitigation to maintain a high level of social and environmental sustainability worldwide (Sueyoshi, Yang & Goto, 2017).

In order to better understand these socioclimatic changes and seek for the best practices of environmental sustainability, Sueyoshi, Yang & Goto (2017) systematized a broad research from the world theoretical framework in the area of energy and environment, being it divided in the areas of energy and environment for a better methodological segmentation.

The energy area was subdivided into three sub-areas (electricity; oil, gas and coal; renewable energy). The oil and gas subarea, focus of this work, presented a quantity of 23 studies since the 1980s and only 9 with a focus on environmental efficiency, shown in Chart 1.

Chart 1 - Variables used by the work on efficiency models applied to the oil industry

		Bevilacqua, Bradia (2002)	Mekaroonreun & Johnson	Sueyoshi; Goto (2012)	Sueyoshi; Goto (2012a)	Ismail; Tai; Kong; Law;	Oke; Kareem (2013)	Francisco;	Sueyoshi; Wang (2014)	Song; Zhang;
Inputs	Produced oil	•								
	Capital		•			•	•			
	Consumed energy		•							
	Assets						•			
	Age									
	Total current assets								•	•
	Total non- current assets									•
	Impairment loss of assets									•
	Costs								•	
	Drilled wells								•	
	Vertical wells									
	Directional wells									
	Crude oil		•							
	Water consumption							•		
	Oil reserve			•	•					
	Idleness							•		
	Gas reserve			•	•					

Outputs	Cost				•	•					
	API Grade										
	Manpower				•	•	•			•	
	Desirable	Oil production			•	•			•		
		Gas		•							
		Distilled		•							
		Gas Production			•	•					
		Profits					•	•		•	
	Undesirable	Gas emission	•		•						
		Produced water									
		Toxic or effluent		•					•	•	
	Uncontroll	Age of refinery							•		
Country			Italy	USA	USA	USA	Multiple Countries	Nigeria	Brazil	USA	China
Number of DMU's			28	113	19	19	17	5	10	50	20
Model			CCR	Hiperbólico	CCR/ DTS*	CCR/DTS*	CCR/ Ecoeficiên	CCR/BCC	CCR/ BCC	UE/ UEN /UEM	DEA

Source: Research data, 2020.

*Disposability and Damages to Scale (DTS)

Bevilacqua & Braglia (2002) assessed the relative environmental efficiency of the seven oil refineries created in Italy over a 4-year period (1993-1996), considering six different types of emissions (CO, CO₂, SO₂, NO_x, TSP, VOC)) as undesirable outputs and the annual amount of oil processed as inputs. The results showed that refineries containing an environmental management system present better efficiencies.

The work of Mekaroonreung & Johnson (2010) aimed to describe and compare various methods in order to estimate the technical efficiency of 113 oil refineries operating in the United States between 2006

and 2007, considering the emission of toxic gases as an undesirable output. A hyperbolic efficiency measure was applied to analyze the potential loss of each refinery due to environmental regulations. The results indicated that domestic refineries could improve efficiency, regardless of disposal assumptions, and that environmental regulations would reduce the amount of potentially desirable products produced by some facilities.

Also in relation to the American reality, Sueyoshi & Goto (2012, 2012a) used the DEA to perform an environmental assessment using non-radial DEA models in 19 oil companies: 14 American and 5 foreign. This study proposes three types of unification for environmental assessment of the DEA. The results denoted greater efficiency for foreign companies, especially those from Saudi Arabia and Russia. Another conclusion obtained was that the national oil companies would need to meet their own country's environmental standard, while international oil companies should comply with international standards stricter than national standards.

The reality of the Nigerian oil industries was studied by Oke & Kareem (2013) in order to investigate the operational efficiency of five oil companies, taking as reference the years from 2006 to 2009. The application of the DEA CCR and the BBC was used for data analysis. The research found that two companies operated below 10% of operational efficiency, causing an average efficiency of the companies studied below 50%.

Ismail, Tai, Kong, Law, Shirazi & Karim (2013) designed a study focusing on analyzing the environmental performance and economic efficiency of the global operations for 17 companies in 2008. These companies were selected from the global oil industry by applying a comparison between technical efficiency and eco-efficiency. The results showed a weak positive relationship between eco-efficiency and technical efficiency in relation to the companies studied.

Song, Zhang & Wang (2015), took advantage of the DEA in networks to develop an environmental efficiency model for 20 companies from the Chinese oil industry,, being compared the results of pollutant treatment efficiency and production efficiency between years 2006 and 2011.

The same market approach adopted by Song; Zhang & Wang (2015), related to the Chinese oil market, was used by Sueyoshi & Goto (2015). They considered 17 companies in the oil sector to calculate the environmental efficiency index under evaluation from 2006 to 2009, evolving the model proposed by Sueyoshi & Goto (2012, 2012a), since the malmquist index was included for this study. They concluded that the industry did not exhibit any major boundary change over the evaluated years. When considering companies, they saw a considerable boundary change under the capacity to manage and improve environmental performance.

Thus, following the trend of studies in refineries (Sueyoshi & Goto, 2012, 2012a), an environmental efficiency assessment, with emphasis on effluents and water consumption in the production process for 10 refineries from the Brazilian public sector was carried out by Francisco, Almeida & Silva (2013). The classical methods of DEA (CCR, BCC) were applied in this research, considering a model of desirable outputs and two others with undesirable outputs. Based on the comparison of the results, it was verified the clear importance of the environmental variable for a more accurate analysis of the production process and the rejection of the hypothesis that the age of the refinery would negatively interfere in production.

Sueyoshi & Wang (2014) proposed a corporate sustainability measure to reduce undesirable outputs (e.g. CO₂) through DEA. The study was conducted using data from 50 companies (integrated and independent companies) from the oil sector of the United States. It was evidenced that integrated companies overcome the independent due to the large supply chain incorporated into the first group provided them a scale of merit in their operations as well as an opportunity to gain consumer opinions about their business operations. Thus, the large supply chain system, which covers upstream and downstream business functions, would increase corporate sustainability in the U.S. oil industry.

Tavana, Khalili-Damghani, Arteaga & Hosseini (2019) presented a multi-objective, customized DEA model to evaluate the dynamic performance of oil refineries in the presence of undesirable results, with an application in 9 refineries located in the United States.

Hu, Yan, Li, Yao & Feng (2020) developed a Network DEA model focusing on the production of produced water. The Stage 1 is related to oil development while Stage 2 is associated with wastewater treatment. Thus, considering that the model needs to solve undesirable results, a Data Envelopment Analysis (DEA) Slack-Based Static Measurement (SBM) network structure model with a feedback variable was established. Furthermore, a total of 13 oil fields were used and the results state there is a stronger relationship between the efficiency of oilfield wastewater treatment and the entire system.

Few studies have been developed regarding the application of DEA in the oil industry focusing on the environmental efficiency, most studies investigated the reality of the American oil industry through the use of classic Models of DEA (CCR and BCC), making clear the need for development for this theme to the use of more complex and robust models - hybrid, dynamic and in networks - already developed.

3. RESEARCH METHOD

This study is characterized as quantitative and exploratory, since it performed an evaluation of the efficiency for 67 oil fields (with oil production below 14000m³/year) located at the basins of Alagoas, Espírito Santo, Potiguar and Sergipe. For this, secondary data from National Petroleum Agency (ANP) were collected for the years 2014, 2015 and 2016.

This sample cut-out made it possible to obtain a more homogeneous set of DMU's, which allowing the use of the DEA tool, which presupposes homogeneity of the DMU's in order to ensure adequate results.

The study carried out by Dyson, Allen, Camanho, Podinovski & Sarrico (2001) discusses in depth the issues related to homogeneity in DEA and how to ensure it. Data Enveloping Analysis (DEA) was chosen because it is a method capable of measuring, with greater robustness, the efficiency of a set of DMU's related to environmental sustainability issues (Sueyoshi & Goto, 2017).

The modeling adopted in the investigation corresponds to the dynamic model of DEA, once that the research seeks to evaluate a three-year time frame. Thus, since it aims to understand the variations by period and total of productive efficiency, the modeling proposed by Kao (2013) described in Equation 1, was elected as the most appropriate for the reality explored in this work.

$$\begin{aligned}
\frac{1}{E_k^R} &= \min. \sum_{i=1}^m v_i \cdot X_{ik} + \sum_{f=1}^g w_f \cdot Z_{fk}^{(0)} \\
s. t. \quad &\sum_{r=1}^s u_r \cdot Y_{rk} + \sum_{f=1}^g w_f \cdot Z_{fk}^{(p)} = 1 \\
&\left(\sum_{i=1}^m v_i \cdot X_{ij} + \sum_{f=1}^g w_f \cdot Z_{fj}^{(0)} \right) \\
&\quad - \left(\sum_{r=1}^s u_r \cdot Y_{rj} + \sum_{f=1}^g w_f \cdot Z_{fj}^{(p)} \right) \geq 0, j \\
&\quad = 1, \dots, n \\
&\left(\sum_{i=1}^m v_i \cdot X_{ij}^{(t)} + \sum_{f=1}^g w_f \cdot Z_{fj}^{(t-1)} \right) \\
&\quad - \left(\sum_{r=1}^s u_r \cdot Y_{rj}^{(t)} + \sum_{f=1}^g w_f \cdot Z_{fj}^{(t)} \right) \geq 0 \\
&\quad j = 1, \dots, n; \quad t = 1, \dots, p \\
&u_r, v_i, w_f \geq \varepsilon, r = 1, \dots, s; \quad i = 1, \dots, m; f \\
&\quad = 1, \dots, g
\end{aligned} \tag{1}$$

Where v_i is the usefulness of input; u_r is the output utility; w_f is the usefulness of the intermediate product; X_{ik} is the amount of input i for DMU k ; Y_{rk} is the quantity of product r for DMU k ; $Z_{fk}^{(p)}$ is the amount of the intermediate product f for DMU k in period p ; $Z_{fj}^{(p)}$ is the amount of the intermediate product f for DMU j in period p ; Z_{fk}^0 is the quantity of the intermediate product f for DMU k that is the input in the initial period; Z_{fj}^0 is the quantity of the intermediate product f for DMU j that is entered in the initial period; X_{ij}^t is the amount of input i of DMU j in the period under analysis; Y_{rj}^t is the quantity of product r in the DMU j for the period; Z_{fj}^{t-1} is the quantity of the intermediate product f for DMU j in the period prior to that the one under analysis; and, Z_{fj}^t the quantity of the intermediate product f of DMU j in the period under analysis.

With the optimal solution (u_r^*, v_i^*, w_f^*) , one can calculate the efficiency of the whole system, E_k^s , and

period, $E_k^{(t)}$, with $t = 1, \dots, p$, for DMU k , using Equations 2 and 3, based on the second and third sets of constraints of the model previously exposed:

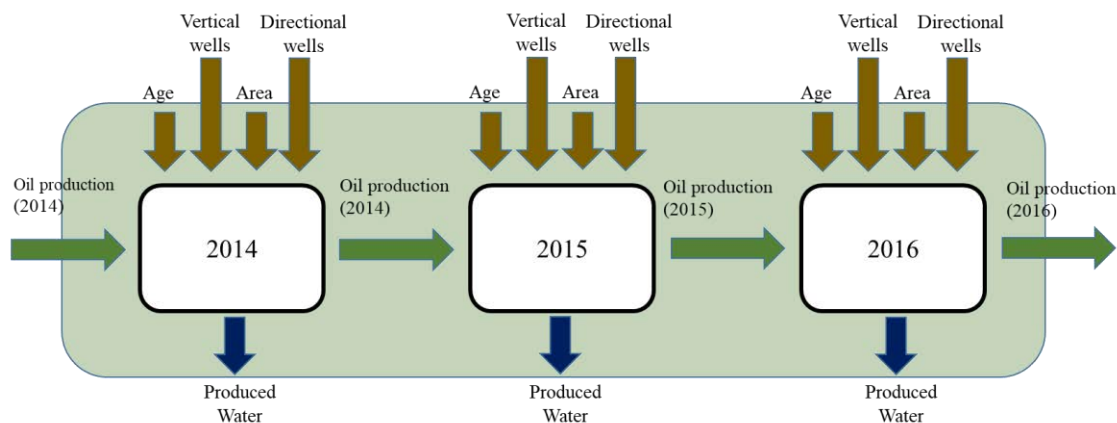
$$E_k^S = \frac{\sum_{r=1}^s u_r \cdot Y_{rk} + \sum_{f=1}^g w_f \cdot Z_{fk}^{(p)}}{\sum_{i=1}^m v_i \cdot X_{ik} + \sum_{f=1}^g w_f \cdot Z_{fk}^{(0)}} \quad (2)$$

$$E_k^t = \frac{\sum_{r=1}^s u_r \cdot Y_{rk}^{(t)} + \sum_{f=1}^g w_f \cdot Z_{fk}^{(t)}}{\sum_{i=1}^m v_i \cdot X_{ik}^{(t)} + \sum_{f=1}^g w_f \cdot Z_{fk}^{(t-1)}} \quad (3)$$

(2)

The variables chosen to elucidate the problem of linear programming are presented in Figure 1, which exposes the model adopted in the research and the respective inputs (vertical wells, directional wells, field age and Area), intermediate product (volume of oil produced) and outputs (produced water), whose variables were selected from the research developed by Asunção, Vieira & Almeida (2018a, 2018b).

Figure 1 – Production model adopted in the research



The model aims to evaluate the DMU's from an environmental perspective, so the produced water, output of the system, should be minimized in order to reduce the environmental impact of the wells. Since the variable produced water is undesirable, the Multiplicative Inverse (MLT) method developed by Dyson, Allen, Camanho, Podinovski, Sarrico & Shale (2001) was applied in order to transform the undesirable outputs into their inverse. Moreover, the orientation of the DDEA model aims to maximize the inverse function of the produced water.

4. RESULTS AND DISCUSSION

The period under analysis comprised the years between 2014 and 2016. In order to achieve a better fit for the proposed model, the Swallow field was excluded, since it had only two periods of production and high variability. For fields with annual production bellow or equal to 14,841 m³, the overall average efficiency ranged from 9.43% (Camamú) to 33.47% (Alagoas), as shown in Table 1. The average indices

are low, however in accordance with the results derived from the relational model used due to the dynamicity of production (Kao, 2013).

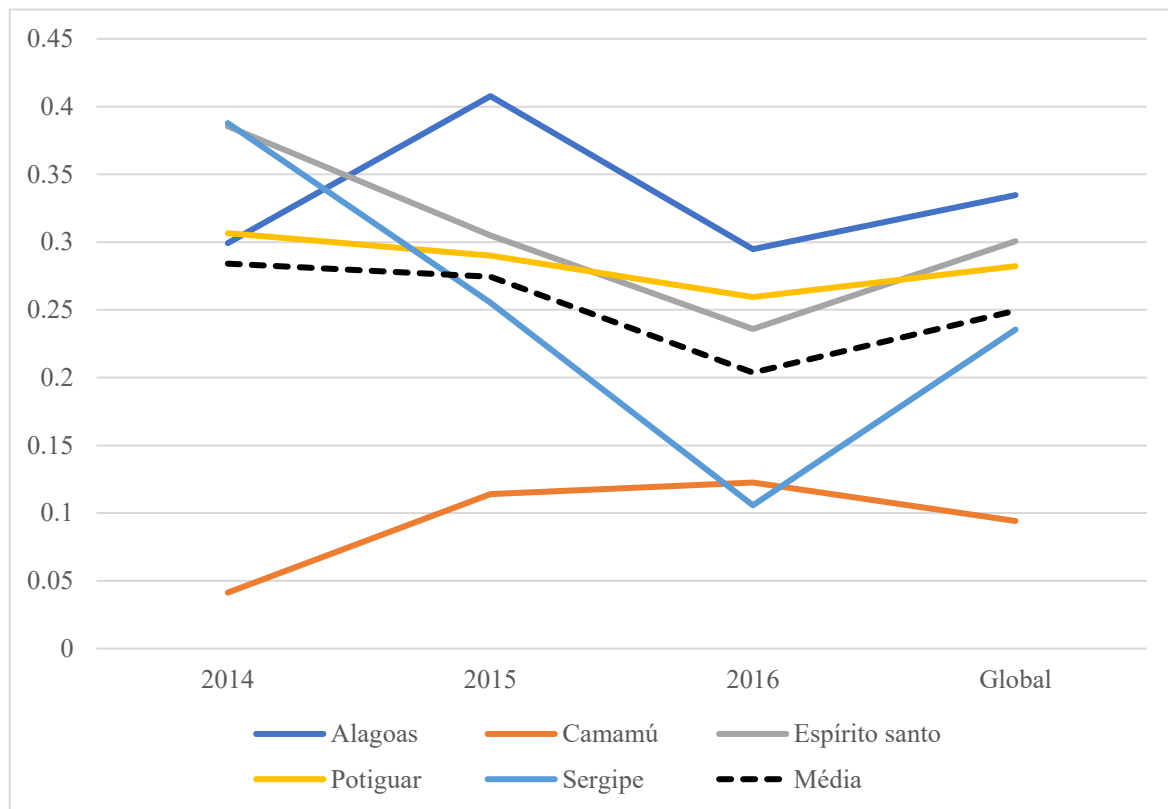
Table 1 - Descriptive by Coastal Basin Group 1

Descriptive	Basins				
	Potiguar	Alagoas	Camamú	Espírito Santo	Sergipe
Average	28,22%	33,47%	9,43%	30,06%	23,54%
Median	22,31%	21,42%	9,43%	25,76%	16,86%
Standard deviation	14,78%	20,95%	7,97%	16,41%	10,79%
Maximum	83,10%	60,76%	17,40%	79,93%	45,57%
Minimum	3,24%	6,25%	1,46%	4,19%	11,30%

Source: Data extracted from Matlab R2014A

It was also observed a high variability of the data confirmed by the discrepant difference between mean and median values for all studied basins, as well as the high standard deviations values, especially in the Alagoas basin (20.95%).

Figure 2 shows the average efficiency for the years analyzed associated to all Brazilian onshore coastal basins. When considering the three years analyzed, one can observe a significant decrease in efficiency for the fields located in the Espírito Santo, Sergipe and Potiguar basins. It should be highlighted that, even with the failure in performance, these basins were above the average of all the studied basins. On the other hand, the Alagoas basin achieved an increase of more than 30% of efficiency in 2015, but presented a sharp drop in the following year, 2016.

Figure 2 – Partial and global efficiencies for Group

Source: Resrach data, 2017.

Table 2 shows the overall and year-on-year efficiency values for the DMU's of Group 1. One can observe that, on average, the performance in 2014 (33.13%) was higher than the others, with a significant reduction of efficiency in the subsequent years, reaching an index of 23.45% in 2016. This result can be associated to an increase of more than 72% in the number of oil wells, between 2014 and 2016 for the studied fields, increasing the inputs without a proportional reduction in the outputs.

Table 2 – Global and year-on-year efficiencies of oilfields located in the brazilian coastal basin

	Basins	Global efficiency	Efficiency 2014	Efficiency 2015	Efficiency 2016	Injection
Sibite	Potiguar	83,10%	96,10%	58,09%	100,00%	A
	Espírito					A
Córrego Dourado	Santo	79,93%	73,22%	100,00%	69,38%	
	Espírito					A
Lagoa Bonita	Santo	72,60%	100,00%	40,06%	79,70%	
Irerê	Potiguar	66,86%	58,17%	100,00%	41,78%	A
Sabiá	Potiguar	62,56%	0,00%	100,00%	70,87%	A
Sul de Coruripe	Alagoas	60,76%	64,01%	57,40%	60,91%	A
Fazenda Pau Brasil	Alagoas	58,55%	24,06%	100,00%	47,83%	A
	Espírito					A
Lagoa Piabanha	Santo	58,17%	71,60%	56,56%	44,45%	

Trinca Ferro	Potiguar	54,87%	66,96%	44,14%	54,24%	A
Carcará	Potiguar	53,14%	40,15%	24,97%	100,00%	A
	Espírito					A
Seriema	Santo	51,19%	56,85%	50,99%	45,49%	
	Espírito					A
Biguá	Santo	48,98%	69,29%	47,23%	27,78%	
Carapitanga	Sergipe	45,57%	68,01%	30,18%	35,03%	A
Maçarico	Potiguar	39,86%	74,25%	27,07%	25,59%	A
Varginha	Potiguar	39,33%	53,19%	36,50%	26,26%	B
Aruari	Sergipe	39,26%	53,35%	37,26%	25,03%	A
Macau	Potiguar	37,43%	39,61%	38,11%	34,66%	A
	Espírito					A
Córrego Cedro Norte	Santo	37,19%	49,00%	31,32%	30,05%	
Morrinho	Potiguar	36,13%	42,00%	34,17%	31,91%	B
	Espírito					B
Fazenda Cedro	Santo	33,87%	52,37%	45,48%	1,77%	
Rio Mossoró	Potiguar	33,62%	26,92%	29,85%	43,78%	B
Araçari	Potiguar	33,32%	50,92%	30,31%	18,45%	A
Poço Xavier	Potiguar	31,67%	41,59%	41,51%	18,05%	B
Asa Branca	Potiguar	31,53%	38,79%	24,51%	31,67%	B
	Espírito					A
Fazenda Cedro Norte	Santo	30,88%	42,93%	27,25%	21,00%	
	Espírito					A
Córrego das Pedras	Santo	26,93%	28,98%	26,97%	24,83%	
	Espírito					A
Campo Grande	Santo	26,76%	38,51%	26,11%	14,18%	
Fazenda Canaan	Potiguar	26,13%	34,87%	11,95%	33,18%	B
Periquito	Potiguar	25,92%	43,69%	19,72%	13,53%	A
	Espírito					A
São Mateus Leste	Santo	25,76%	36,65%	24,97%	16,23%	
Barrinha Sudoeste	Potiguar	23,59%	40,73%	19,64%	7,55%	A
	Espírito					A
Guriri	Santo	21,48%	31,83%	22,35%	9,08%	
Jequiá	Alagoas	21,42%	21,64%	22,63%	20,00%	A
Iraúna	Potiguar	21,02%	25,75%	22,38%	16,23%	A
Colibri	Potiguar	20,93%	21,70%	21,13%	20,15%	A
Acauã	Potiguar	20,37%	19,19%	18,57%	23,00%	A
São Miguel dos						A
Campos	Alagoas	20,36%	29,02%	18,17%	14,87%	
Angico	Potiguar	20,25%	23,66%	25,21%	12,30%	A

Ilha Pequena	Sergipe	19,78%	32,55%	26,72%	0,00%	A
Pedra Sentada	Potiguar	19,73%	21,47%	22,61%	15,15%	A
	Espírito					A
Rio Ipiranga	Santo	18,93%	24,86%	0,00%	36,18%	
Barrinha	Potiguar	18,62%	19,05%	20,92%	15,96%	A
	Espírito					A
Mariricu	Santo	18,54%	26,60%	14,30%	14,45%	
	Espírito					A
Tabuiaiaá	Santo	17,82%	14,91%	27,94%	12,62%	
Jiribatuba	Camamú	17,40%	7,28%	21,83%	22,11%	A
Juazeiro	Potiguar	17,08%	16,89%	21,49%	13,04%	A
Serra do Mel	Potiguar	16,86%	20,39%	38,54%	12,10%	A
Angelim	Sergipe	16,86%	23,48%	18,45%	8,30%	A
Atalaia Sul	Sergipe	16,69%	42,21%	44,11%	0,00%	A
Riacho Velho	Potiguar	16,51%	0,00%	35,98%	13,92%	A
	Espírito					A
Mariricu Norte	Santo	15,91%	29,99%	28,99%	7,87%	
Tigre	Sergipe	15,32%	27,53%	14,87%	2,29%	A
João de Barro	Potiguar	13,99%	17,44%	14,85%	10,10%	A
Fazenda Junco	Potiguar	13,02%	9,20%	16,92%	12,95%	A
	Espírito					A
Nativo Oeste	Santo	11,59%	35,64%	28,17%	0,00%	
Foz do Vaza-barris	Sergipe	11,30%	24,34%	7,13%	3,36%	A
	Espírito					A
Crejoá	Santo	11,08%	11,49%	11,57%	10,32%	
	Espírito					A
Gaivota	Santo	10,98%	0,00%	17,43%	14,84%	
Rio São Mateus	Espírito					A
Oeste	Santo	8,49%	9,11%	7,51%	13,36%	
Guamaré Sudeste	Potiguar	7,99%	16,70%	6,85%	3,87%	A
Icapuí	Potiguar	6,52%	8,12%	7,54%	4,16%	A
Coqueiro Seco	Alagoas	6,25%	10,94%	5,68%	3,79%	A
	Espírito					A
Rio São Mateus	Santo	4,19%	5,66%	5,13%	1,78%	
Barrinha leste	Potiguar	4,09%	3,22%	6,77%	2,48%	A
Rolinha	Potiguar	3,83%	5,35%	5,54%	1,14%	A
Serra Vermelha	Potiguar	3,24%	4,97%	2,64%	2,17%	A
Morro do Barro	Camamú	1,46%	0,98%	0,97%	2,40%	A
Average		27,30%	33,13%	29,46%	23,45%	

Note: The letter A in the Injection column represents that the field does not use water reinjection as a secondary method of recovery, while the letter B denotes the use of reinjection.

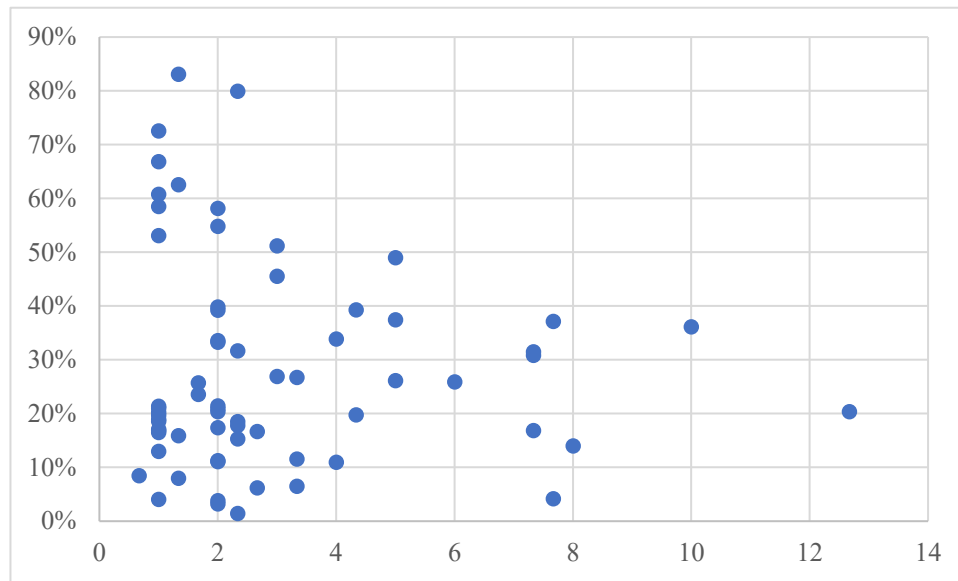
Source: Data extracted from Matlab R2014A.

It is important to report that, except the fields Pau Brasil (Alagoas), Maçarico (Potiguar), Sibite (Potiguar), Araçari (Potiguar) and Lagoa Bonita (Espírito Santo) the others have similar efficiency indices in all observed periods. This result provides indications of the need for improvement in processes, aiming to ensure higher levels of efficiency and strategies that do not print a methodological continuity, making it impossible to promote a better management of the produced water from these fields.

It is important to highlight that the two most efficient fields of Group 1, Sibite (Potiguar - 83.10%) and Córrego Dourado (Espírito Santo - 79.93%), are among the three largest producers of this group, although no field has reached the global efficiency frontier. If the annual results were observed, it can be observed that in 2014 only the Lagoa Bonita field reached 100% efficiency. While in 2015, the fields Córrego Dourado (Espírito Santo), Irerê and Sabiá (Potiguar) and Fazenda Pau Brasil (Alagoas) reached the frontier of efficiency. In 2016, only the Carcará and Sibite (Potiguar) fields achieved this result. In addition, the Carcará (Potiguar) field reached the efficiency frontier in 2016, after a 1300% reduction in the volume of produced water, while the Sibite (Potiguar) field achieved a significant decrease in efficiency in 2015 (58.09%), which can be explained by a 32% reduction in oil production and a 28% increase in water production.

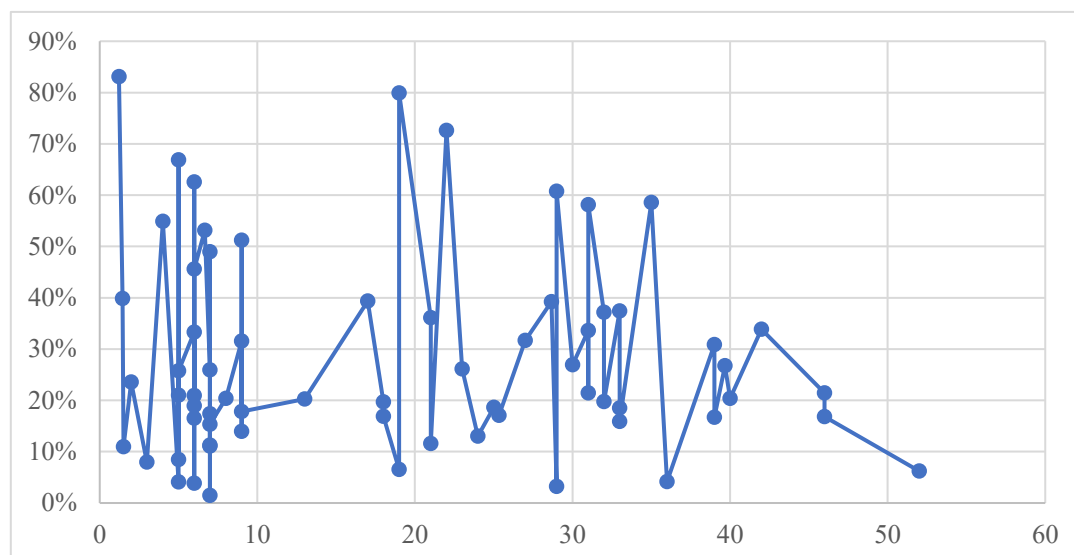
Another reality that deserves attention concerns the fields of Lagoa Bonita (Espírito Santo) and Fazenda Pau Brasil (Alagoas). The first obtained a significant decrease in its efficiency index, from 100% to 40.06%, given an increase of 34 times the amount of produced water. The second increased its rate from 24.06% (2014) to 100% in 2015, driven by a 584% increase in oil production. In the following year, Fazenda Pau Brasil (Alagoas) reduced its rate due to the increase in water production and shrinking of oil production.

Figure 3 systematizes the comparison between efficiency per period and the number of wells per field. The values obtained allow to state that fields with the same number of wells have significantly different efficiencies, indicating that the environmental management adopted by each field can positively or negatively influence their performance. It should be noted that the fields that presented the highest efficiencies have one or two wells. These DMU's presented low inputs, justifying the high rates of efficiency obtained.

Figure 3 - Comparison between efficiency and number of wells per field Group 1

Source: Research data, 2020.

Figure 4 illustrates the comparison between the age of the field and the measured efficiency. Higher values were observed for the fields at the beginning of production, followed by falls over the second decade of exploration. However, there is a recovery after the twenty years of operation always followed by a downward trend in efficiency. This decline may be related to the effects of increased water production already reported by Khatib & Verbeek (2003); Clark & Veil (2009). These results can be explained by how the output (produced water) is managed over the lifetime of the fields.

Figure 4 - Comparison between efficiency and age of the field Group 1

Source: Research data, 2020.

The authors highlight the good efficiency indexes attributed to the Fields Sibite, Irerê and Sabiá (Potiguar) with production age between 1 and 6 years, to the fields Córrego Dourado and Lagoa Bonita (Espírito Santo) with production time between 19 and 22 years and to the fields Sul de Coruripe and

Fazenda Pau Brasil (Alagoas) with production age between 29 and 35 years. These data suggest that although there is a global trend of falling efficiencies, as the production years go by, there are cases in which the managements of the produced water stand out.

Thus, field managers have better know-how regarding the management of this unwanted output with more exploration time, which explains the observed recovery of some of the fields reported in this study.

5. CONCLUSIONS

The proposed model of environmental sustainability for the onshore oil fields of the Brazilian coastal basins highlighted the importance of multidisciplinary regarding the use of various sciences in order to construct methodologies capable of pointing out/solving latent problems of society.

The relevance of the variables Vertical Wells and Directional Wells for the construction of the dynamic efficiency index was also explained, since their weights had a significantly higher relevance than those adopted for the variables Area and Age.

It was also found that there is a discrepancy in the environmental management practiced by the fields studied, taking into account that the DMU's with similar technological resources presented different productions of produced water and oil, causing inefficiency and unsustainable plants. Inefficiency is the result of unnecessary costs and environmental impacts arising from lack of control and planning of the processes that permeate the oil and gas industry, especially those associated with the reuse and/or disposal of water produced from oil.

Therefore, it can be stated that the management of technological resources, associated with responsible planning, contributes to the volume of produced water for the oil fields of the Brazilian coastal basins. The geometry of the chosen well and the time of exploration are fundamental factors for greater control of the water produced. There is still a large dispersion in the results of similar DMU's, which attests, in general, a mismanagement of resources, especially environmental, resulting in the low rates of overall efficiency measured in this research.

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Hydrogen Peroxide Production in an Electrochemical Flow-by Reactor using Gas Diffusion Electrodes Modified with Organic Redox Catalysts

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Abstract

This paper presents a proposal to use an electrochemical flow-by reactor for hydrogen peroxide electrogeneration using cathodes formed from the incorporation of organic redox catalysts (2-ethylantraquinone, 2-tert-butylantraquinone, alizarin, and azobenzene) in the structure of gas diffusion electrodes. These electrodes help circumvent the low solubility of oxygen in aqueous solutions. Organic redox catalysts, which typically contain quinone or azo groups in their structure, were added to the electrode mass in a 10% proportion. The electrodes were used to study the electrogeneration of hydrogen peroxide in situ, in an acid medium (0.1 mol L⁻¹ H₂SO₄ and 0.1 mol L⁻¹ K₂SO₄, pH 1), inside an electrochemical flow-by reactor. Comparative analysis among the different catalysts indicated that the best electrode for hydrogen peroxide electrogeneration was the gas diffusion electrode modified with 10% of 2-ethylantraquinone. With an underflow rate of 200 L h⁻¹, hydrogen peroxide was formed with a maximum yield of 998.12 mg L⁻¹ after 2 h at -2.0 V vs Pt//Ag/AgCl, for which the energy consumption was 11.21 kWh kg⁻¹. The use of the electrochemical flow-by reactor was much more efficient, in that it yielded higher concentrations of hydrogen peroxide with extremely low energy consumption, compared to that obtained when using an electrochemical cell. In addition, for ensuring appropriate usage of the electrodes, optimizing their potential for the maximum generation of hydrogen peroxide, and obtaining the highest efficiency for the reduction of oxygen, a fuzzy algorithm was developed to help support the user's decision.

Keywords: electrochemical flow-by reactor; hydrogen peroxide; gas diffusion electrodes; organic redox catalysts; fuzzy logic decision support

1. Introduction

Concern about the environment, especially regarding the increasing contamination and pollution levels, has fueled studies on the prevention and control of pollutants. In recent years, many processes have been tested to increase the efficiency of treatment of resistant effluents. Among them, advanced oxidative processes, which are based on the generation of the hydroxyl radical ($\cdot\text{OH}$), have high oxidizing powers, and can promote the degradation of several pollutants in a short time [1-3]. In this context, the use of hydrogen peroxide (H_2O_2) is an advantage, as it is one of the most versatile oxidants known. It is superior to chlorine, chlorine dioxide, and potassium permanganate. H_2O_2 can be converted to a hydroxyl radical by catalysis, with a reactivity lower than that of only fluorine [4].

Among the procedures studied for the production of H_2O_2 , one involves the use of gas diffusion electrodes (GDEs), which, because of their structure, favor contact between the reagents, facilitate rapid removal of the reaction products, and easily transport the current to the electrode [5]. The use of a GDE, in addition to cathodically generating a highly oxidant species *in situ*, such as H_2O_2 , allows one to modify the cathodic reaction in industrial anode processes (such as chlorine generation or effluent treatment). This typically manifests in the evolution of hydrogen during the oxygen reduction reaction. This preferential cathodic reaction exchange, possible only with the use of a GDE as a cathode, displaces the cathode equilibrium potential toward the direction of a more positive potential, implying a decrease of the same order in the potential difference between the cathode and the anode [6].

The production of H_2O_2 in a GDE is based on the reduction of oxygen in an aqueous medium. This type of electrode is not subject to limitations imposed by the concentration of the gas in the medium, or by the diffusion of the O_2 molecules from the interior of the solution to the surface of the electrode, as in conventional electrodes.

There has been immense interest to modify GDEs with organic redox catalysts in order to increase the generation of H_2O_2 . Modification of the carbon surface by quinones can be performed to establish the relationship between the structure and catalytic activity for the reduction of O_2 and in particular, for the production of H_2O_2 [7].

Many of these studies used electrodes modified with a quinone or azo group, and the results showed an increase in the speed of the O_2 reduction reaction and a better yield of H_2O_2 . 2-ethylanthraquinone, when used as a catalyst for the GDE, increased the H_2O_2 formation rate in an electrochemical cell and reduced the overpotential for oxygen reduction by 400 mV when compared to the performance of a non-modified electrode [6]. Azobenzene, when used as a catalyst, also improved the efficiency of H_2O_2 production in an electrochemical cell but reduced the overpotential for oxygen reduction by 300 mV less negative compared to that using a non-modified electrode [8]. Experiments using GDEs modified with 2-ethylanthraquinone, 2-tert-butylanthraquinone, or azobenzene carried out in an electrochemical cell have proven promising for the use of GDEs toward *in situ* H_2O_2 electrogeneration [9]. In addition to a considerable amount of H_2O_2 electrogenerated in an acidic medium, these electrodes required less energy, as the H_2O_2 electrogeneration reaction overpotential shifts to less negative values compared to non-modified GDEs [9].

In this study, an electrochemical flow-by reactor was used to monitor the electrochemical efficiency of oxygen reduction and consequently, to increase the yield in the production of H_2O_2 *in situ*. For this

purpose, GDEs modified with 10% organic redox catalysts (2-ethylanthraquinone, 2-tert-butylanthraquinone alizarin, and azobenzene) were used as the cathode. Further, to enable the appropriate use of the electrodes for the maximum generation of H_2O_2 and to obtain the best efficiency in the reduction of oxygen, a fuzzy algorithm was developed. This algorithm was applied to support the decision for the selection of the electrode and potentials, taking into account the feasibility of operation using the experimental results herein.

The proposed fuzzy decision support system follows the methods presented by Erozan [10] to manage the maintenance activities of critical components in manufacturing systems, and those by Gallab et al. [11] to quantify the risks associated with maintenance activities, by coupling the risk analysis method with fuzzy logic. This branch of artificial intelligence allows the transfer of knowledge generated in the experiments, to a decision system that clearly defines the correct selection parameters necessary to obtain greater efficiency in the results, toward their application in the treatment of resistant effluents.

2. Materials and Methods

2.1 Chemicals

An electrochemical flow-by reactor was constructed using a set of two polypropylene plates containing the cathode and anode (both with a geometric area of 20 cm^2), according to the scheme shown in Figure 1. These plates were separated by a 2 mm-thick inert rubber spacer. The recirculation system used 1.0 L of the supporting aqueous electrolyte (pH 1) containing H_2SO_4 (0.1 mol dm^{-3}) and K_2SO_4 (0.1 mol dm^{-3}), which was pumped into the reactor by a peristaltic pump. A recirculation system ensured that the electrolyte was pumped at a controlled and constant flow through the reactor (200 L h^{-1}). The reservoir contained a refrigeration system that maintained the carrier electrolyte at a temperature of $20\text{ }^\circ\text{C}$. The reactor was then coupled to an Autolab PGSTAT-30 potentiostat/galvanostat with a high-current module (BSTR-10), in which linear voltammetry and electrolysis at constant potential were performed.

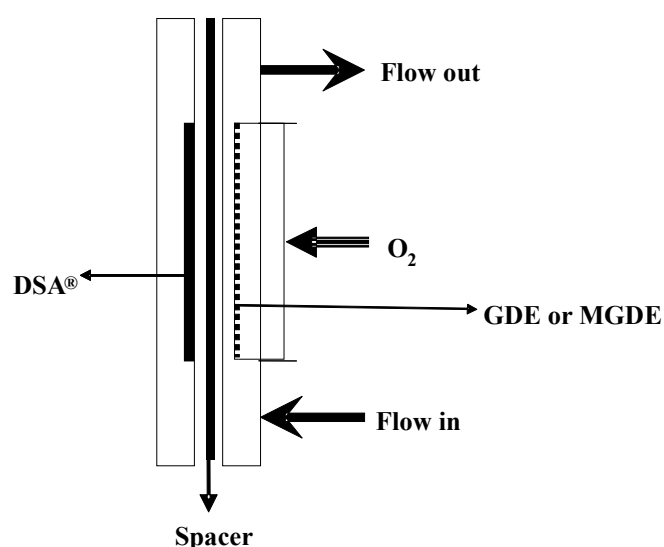


Figure 1. Schematic representation of electrochemical flow-by reactor with gas diffusion electrode and dimensionally stable anode

Printex 6L was used to construct the GDEs according to methods described previously [6-9]. The GDE was modified with 10% (w/w) of organic redox catalysts (2-ethylanthraquinone (EAQ), 2-tert-butylanthraquinone (BAQ), alizarin (ALZ), and azobenzene (AZO)) to yield modified gaseous diffusion electrodes (MGDEs) [6-9]. These electrodes (GDE or MGDE) were used as cathodes. The anode used was dimensionally stable (DSA[®]-Cl₂ from De Nora do Brazil Ltda). A pseudo-reference Pt//Ag/AgCl system positioned on the face of the cathode was also used [12].

The electrodes were subjected to initial conditioning. This involved the application of a potential of -2.0 V vs Pt//Ag/AgCl for 30 min in the presence of N₂ at a pressure of 0.2 bar. This was followed by linear voltammetry (30 scans) performed in the range of -0.5 to -4.0 V vs Pt//Ag/AgCl, at a scan rate of 20 mVs⁻¹, in the presence of N₂ and again in the presence of O₂. The voltammetric response allowed better visualization of the processes of O₂ reduction and H₂O₂ decomposition, in less negative potentials, thus providing the range of potentials for the realization of electrolysis.

The *in situ* electrochemical production of H₂O₂ was achieved by the reduction of O₂, through electrolysis in the GDE or MGDE for 2 h in the electrochemical flow-by reactor, under a constant flow of O₂ (P = 0.2 bar) at the backside of the electrode. The interval for conducting the electrolysis was defined as -1.5 V ≤ -3.0 V vs Pt//Ag/AgCl, based on the voltammetry performed.

Samples were collected at 10 min intervals and the H₂O₂ production was quantified spectrophotometrically using a UV-Vis spectrophotometer (UV Mini-1240 UV-VIS Spectrophotometer SHIMADZU). For this procedure, it was necessary to react to the samples collected with (NH₄)₆Mo₇O₂₄·4H₂O 2.4 mmol dm⁻³ in H₂SO₄ 0.5 mol dm⁻³ [13].

2.2 Fuzzy Logic Algorithm

As stated by Gallab et al. [11], fuzzy logic is based on the theory of fuzzy sets developed by Zadeh [14], and is a generalization of the classical set theory. This technique provides flexibility for reasoning and considers inaccuracy, subjectivity, uncertainty, imprecision. It also provides wide opportunities for working with imprecise linguistic data by defining rules and membership functions in sets called “fuzzy sets” [15].

Gallab et al. [11] also state that the fuzzy sets theory is applicable when assessing indicators for which there is no conventional model for estimating and measuring, or if the model is too complex.

This theory, presented by Zadeh [16, 17], is the most suitable formalism to qualitatively describe linguistic variables. According to Lamrani and Tkiouat [18], fuzzy inference is a formulation process for converting a given input data combination scenario into a single output data using fuzzy logic and involves the association function, fuzzy logic operators and if-then rules.

According to the guidelines outlined by Deroncourt [15], the choices made by the designer of a fuzzy system, such as defining the membership functions and the decision matrix, are based mainly on the advice of the expert or statistical data.

In this work, a fuzzy logic system was established as per the following steps:

- i) Fuzzyfication, which uses the inputs as parameters. The inputs were obtained from the types of electrodes and from the possible values of potentials available in the potentiostat/galvanostat, converted to pertinence functions;

- ii) Fuzzy inference system, which considers one base of rules established by experts and an inference engine to assess the degree of relevance of each of the variables in each proposed scenario, and then infers the triggering of the rules governing the system;
- iii) Defuzzification (used to provide a fuzzy output numerical value obtained from the fuzzy output membership values and the fuzzy numerical value represents the center of gravity of the fuzzy output possibility distribution that shows the expected efficiency electrogeneration of H_2O_2).

Gallab et al. [11] list the steps to build the algorithm framework:

- Select the key indicators that affect the dependent variables;
- Create fuzzy sets for both independent and dependent variables, and then use the membership functions to specify the degree of truth up to which each variable belongs in a certain fuzzy set;
- Establish the inference rules in the system;
- Generate the output fuzzy set of the dependent variables based on the independent variables and the inference rules. A numerical value of the output fuzzy set is then calculated by the defuzzification operation;
- Use the model results to make a decision.

The fuzzy logic algorithm was built as per the steps above. The Mathworks software tool “MatLab”, with 'Electrode Type' and 'Potential' data, and controllers based on fuzzy concepts, were used to decide H_2O_2 productivity. As a starting point, the data categorized as 'Electrodes' and 'Potentials' were translated into fuzzy variables.

When working with data in classical systems, one must consider the truth function, which assigns to each variable the truth value 1 (true) or 0 (false). Let v be a function defined from the set of variables (V) for the set binary $\{0; 1\}$, that is:

$$v: V \rightarrow \{0; 1\}$$

$$v(p) = 0 \text{ or } v(p) = 1, \text{ for variable } p$$

In non-classical situations, the fuzzy valuation function carries the variables for the closed interval $[0, 1]$. This implies that a variable 'p' can have $\mu_f(p) = 0.8$, thus assigning it a degree of membership of 0.8 of its occurrences. As 0.8 is closer to 1 than to 0, semantically, this denotes that the event or data bound to the variable 'p' has a high chance of occurring. Formally, the fuzzy valuation (μ_f) is given by $\mu_f: V \rightarrow [0, 1]$

$$\mu_f(p) = a, a \in [0, 1]$$

In terms of the variables for the potentials and electrodes, the function was modeled according to Figures 2.a and 2.b.

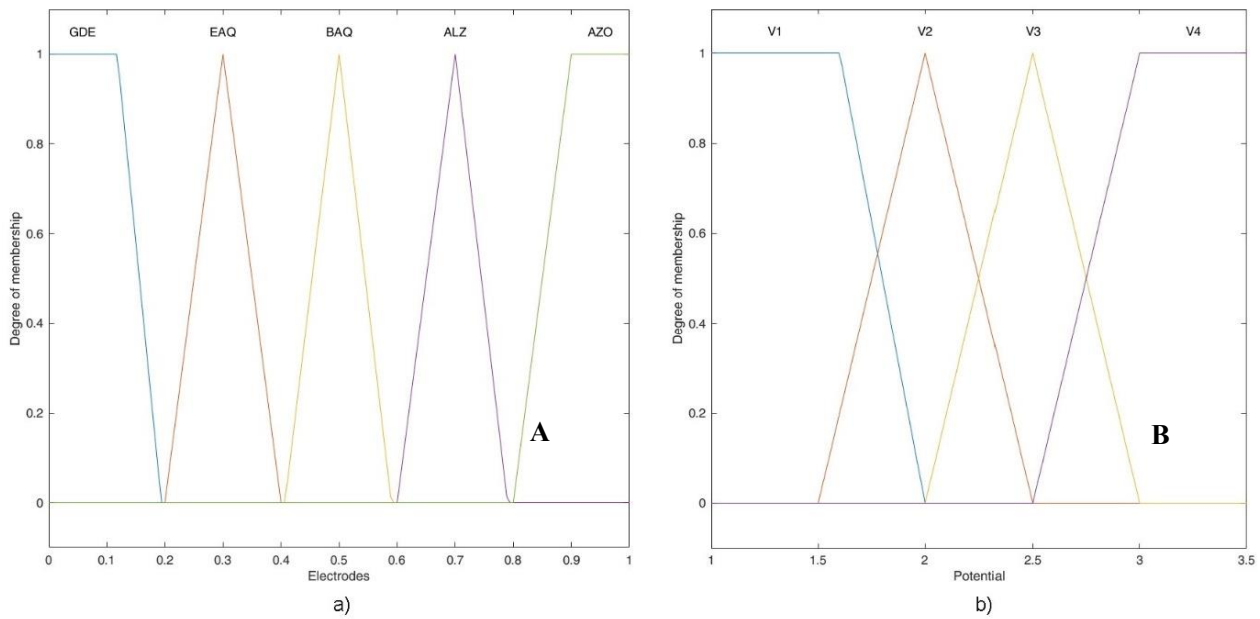


Figure 2. Fuzzyfication of the variable (A) electrode and (B) potential.

In Figure 2.a, the abscissa axis represents the types of electrodes and the ordinates represent the degrees of pertinence of the respective electrodes. The data used are as follows:

- i) GDE: 0.1 (Params: [-0.225 -0.025 0.118 0.194])
- ii) EAQ: 0.3 (Params: [0.2 0.3 0.4])
- iii) BAQ: 0.5 (Params: [0.4067 0.5 0.59])
- iv) ALZ: 0.7 (Params: [0.6 0.7 0.79])
- v) AZO: 0.9 (Params: [0.8 0.9 1 100])

Similarly, in Figure 2.b the x-axis denotes the values of the potentials (1.5, 2.0, 2.5, and 3.0) and the y-axis their respective degrees of pertinence.

- i) V1 = 1.5 (Params: [1 1 1.6 2])
- ii) V2 = 2.0 (Params: [1.5 2 2.5])
- iii) V3 = 2.0 (Params: [2 2.5 3])
- iv) V4 = 2.0 (Params: [2.5 3 3.657 4.157])

From these input data, the fuzzy controller will determine the desired output values in the system, namely, the GDE productivity, EAQ productivity, BAQ productivity, ALZ productivity, and AZO productivity. The scheme is illustrated in Figure 3.

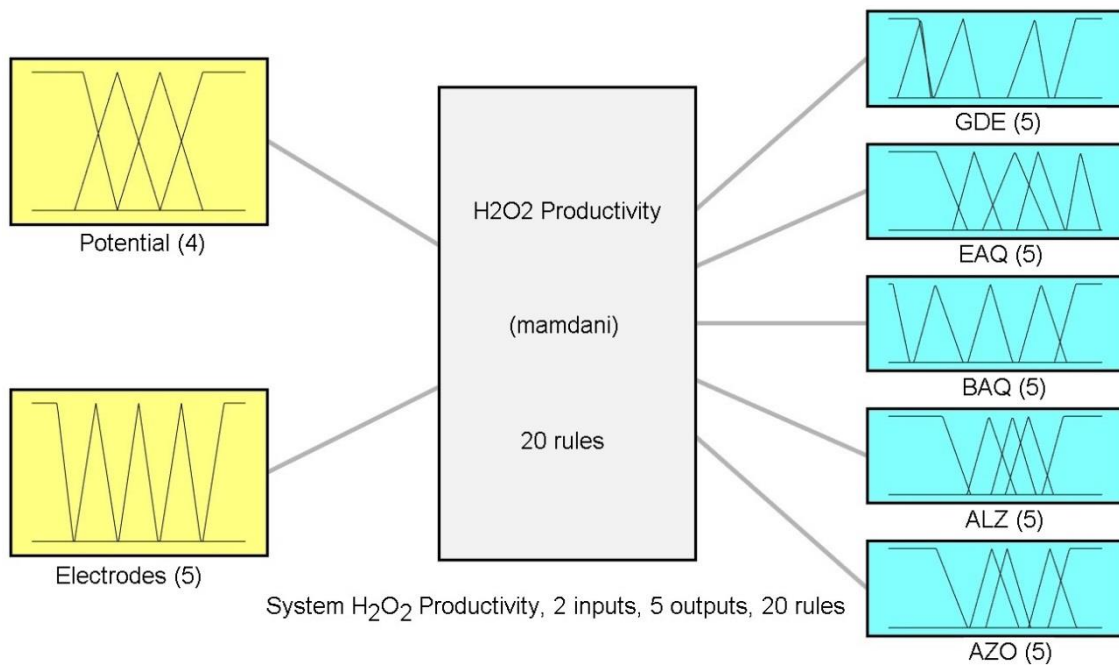


Figure 3. Generalized Fuzzy system for H_2O_2 production.

The fuzzy controller performs the decision making process through a set of rules formalized from the experience of a subject specialist. The method of inference adopted was the one proposed by Mamdani and Assilian [19], the most commonly used fuzzy inference technique.

For our purposes, the explicit tables with the data acquired from the experiments guided the basis of rule construction. They are as follows:

- R₁: If (Potential is V1) and (Electrode is GDE) then (PROD_GDE is BAD)
- R₂: If (Potential is V2) and (Electrode is GDE) then (PROD_GDE is GOOD)
- R₃: If (Potential is V3) and (Electrode is GDE) then (PROD_GDE is AVERAGE)
- R₄: If (Potential is V4) and (Electrode is GDE) then (PROD_GDE is REGULAR)
- R₅: If (Potential is V1) and (Electrode is EAQ) then (PROD_EAQ is MEDIA)
- R₆: If (Potential is V2) and (Electrode is EAQ) then (PROD_EAQ is EXCELLENT)
- R₇: If (Potential is V3) and (Electrode is EAQ) then (PROD_EAQ is GOOD)
- R₈: If (Potential is V4) and (Electrode is EAQ) then (PROD_EAQ is GOOD)
- R₉: If (Potential is V1) and (Electrode is BAQ) then (PROD_BAQ is BAD)
- R₁₀: If (Potential is V2) and (Electrode is BAQ) then (PROD_BAQ is MEDIA)
- R₁₁: If (Potential is V3) and (Electrode is BAQ) then (PROD_BAQ is GOOD)
- R₁₂: If (Potential is V4) and (Electrode is BAQ) then (PROD_BAQ is REGULAR)
- R₁₃: If (Potential is V1) and (Electrode is ALZ) then (PROD_ALZ is REGULAR)
- R₁₄: If (Potential is V2) and (Electrode is ALZ) then (PROD_ALZ is EXCELLENT)
- R₁₅: If (Potential is V3) and (Electrode is ALZ) then (PROD_ALZ is GOOD)
- R₁₆: If (Potential is V4) and (Electrode is ALZ) then (PROD_ALZ is MEDIA)
- R₁₇: If (Potential is V1) and (Electrode is AZO) then (PROD_AZO is REGULAR)
- R₁₈: If (Potential is V2) and (Electrode is AZO) then (PROD_AZO is GOOD)

R₁₉: If (Potential is V3) and (Electrode is AZO) then (PROD_AZO is EXCELLENT)

R₂₀: If (Potential is V4) and (Electrode is AZO) then (PROD_AZO is MEDIA)

The metric used to classify attributes BAD, REGULAR, AVERAGE, GOOD and EXCELLENT is given by:

- i) BAD: Productivity (mg L^{-1}) ≤ 370
- ii) REGULAR: $371 \leq \text{Productivity (mg L}^{-1}) \leq 525$
- iii) AVERAGE: $500 \leq \text{Productivity (mg L}^{-1}) \leq 655$
- iv) GOOD: $657 \leq \text{Productivity (mg L}^{-1}) \leq 825$
- v) EXCELLENT: $830 \leq \text{Productivity (mg L}^{-1}) \leq 1000$

3. Results and Discussion

Figure 4 compares the voltammetric behavior of the GDE and MGDE with O₂ (0.2 bar), flowing through the backside of the electrode. Although poorly defined, it is possible to observe thresholds that are related to the reduction reactions of O₂ forming H₂O₂ ($\text{O}_2 + 2 \text{H}^+ + 2 \text{e}^- \rightarrow \text{H}_2\text{O}_2$), probably occurring in the range of -1.25 to -2.5 V vs Pt//Ag/AgCl, and the decomposition reaction of this product ($\text{H}_2\text{O}_2 + 2 \text{H}^+ + 2 \text{e}^- \rightarrow 2 \text{H}_2\text{O}$) after -2.5 V vs Pt//Ag/AgCl.

Note that the current values range from nearly zero to approximately -1.25 V vs Pt//Ag/AgCl. From this potential, an increase in current related to the beginning of the reduction reaction of O₂ occurs. This increase is more accentuated for the GDE modified with ALZ and BAQ. This increase in current implies the beginning of the O₂ reduction reaction in less negative overpotentials, and indicates that the MGDE will present a greater efficiency in generating H₂O₂ when compared to the GDE.

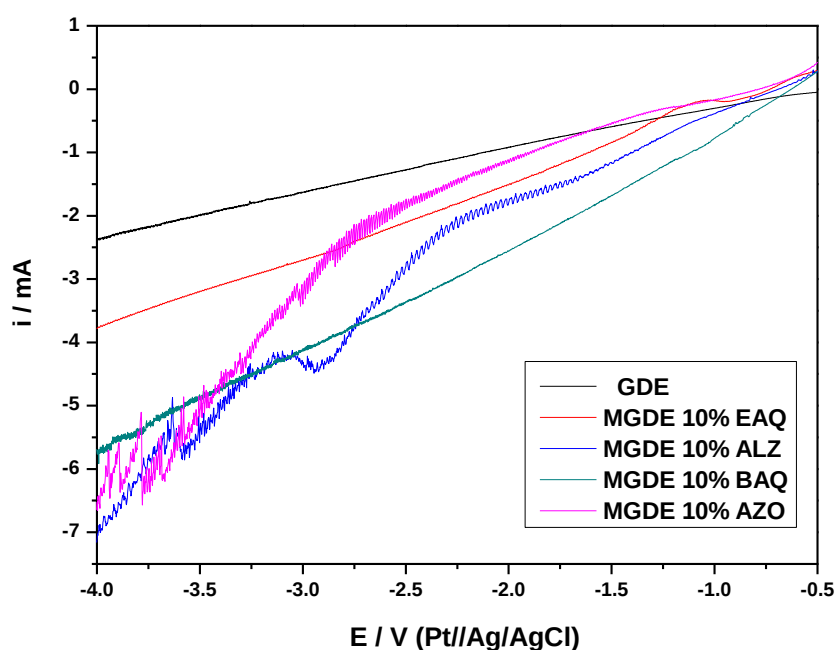
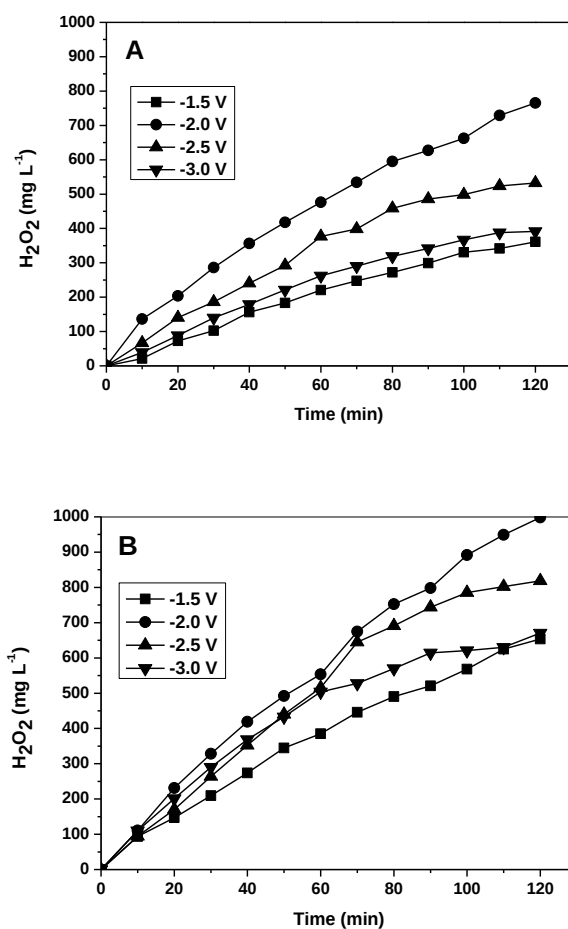


Figure 4. Linear voltammograms obtained using an electrochemical flow-by reactor with a gas diffusion electrode (GDE) and modified gas diffusion electrodes (MGDE) pressurized with oxygen (0.2 bar). Acidic medium (1.0 L of 0.1 mol L⁻¹ K₂SO₄ in 0.1 mol L H₂SO₄, pH 1) supplied at flow rate of 200 L h⁻¹. $v = 20 \text{ mV s}^{-1}$ and $T = 20^\circ \text{C}$.

As described, electrolysis was carried out at a constant potential for 2 h, and the samples were collected at 10-min intervals to analyze the H₂O₂ production by UV-Vis spectrophotometry. Figure 5 shows the H₂O₂ production versus time using the GDE and MGDE. In all cases, the H₂O₂ concentration increased linearly as a function of time.



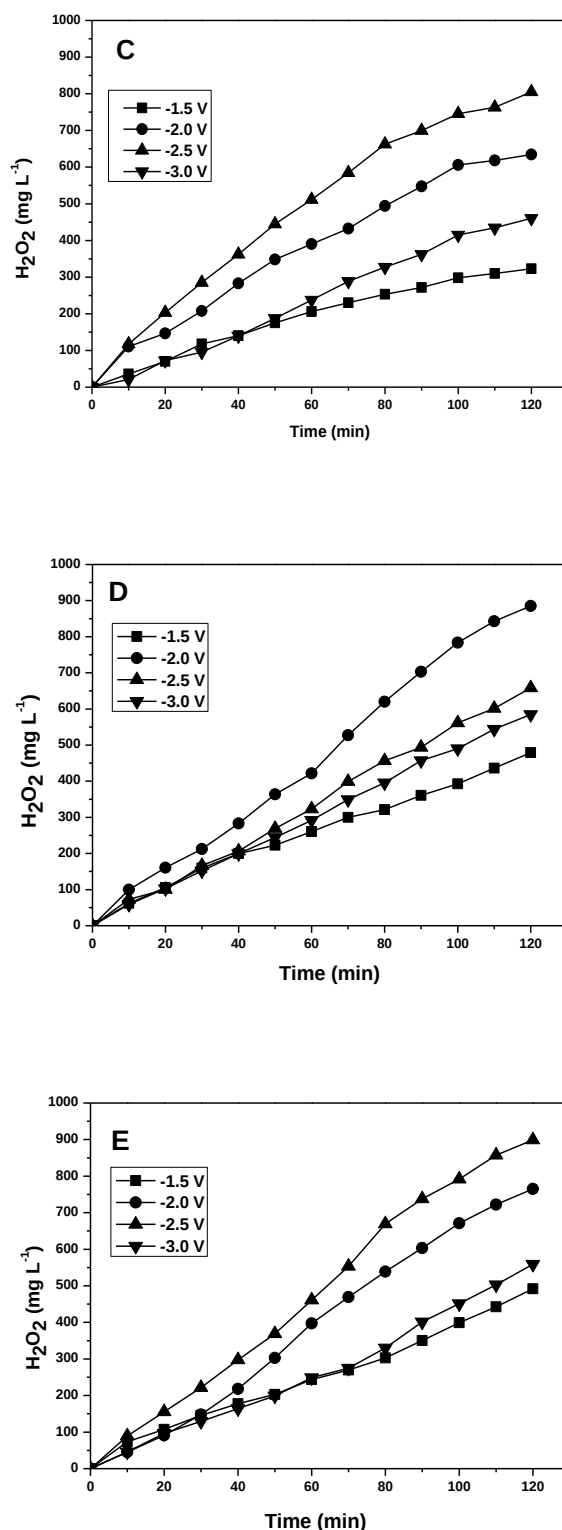


Figure 5. Concentration of hydrogen peroxide formed as a function of time using an electrochemical flow-by reactor with a gas diffusion electrode (GDE) and modified gas diffusion electrodes (MGDE) pressurized with oxygen (0.2 bar). Acidic medium (1.0 L of 0.1 mol L⁻¹ K₂SO₄ in 0.1 mol L H₂SO₄, pH 1) supplied at flow rate of 200 L h⁻¹ and T = 20 °C. (A) GDE; (B) MGDE with 10% EAQ; (C) MGDE with 10% ALZ; (D) MGDE with 10% BAQ and (E) MGDE with 10% AZO.

An initial increase in the H_2O_2 concentration up to -2.0 V vs Pt//Ag/AgCl for the GDE (Figure 5A) and for the MGDE with EAQ and BAQ was observed (Figure 5B and 5D). For the MGDE with ALZ and AZO, this increase extended to -2.5 V vs Pt//Ag/AgCl (Figure 5C and 5E). Beyond these potentials, the efficiency of production began to decrease due to the decomposition of the electrogenerated H_2O_2 with H_2O formation. The hydrogen evolution reaction was also responsible for this decrease as it tended to be more pronounced, competing with the H_2O_2 formation reaction. In terms of performance, it was observed that the use of the MGDE resulted in higher H_2O_2 production, independent of the nature of the added catalyst. Thus, the MGDE was comparatively more efficient than the GDE.

An important electrochemical parameter is the energy consumption (EC), which was calculated from the cell potential monitored during electrolysis [20]. Table 1 shows a comparative analysis of the EC during H_2O_2 production in the different electrodes studied, and the maximum concentration of H_2O_2 obtained.

Table 1. H_2O_2 production and energy consumption (EC) obtained after 2 hours of electrolysis using the GDE or MGDE cathodes.

cathodes	E (V)	H_2O_2 (mg L^{-1})	EC (kWh kg^{-1})
GDE	-2.0	765.29	29.32
MGDE 10% EAQ	-2.0	998.12	11.21
MGDE 10% BAQ	-2.0	885.33	16.62
MGDE 10% ALZ	-2.5	804.95	19.27
MGDE 10% AZO	-2.5	899.15	20.18

The results presented in Table 1 show that the modification of the electrodes with organic redox catalysts resulted in an increase in the H_2O_2 production efficiency, with lower energy consumption, compared to the unmodified electrode (GDE). Therefore, the use of the MGDE with EAQ (10% (w/w)) resulted in better catalytic efficiency and lower EC at all studied potentials.

Comparing the results shown in Table 1 with the results obtained in experiments performed in the electrochemical cell [9], it can be concluded that the use of the electrochemical flow-by reactor was much more efficient. It resulted in higher concentrations of H_2O_2 with significantly lower EC, even at a higher optimum potential.

The implementation of the decision algorithm is described in Figure 3. First, the algorithm takes the two input linguistic variables and assigns them a membership to one or more linguistic terms based on the membership functions. Once each of the input linguistic variables is assigned membership, the step size output is determined via the “if . . . then” rule base as shown in Figure 5. The rule base was created through the data obtained in the experiments. With the aid of the MatLab software tool, the results were obtained from the input data (type of electrode and potential applied).

a) The GDE electrode (0.1) and all available potentials in another type of modeling of Figure 5 are shown in Figure 6 and 7.

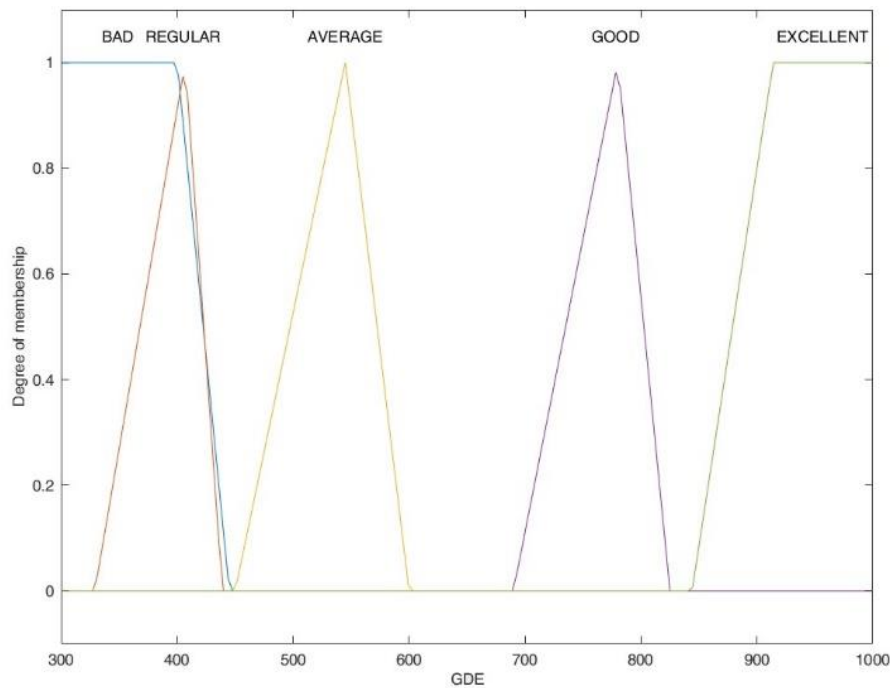


Figure 6. Pertinence function associated with the first output variable (GDE).

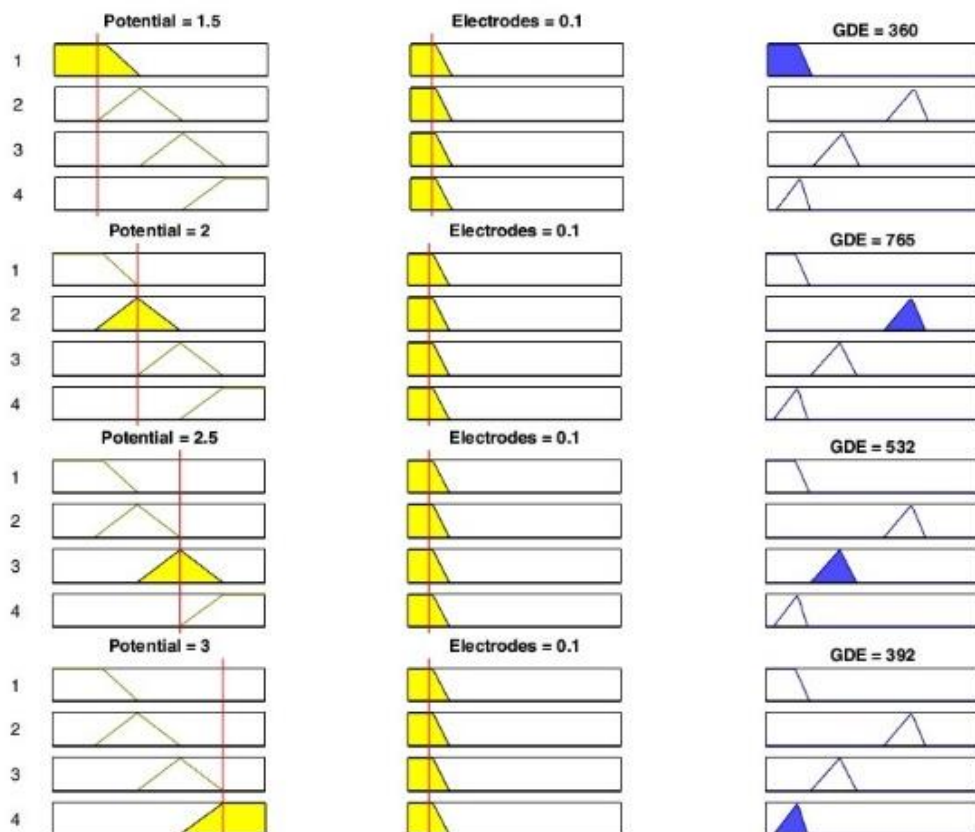


Figure 7. Result obtained of triggering the base rules considering the potentials 1.5, 2.0, 2.5 and 3.0V (GDE).

The values obtained were very close to those generated in the experiment according to Figure 5.

Numbers 1, 2, 3, and 4 refer to the rules used in the process by the controller, i.e., R1, R2, R3, and R4.

b) The EAQ electrode (0.3) and all available potentials in another type of modeling of Figure 5 are shown in the Figure 8 and 9.

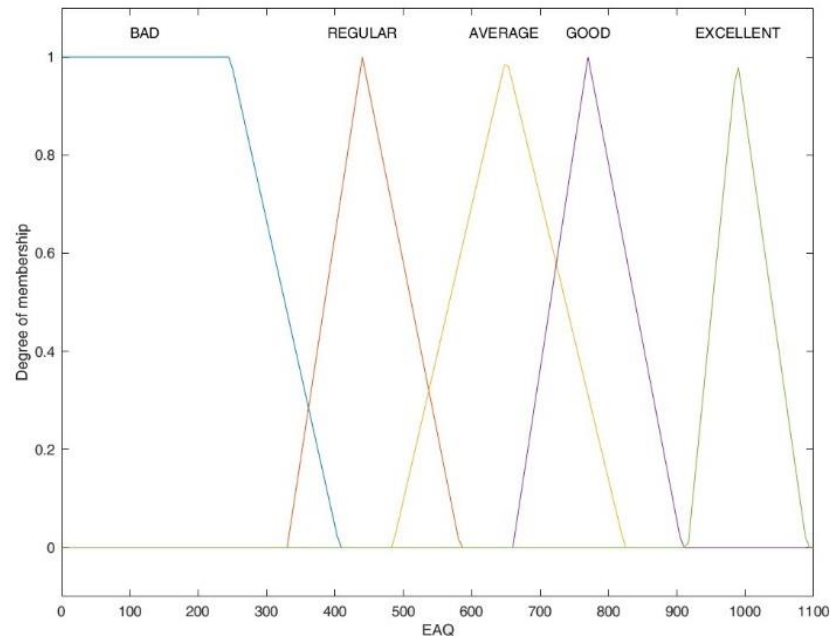


Figure 8. Pertinence function associated with the first output variable (EAQ).

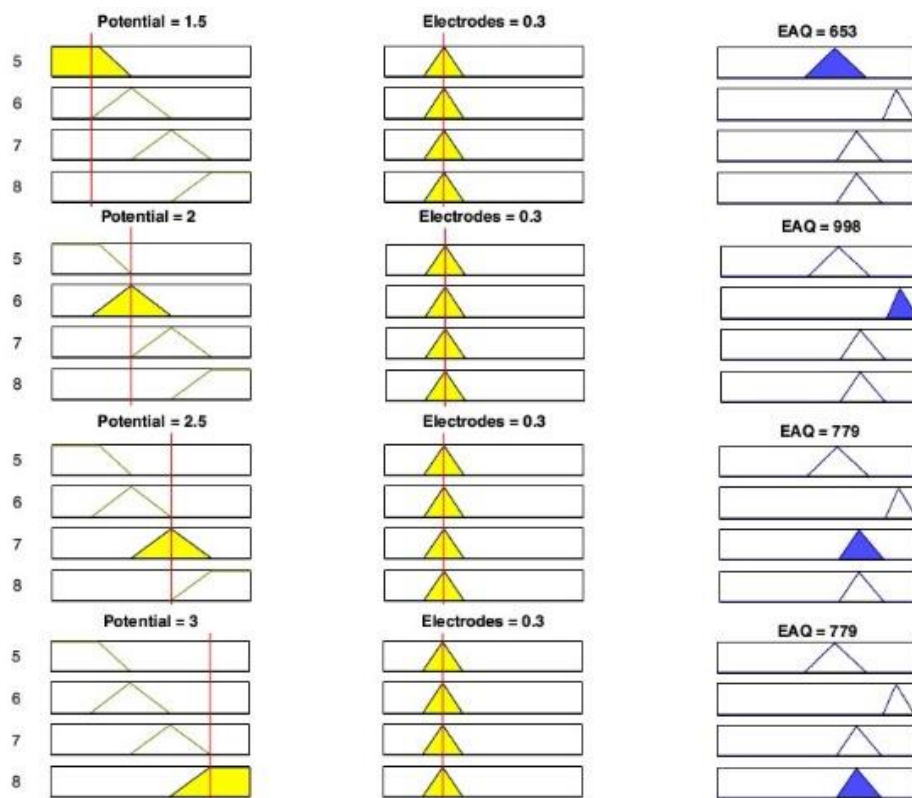


Figure 9. Result obtained of triggering the base rules considering the potentials 1.5, 2.0, 2.5 and 3.0V (EAQ).

c) The BAQ electrode (0.5) and all available potentials in another type of modeling of Figure 5 are shown in the Figure 10 and 11.

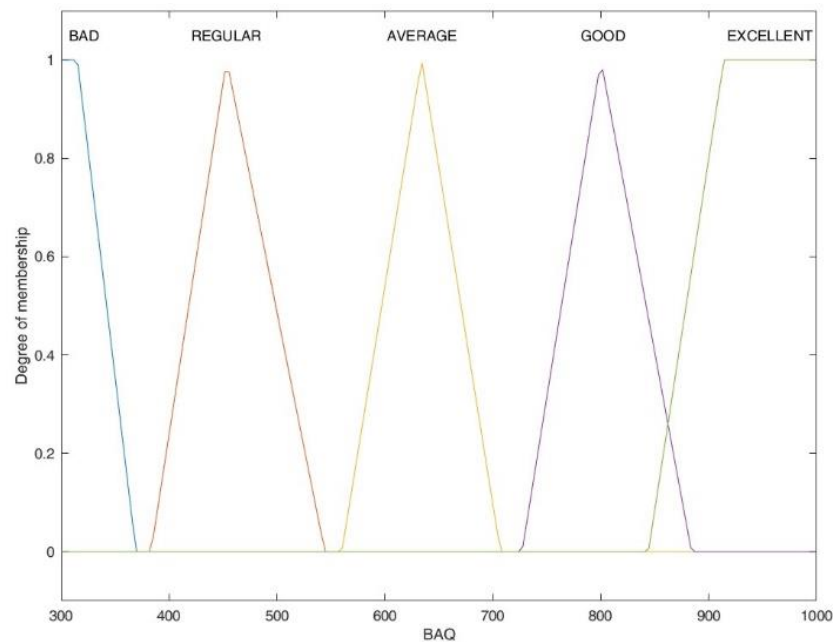


Figure 10. Pertinence function associated with the first output variable (BAQ).

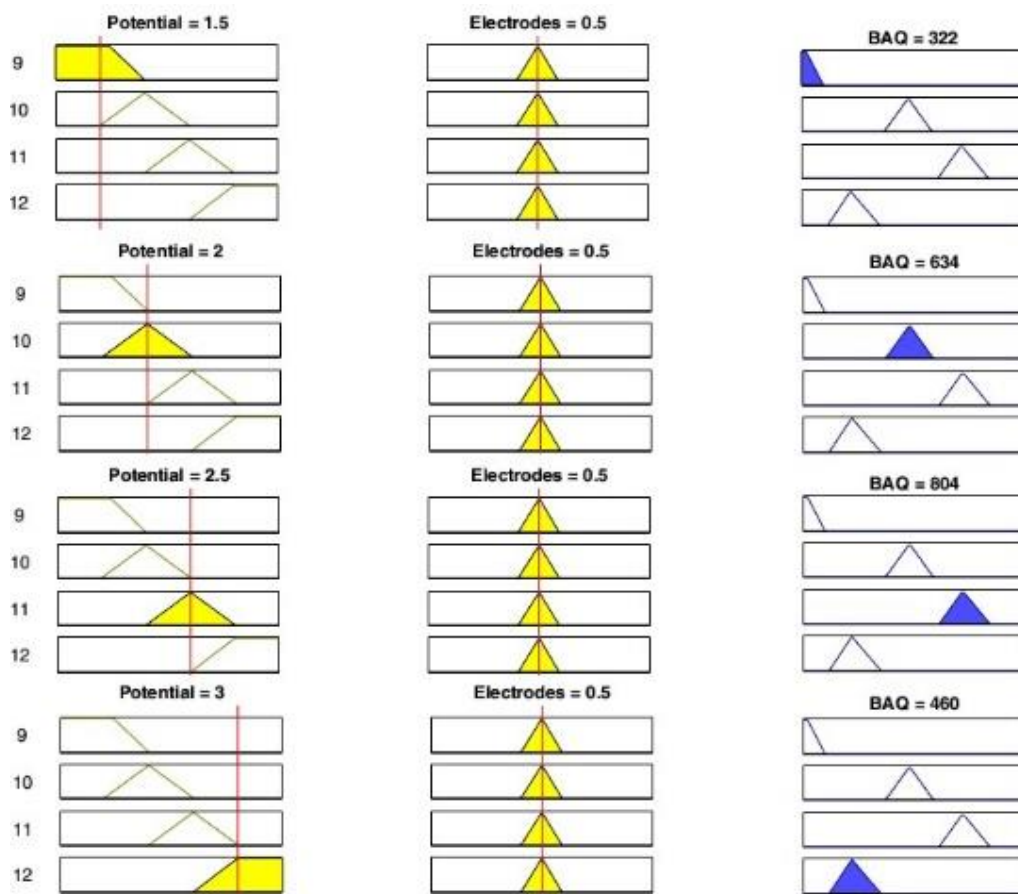


Figure 11. Result obtained of triggering the base rules considering the potentials 1.5, 2.0, 2.5 and 3.0V (BAQ).

d) The ALZ electrode (0.7) and all available potentials in another type of modeling of Figure 5 are shown in the Figure 12 and 13.

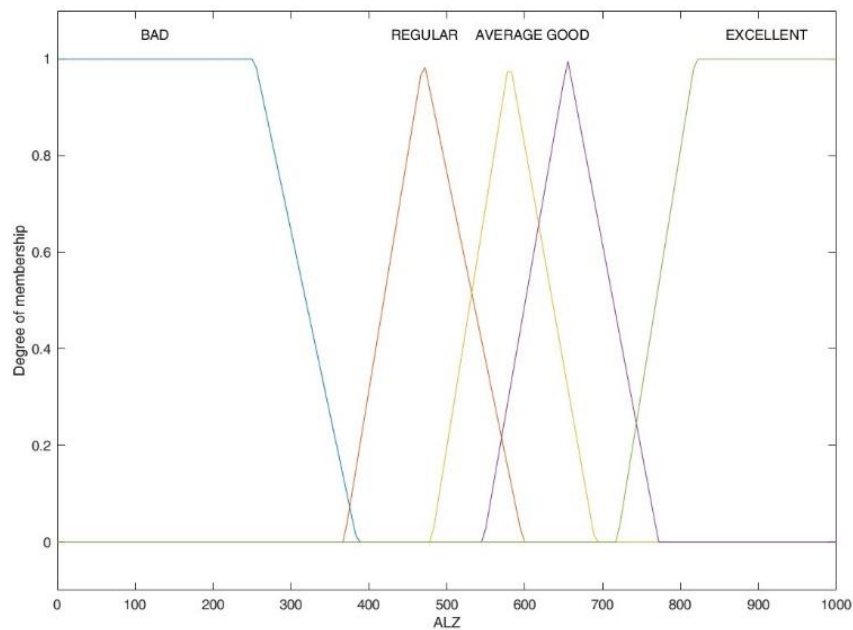


Figure 12. Pertinence function associated with the first output variable (ALZ).

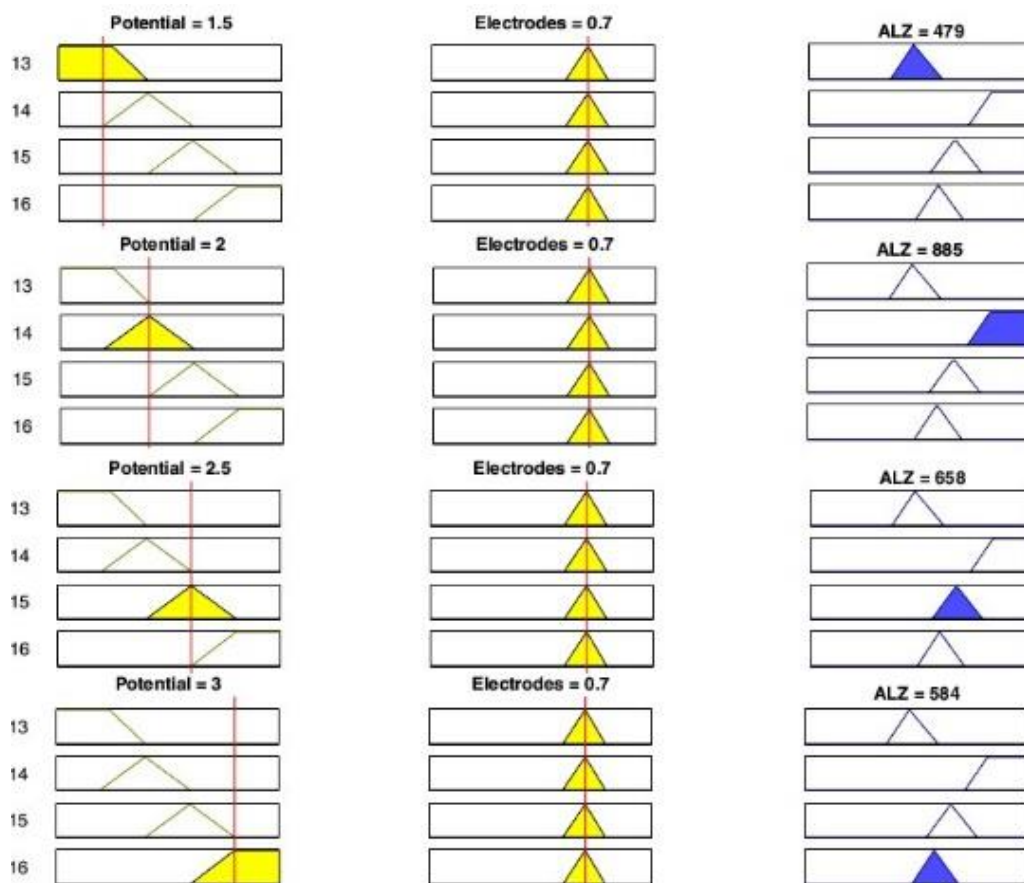


Figure 13. Result obtained of triggering the base rules considering the potentials 1.5, 2.0, 2.5 and 3.0V (ALZ).

e) The AZO electrode (0.9) and all available potentials in another type of modeling of Figure 5 are

shown in the Figure 14 and 15.

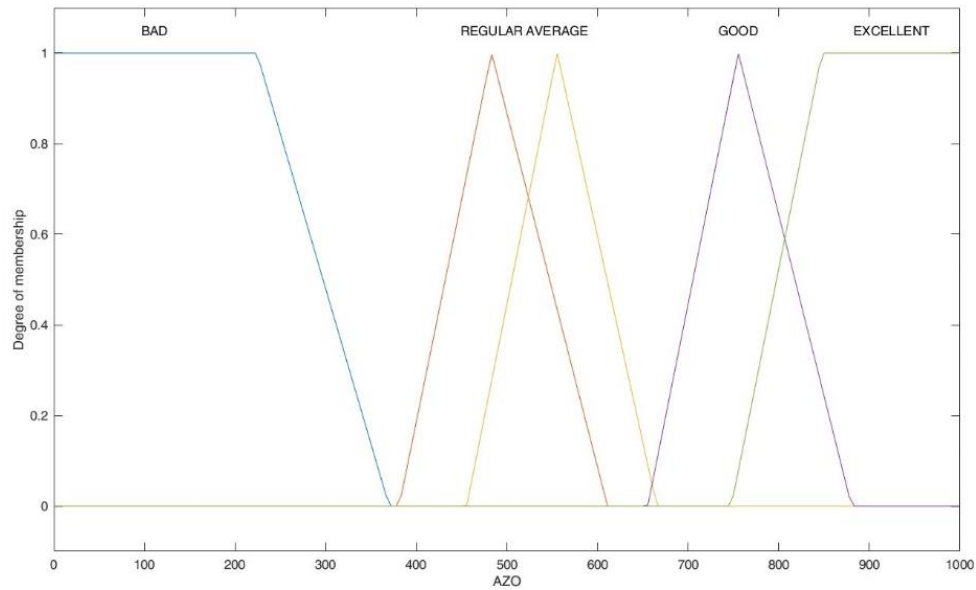


Figure 14. Pertinence function associated with the first output variable (AZO).

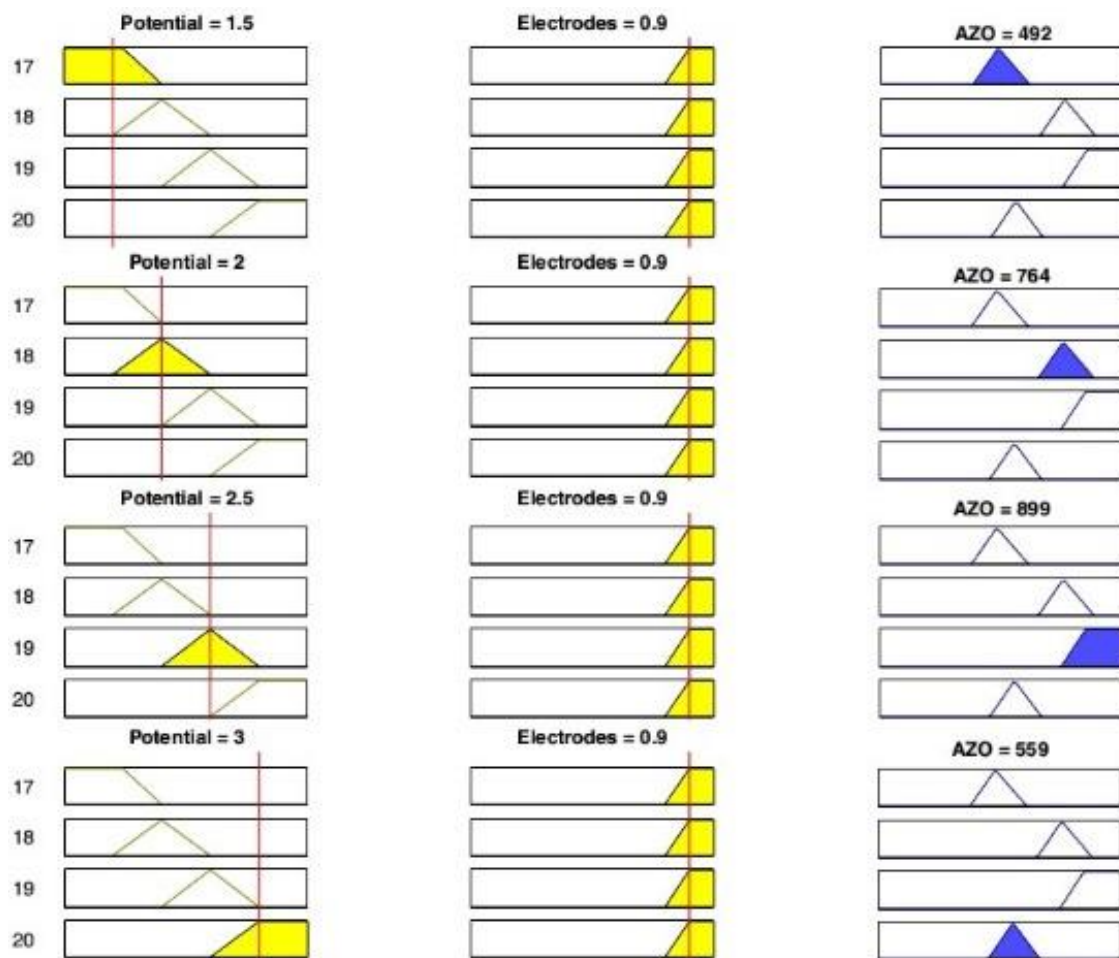


Figure 15. Result obtained of triggering the base rules considering the potentials 1.5, 2.0, 2.5 and 3.0V (AZO).

Despite being a software tool that works with uncertainties, the results obtained by the scenarios inputted in the developed algorithm of inference were analogous to those obtained experimentally. For future work, we aim to transpose the algorithm of this system into windows desktop application developed in Microsoft Visual Studio Rapid Application Development (RAD) and in the form of an application on an Android platform developed in the integrated development environment Android Studio.

4. Conclusions

All MGDEs presented a superior yield of H_2O_2 in relation to the GDE. The GDE modified with 10% of 2-ethylanthraquinone showed better performance. Under a flow rate of 200 L h^{-1} , H_2O_2 was formed with a maximum yield of 998.12 mg L^{-1} after 2 h at -2.0 V vs Pt//Ag/AgCl and $11.21 \text{ kWh kg}^{-1}$ energy consumption.

In general, the results demonstrated the immense potential of the MGDE with organic catalysts in an electrochemical flow-by reactor for the electrogeneration of H_2O_2 . The process showed a high catalytic efficiency with lower energy consumption.

To provide decision support to users, a fuzzy algorithm with an inference engine based on the Mamdani and Assilian [19] method was developed to help decide the productivity of H_2O_2 by entering the values of only two inputs (electrode type and potential).

It was observed that the knowledge obtained by the expert in the execution of the experiment could be fully transferred to a fuzzy inference algorithm, thus eliminating the need for new queries or experiments, and automating the scenario selection process that presents the best result in terms of H_2O_2 productivity through the availability of electrode type and the potential generated from the potentiostat/galvanostat.

5. Acknowledgement

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Conflicts of interest

The authors declare no conflict of interest.

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Canonical correlations in agricultural research: Method of interpretation used leads to greater reliability of results

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Abstract

Canonical correlations analyzes are being used in the agrarian sciences and constitute an important tool in the interpretation of results. This analysis is performed by complicated mathematical equations and it is only possible to use it thanks to the development of computational software, which allows different interpretations of results, and it is up to the researcher to choose according to his knowledge. Canonical correlations can be interpreted using canonical weights, canonical loadings, or canonical cross-loadings. In Brazil, most of the works that use these analyzes interpret the canonical weights. Therefore, this study aims to show, through an analysis of canonical correlations, the best way to interpret the results, so that they are presented in the most reliable way possible. Data from an experiment with two cultivars of biquinho pepper seeded in 5 light spectrums were performed. The variables were root length and volume, plant height, number of leaves, fresh shoot and root mass, shoot dry mass. Two groups of variables were organized, the multicollinearity was determined through the condition number and the inflation factor of the variance. Canonical correlations analysis was carried out, and weights, loadings, and canonical cross-loadings were estimated for the interpretation of the results. After the interpretations, it was defined that the canonical cross-loadings should be preferred for the interpretation of the canonical correlations. Weights or canonical coefficients provide dubious results of relationships between groups of characters and should be avoided.

Keywords: Canonical weights; Canonical loadings; Cross-loadings; Multicollinearity; Methods.

Introduction

Canonical correlation analysis is the most generalized technique of all statistical procedures to determine relationship and interdependence between two or more variables (Basu and Mandal 2010;

Cocozzelli 1990). It is used to determine the relations between groups of variables (Cruz, Regazzi, and Carneiro 2012), that is, the variation in a group of dependent variables analyzed in terms of a group of independent variables (Cocozzelli 1990), and was developed by Hotelling, (1936). This type of analysis allows us to obtain canonical statistical variables, which are linear combinations of two groups of variables (X and Y), and the information contained in the parameters should be focused on the correlation between these new variables (Hair Júnior et al., 2009).

Canonical correlations are determined from the correlation between a linear combination of two groups of variables (Hotelling 1936). Thus, a canonical correlation is one that maximizes the relationship between the linear combinations X and Y with: $X'=[x_1x_2...x_p]$, being the vector of the measures of p characters that constitute the group I and $Y'=[y_1y_2...y_q]$ is the vector of measures of q characters that constitute group II. The first canonical correlation is one that maximizes the relationship between X1 and Y1. The functions X1 and Y1 form the first canonical pair associated with that canonical correlation (Cruz et al. 2012), the highest possible among all these linear combinations. Next, a new pair of linear combinations X2 and Y2. The process continues until a subsequent pair of linear combinations no longer produces a significant correlation (Basu and Mandal 2010), that is until all variation is explained in both sets of variables (Cocozzelli 1990).

This type of analysis is widely used as indirect selection methods for the genetic improvement of plants. However, some precautions should be taken when performing the analyzes, such as the presence of multicollinearity, common in correlations and regression analyses (Blalock 1963; Montgomery and Peck 1982), because when there is the presence of high multicollinearity, errors occur and can produce biased estimates of the effects for the group of variables under study (Montgomery and Peck 1982). To avoid errors, the multicollinearity diagnosis must be performed within each group of variables (Blalock 1963; Cruz et al. 2012).

Many studies have been carried out with canonical correlations analyze, in several areas. Kazmi et al., (2017) calculated the canonical correlation between the groups of metabolic and phenotypic variables for the performance of tomato seeds. Rigão et al., (2009) evaluated through canonical correlation characters of planted tubers, related to those harvested, for the early selection of potato clones.

The interpretation of canonical correlation analysis can be performed in different ways: canonical weights or standardized coefficients, canonical loadings, and canonical cross-loadings (Hair Júnior et al., 1998), and the researcher generally uses the measure that his statistical program used for analysis offers. The canonical coefficients were used for the interpretation by (Alves, Filho, et al. 2017; Alves, Cargnelutti Filho, and Burin 2017; Brum et al. 2011; Rigão et al. 2009). Canonical weights, canonical loadings, and canonical cross-loadings were used for interpretation by (Protasio et al. 2014, 2012).

The interpretation of canonical correlations by canonical weights or standardized coefficients is performed by its magnitude, that is, the greater the magnitude of a certain variable, the greater its contribution, and when they have opposing signs, they exhibit an inverse relationship to each other and will have a direct relationship when the signals have the same signal. Canonical weights are subject to high variability are sensitive to multicollinearity (Hair Júnior et al., 2009).

When interpretation is performed by canonical loadings they measure the simple linear correlation

between an original observed variable in the dependent or independent set and the canonical statistical variable of the set; and the higher the coefficient, the more important is the variable for the canonical statistical variable (Hair Júnior et al., 1998). Canonical loadings have advantages over canonical weights, such as lower standard error and greater stability in replicate samples (Meredith 1964). The use of canonical cross-loadings consists of the correlation between the observed dependent variable and the independent canonical statistical variable, and vice versa, providing a direct measure of the relations of dependent-independent variables by eliminating an intermediate step involved in conventional loadings (Hair Júnior et al., 2009).

In Brazil, one of the most used programs for the analysis of data in experimental statistics and quantitative genetics is Genes, this program created at the Federal University of Viçosa presents as an output for the analysis of canonical correlations only the canonical weights (or canonical coefficients) and the canonical loadings (Cruz 2013). The software R, which is one of the most widely used free software in the world for data analysis has implemented some packages that allow the researcher to choose according to their knowledge, what kind of interpretation to do. The package CCA (González et al. 2008) e and the package yacca (Butts 2018) are packages that allow outputs of results with three measures of evaluation of canonical correlations.

Based on the issues discussed above, this study aims to obtain canonical weights, canonical loadings, and canonical cross-loadings, detailing the interpretation, advantages, and disadvantages in each method to answer the best method to interpret the results of studies that use analysis of canonical correlations.

Material and Methods

Local, plant material and culture conditions

For the evaluation, we used data from an experiment conducted at the Federal University of Santa Maria - RS, Frederico Westphalen *campus*. An experiment, with two cultivars of biquinho pepper seeded in 5 light spectra was carried out. For this, seeds of the cultivars of biquinho pepper were used (*Capsicum chinense*) BRS Moema and Airetama Biquinho of brand ISLA[®], which were pre-germinated on Germitest[®] paper in transparent gerbox, kept in a growth chamber at a constant temperature of 25 °C, photoperiod of 12h/12h with an irradiance of 40 $\mu\text{mol m}^{-2} \text{s}^{-1}$, and when 50% of seeds presented protrusion of the root were transplanted in plastic cups of white color (0.3 cm³) filled with commercial substrate Carolina[®].

After emergence and until the beginning of flowering [76 days after emergence (DAE)] the seedlings were kept in a growth room with a constant temperature of 25 $\pm$ 2 °C, photoperiod of 16h/8h, and under different amounts and spectral qualities of light. For this, it was used LED lamps (TEC LED[®]) white, red, blue, red/blue color (60/40% ratio), and fluorescent lamps (40 W Osram, Brazil). Initially, up to 62 DAE the amount of light was 40 $\mu\text{mol m}^{-2} \text{s}^{-1}$, later this was increased to 80 $\mu\text{mol m}^{-2} \text{s}^{-1}$.

At 76 DAE (beginning of flowering, 50% of flowering plants) the plants were transplanted into black pots (cm³) filled with soil plus substrate and kept in a greenhouse. Irrigation was performed manually according to the needs of the crop. Plant nutrition was carried out via fertigation.

Experimental design

The experimental design was a randomized block design, in a 2x5 factorial scheme, with two cultivars of biquinho pepper (BRS Moema and Aretama Biquinho) and seedlings from five different light conditions (white LEDs, red LEDs, blue LEDs, red/blue LEDs and fluorescent lamps light), totaling ten treatments with ten replicates per treatment, where each replicate is composed of one plant, totaling 10 plants per treatment.

Variables analyzed

From the emergence to the beginning of flowering (76 DAS) the height of the plant was evaluated, a number of leaves. The number of leaves, height (cm) were evaluated from the emission of the first expanded leaf to the first bifurcation in the main stem of the plant.

At the 76 DAS (before transplant) was evaluated fresh and dry mass (g) of shoot and root, root volume, root length, leaf area.

The fresh mass was calculated shortly after the removal of the substrate from the roots to avoid dehydration of the plant. For the dry mass, the plants were removed from the substrate and then placed in paper bags to be kept in a drying oven. The root volume was calculated after the fresh mass was calculated by displacing the water in a graduated cylinder after submerging the root. The root length was evaluated by measuring the length of the main root (root pivoting).

Statistical analysis

Two groups were defined to verify the relation and interdependence between them. For this, the multicollinearity diagnosis was performed on the linear correlation matrix in each of the groups of variables (X, Y) using the condition number analysis $NC = \frac{\lambda_{\max}}{\lambda_{\min}}$ representing the ratio between the largest and

the smallest eigenvalue of the correlation matrix and by the variance inflation factor $VIF = \frac{1}{1 - R_j^2}$, where

R_j^2 is the determination coefficient.

With each group of variables presenting low multicollinearity, that is, NC less than 100 and VIF less than 10, we proceeded with canonical correlation analysis. The groups formed were root variables such as root length (CR) and root volume (VR) and a plant growth group: plant height (ALT), leaf number (NF), fresh shoot mass MFPA), fresh root mass (MFR) and dry shoot mass (MSPA).

The number of canonical correlations to be estimated is equal to the number of characters of the smallest group (p or q) and the magnitude decreases in the order in which they are estimated. Thus, a canonical correlation is one that maximizes the relationship between the linear combinations X and Y with:

$X' = [x_1, x_2, \dots, x_p]$, being the vector of the measures of p characters that constitute the group I and

$Y' = [y_1, y_2, \dots, y_q]$ is the vector of measures of q characters that constitute group II (Cruz et al. 2012). Thus,

two canonical correlations were estimated.

The estimation of the maximum correlation between linear combinations of characters of groups I

and II, where X_1 and Y_1 are the linear combinations of the characters of groups I and II respectively:

$$X_1 = a_1x_1 + a_2x_2 + \dots + a_px_p \quad \text{and} \quad Y_1 = b_1y_1 + b_2y_2 + \dots + b_qy_q \quad \text{on what:} \quad a' = [a_1a_2\dots a_p] \quad \text{vector } 1 \times p \text{ of}$$

weights of the group I character and $b' = [b_1b_2\dots b_q] =$ vector $1 \times q$ of II characters weights. In this way, the

first canonical correlation will be that which maximizes the relation between X_1 and Y_1 . The functions X_1 and Y_1 form the first canonical pair associated with that canonical correlation expressed by:

$$r_1 = \frac{C\hat{o}v(X_1, Y_1)}{\sqrt{\hat{V}(X_1)\hat{V}(Y_1)}} \quad , \quad \text{being} \quad C\hat{o}v(X_1, Y_1) = a'S_{12}b \quad , \quad \hat{V}(X_1) = a'S_{11}a \quad \text{and} \quad \hat{V}(Y_1) = b'S_{22}b \quad \text{where: } S_{11} =$$

matrix $p \times p$ of covariance between the characters of group I; $S_{22} =$ matrix $q \times q$ of covariance between the characters of group II; $S_{12} =$ matrix $p \times q$ of covariance between the characters of group I and II (Cruz et al. 2012). The coefficients or canonical weights are the weights that each variable received for the calculation of the linear combinations, the canonical loadings, which are the correlations between the original variables and their respective canonical statistical variables, and the canonical cross-loadings that represent the correlation between an original variable of a given group and the canonical statistical variable of the other group (Hair Júnior et al., 2009).

The canonical R^2 was calculated by squaring the estimated canonical correlation and represents the correlation between the actual dependent variable and the predicted value, representing the amount of variance in the dependent variable explained by the regression function of the independent variables (Hair Júnior et al., 2009). The significance test was performed through a series of canonical correlations (sequentially) against the null hypothesis that the coefficient tested and all of the following coefficients are zero (Butts 2018). The Wilks' multivariate Lambda significance test (F distribution approximation) was used to evaluate the significance of the canonical roots together.

Statistical analyses were performed at 5% significance. with the help of the yacca (Butts 2018), pracma (Borchers 2018), and faraway packages available in program R.

Results

The multicollinearity diagnosis determined in the correlation matrix in each group of variables resulted in VIF less than 10 and NC less than 100, indicating weak multicollinearity. The results of multicollinearity are important from estimating reliable canonical correlations that reflect the real influence of one group on the other and vice versa. For this study, the results of VIF for the group I was 1.08647 for the two variables, and the NC was 1.78595. For group II, FIV was 3.08 for ALT, 3.52 for NF, 7.40 for MFPA, 1.44 for MFRA, and 10.03 for MSPA. The NC was 54.42.

The first canonical correlation was high and significant and revealed the existence of interdependence among the groups. The canonical R^2 found did not present a very high result, ie, the amount of variance explained (56.25%) between the canonical statistical variables independent and dependent on function 1 was only 56.25% for the groups of characteristics analyzed (Table 1).

Table 01. Canonical correlations, canonical R^2 , and multivariate test of significance.

Function	Canonical correlations	Canonical R^2	Total Variance Explained	Degrees of freedom	χ^2	p-value
1	0.75	0.5625	0.34	10	83.76	9.43E-14
2	0.17	0.0289	0.11	4	3.04	0.54

By interpreting the results by canonical weights (or standardized coefficients) for the first function, we can see that the variables MFRA and MSPA contribute to increasing the variable VR or vice versa, whereas root length (CR) has little or almost none contribution to the independent variables. The second function presented a non-significant canonical correlation and, therefore, does not require interpretation (Table 02).

Table 02. Canonical weights, canonical loadings, and canonical cross-loadings for the two groups of growth variables of biquinho pepper under light spectra.

Variables	Canonical weights		Canonical loadings		Canonical cross-loadings	
	Group I					
	1°	2°	1°	2°	1°	2°
CR *	0.077	-0.432	0.447	-0.895	0.3378	-0.1590
VR	1.608	0.803	0.984	0.176	0.7448	0.0313
Group II						
ALT	-0.1057	-0.4048	0.0213	-0.1575	0.0161	-0.0280
NF	0.0004	-0.0241	0.1378	0.2346	0.1042	0.0417
MFPA	-0.1528	1.4052	0.0960	0.4651	0.0727	0.0827
MFRA	2.1143	0.1915	0.9610	0.0299	0.7271	0.0053
MSPA	1.2681	-5.2556	0.2716	0.1671	0.2055	0.0297

*CR: root length; VR: root volume; ALT: plant height; NF: leaf number; MFPA: fresh shoot mass; MFRA: fresh root mass; MSPA: dry shoot mass.

The interpretation via canonical loadings must be performed considering the correlation between the variables and their canonical variables. Analyzing the canonical loadings for the canonical variable in group I (dependent) it is observed that the root volume (RV) presented the highest value. For group II (independent), the MFRA variable presented a higher value. The canonical loadings reveal that CR is positively correlated with VR. Besides, the increase in these two variables increases the MFRA, the MSPA, and vice versa. The relationship between ALT, NF, and MFPA was not sufficiently explained by the canonical correlation analysis because the values of the canonical loadings were low.

The results for canonical cross-loadings are similar to canonical loadings. This measure allows for more direct identification of the relationship between the dependent variables - independent. The results show a strong relationship between the MFPA with RV and CR and on the contrary, showing that the increase of VR and CR increases the MFRA and MSPA.

The interpretation of the canonical loadings and the canonical cross-loadings showed the same

result, however, the magnitude of the relations decreased for the canonical cross-loadings. Regardless of the interpretation used, it is evidenced that the groups have linear relations and that the characters CR and VR can be used to increase the MFPA, for example. This characteristic is desirable from a photosynthetic point of view because the larger the aerial part in the pepper plants the greater the photosynthetic area in the plant, besides producing more shoots, important for the production of fruits.

Discussion

In the analysis of canonical correlations, the diagnosis of multicollinearity is essential so that the correlation estimates are not biased. The presence of multicollinearity is present in regression and correlation analyzes and this affects the ability to estimate reliable regression or correlation coefficients (Montgomery and Peck, 1982).

The amount of explained variance calculated by the coefficient of canonical correlation squared, called canonical R^2 , presented a result of 56.25%, which indicates that although the canonical correlation was significant, it has a little more than 56% explanation of the variance of the dependent variables, and this measure must be taken into account in this type of analysis since the canonical correlation is calculated in such a way as to maximize the relations between them, while R^2 maximizes the explanation or variance between them (Hair Júnior et al., 1998). Akbaş and Takma, (2005) found results that suggest 33.3% of the variance in the Y variables is accounted for by the X variables, and according to the authors, this value indicates that the first correlation has a high significance. Marubayashi Hidalgo et al., (2014), found R^2 of 0.658 and indicated that two sets of variables are highly correlated in all the lines tested revealing an association between the groups of variables.

The interpretation of variables by canonical weights or standardized canonical coefficients allows us to identify the importance of each variable in the calculation of canonical variables, that is, the canonical coefficients give the contribution of each variable in the analysis (Akbaş and Takma, 2005); the canonical weights are similar to the beta coefficients of multiple regression (Protasio et al., 2014).

the canonical weights are similar to the beta coefficients of multiple regression. In this case, the variable CR had low weight computed, this can be attributed to the instability of the canonical coefficients discussed in some studies due to the small sample size or presence of multicollinearity in the data (Akbaş and Takma, 2005; Hair Júnior et al., 2009). In the results of this study, the presence of multicollinearity is not a problem, since the diagnosis of multicollinearity in each group of variables was weak.

When interpreting canonical weights, a measure of shared variance other than square canonical correlations must be used to overcome the uncertainties with this interpretation, and the use of the redundancy index is indicated (Akbaş and Takma, 2005; Hair Júnior et al., 2009). According to Meredith, (1964), if the variables within each set are moderately interrelated, the interpretation of the canonical variables by the weights is practically null, without correcting these correlations.

The interpretation of the canonical correlations using the canonical loadings presented differences of those interpreted by the canonical weights. In this case, the variable CR that had low canonical weight had a high canonical charge. When interpreting the canonical loadings, we can identify the correlation between the variables and their respective canonical variables (Marubayashi Hidalgo et al., 2014), that is,

it reflects the shared variance between the observed variable and the linear combination (Hair Júnior et al., 2009).

By the interpretation via canonical cross-loadings the result was similar to the one obtained by the canonical loadings, these indicate the correlation between the variables and the opposite canonical variable (Marubayashi Hidalgo et al., 2014) and can provide a more direct measure of the relationships between dependent and independent variables (Hair Júnior et al., 2009). Similar results between canonical loadings and canonical cross-loadings were found in other works that used these two forms of interpretation (Marubayashi Hidalgo et al., 2014; Protasio et al., 2014) and indicate that the influencing characteristics would be the same using interpretation by canonical loadings or canonical cross-loadings.

In a work carried out in 1975 the problems associated with interpretations of canonical correlations were already discussed, where Lambert and Durand, (1975) reported the dangers when interpreting the analysis of correlations by canonical weights since in showing the contribution of each original variable to the canonical score, they do not show the correlations between the variables.

The weights are used in a way that maximizes the canonical correlations (Meredith, 1964), and if the large correlation is improved, although the correlation with the variables is low, multicollinearity problems may mask the results attributed to canonical weights, and the variables may have little or no correlation between them (Lambert and Durand, 1975). These same authors affirm that the canonical weights are very inadequate and indicate relations between non-existent variables. Most often the interpretation by canonical weights does not provide enough information to fully interpret a canonical effect, because these coefficients still cannot articulate clearly the contributions to the achieved effect (Nimon et al. 2010).

In canonical loadings, the problems related to multicollinearity that affect interpretation by canonical weights are diminished because they show the simple relation with the canonical scores, ignoring the correlation between other variables and the scores, that is, they are not affected by multicollinearity (Lambert and Durand, 1975; Nimon et al., 2010). A limitation of the loadings is that even if they are stable they cannot provide a direct measure of the variation between the variables (Lambert and Durand, 1975).

The canonical charges are preferable to the use of canonical weights, however, the R^2 must be calculated to determine how much of the variance of the observed variable is shared with the canonical scores of this linear combination (Lambert and Durand, 1975). In the case of the present work, for the variable MFRA that presented canonical loadings of 0.9610, we conclude that it presents a high correlation, and raising it to the square, the canonical loadings obtained 92% of the variance in the shared variable. However, the high canonical loadings for the variable CR (0,447) present a low variance of the shared variable with only 19.9%.

Canonical cross-loadings are more reliable than the use of canonical weights or canonical loadings as they provide a more direct measure of the relationships between variables by eliminating an intermediate step involved in canonical loadings (Hair et al., 2009; Lambert and Durand, 1975)

As we have seen here, the interpretations of canonical correlations require great care and attention, since there are many cases in which the results may not be reliable, simply because of the lack of care with the analyzes and their interpretation, besides can be replicating errors in the scientific environment for the lack of knowledge and misuse of this type of analysis. As said by the author's Lambert and Durand, (1975),

the aim is not to discourage the use of these analyses, but to make them more accurate and that the researchers use them to make their research more effective, reducing errors of interpretation.

Many works have been published where the interpretation of the analyzes is carried out via canonical weights (coefficients) as in (Alves et al., 2017b, 2016; Bandinelli et al., 2017; Rigão et al., 2009), e even using a standardized structure, they can not fully report the canonical effects (Nimon et al., 2010). Thus, the use of canonical loadings and canonical cross-loadings for the interpretation of canonical correlations is preferable (Takada et al., 1984).

But what method of interpretation should I use? The researcher must use that measure that is available in the computational program for the analysis of data that he dominates, since the analysis of canonical correlation without the aid of software is laborious and can be unsustainable (Nimon et al., 2010), nevertheless one must avoid making interpretations by the canonical weights since they do not present us a measure of relations between the variables (Hair Júnior et al., 2009). The use of canonical cross-loadings is the most indicated, and by the computational advance that facilitates the determination of this measure, it becomes possible to use this measure. When calculating cross-loadings is not possible, the option to be chosen is canonical loadings that are more reliable than canonical weights (Hair et al., 2009; Lambert and Durand, 1975).

Conclusion

Interpretations of canonical correlation analyzes should be made using canonical cross-loadings. Weights or canonical coefficients provide dubious results of relationships between groups of characters and should be avoided.

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The resignification of medical practices based on contact with the Other - with indigenous and caboclo-riverside residents: An experience report in the Amazon

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Abstract

Introduction: The Amazonas' State University provides Nursing, Medicine, Dentistry, and Pharmacy degrees with the experience of Rural Training in Public Health. Two MD students had high expectations of experiencing health care in the Amazonas interior, as they realized that there was a lapse in their academic training. They questioned the fact that they were about to take the place of "doctors trained by the state of Amazonas" without knowing the population, ethnocultural and geographical variety of the region. This lack encouraged the choice of the location of the internship to be the city of São Gabriel da Cachoeira. Methods: Meetings and lectures were held with health teams that enabled clinical experiences and interactions with indigenous and riverside residents. Finally, seminars/activity reports were produced, which contributed to the awakening of reflections on medical practices. Thus, this experience report is based on the particular apprehension of the reality described, based on daily observation. Results and Discussions: During the internship, the students began to question and deconstruct the doctor-user relationship hierarchy. Conclusions: Thus, they re-signified their practices beyond technical and biological knowledge, in line with the decolonial epistemology.

Keywords: Indigenous health; biopsychosocial medicine;

1. Introduction

Since the first half of the 20th century, care delivery models have been discussed in medical education. For a long time, the legacy of the biomedical model preached technology's sovereignty to the detriment of the health/disease and society relationship. However, currently, there is a growing awareness of the biopsychosocial perception of western white medicine. It begins to question traditional values in health practice and the emerging role of users and society in general, in order to provoke another reflection on the training and practice of health professionals¹

The biomedical model is still hegemonic, human medicine does not adequately address the needs of the population and coexists in a contradictory way in the practices of the health teams^{2;3}. Because of this, some institutions signal a concern with the reversal of this panorama when they propose pedagogical models that consider the individual in its social, economic, and cultural dimensions^{2;3}. Within this context, the Amazonas' State University (UEA), a multicampus institution in all state cities, proposes to the students in Nursing, Medicine, Dentistry, and Pharmacy courses the Rural experience Internship in Public Health (ERSC). This opportunity has as a premise to allow students to live new experiences, through participation in

decision-making and actions in primary health care services and society in cities in the interior.

Thus, based on a decolonial conscience(A), this article seeks to reflect on the biomedical training model and emphasize the importance of the rural academic internship. From methodological construction, it is characterized by a particular apprehension of the reality described, based on the daily observation of academics who undertook a 43-day internship in the city of São Gabriel da Cachoeira. Therefore, the present work is part of a “report of experience” perspective.

EXPERIENCE REPORT:

The Brazilian state of Amazonas has continental dimensions, where there are regions isolated by nature. Particularly in health practice, there is great difficulty in fully serving the entire territory⁴. In Brazil, 817,900 indigenous people reside, and 342,800 of these populations live in the Northern region, who are speakers of 27 languages and represented by more than 72 organizations^{5,6}. Each region has developed a specific part of our National Health System (SUS) with different particularities and distinct conceptions about the body and health⁷.

The capital Manaus, where most of the medical schools in Amazonas are located, different social groups coexist, but culture and colonizing thinking predominate, making ancient indigenous knowledge invisible, as well as different ontological conceptions about the body and the process of illness^{6,8}. Due to these notorious cultural differences present in urban and rural regions, which permeate the Amazon, it is necessary to move students to the interior to understand that the reality of the state is neither homogeneous nor uniform; and mask disparate and negligent social relationships⁹.

Thus, during the rural internship, the student can learn more about the singularities and complexities of the people they will provide in the different regions in the future. Immersion in the countryside allows health students to get to know the Amazonians better (B). It is an essential tool for the doctor-user dialogical process, as well as for producing health^{8,10}. Besides, the Rural Internship encourages the consolidation of the concept of multidisciplinary and interdisciplinary medical practice, contributing to the development of proposals aimed at assisting managers, workers, and the local community in solving health challenges in their daily lives¹¹. One of the cities linked to the rural internship is São Gabriel da Cachoeira, which is located in the extreme northwest of State of Amazonas, in the Upper Rio Negro basin, within the largest tropical forest on the planet, where 23 indigenous peoples are estimated to live¹².

In São Gabriel da Cachoeira, 76.60% of the population declares they are indigenous, their lands occupy about 80% of the city, and they are distributed in 750 villages/communities⁵. Not diverging from the rest of Brazil, its official language is Portuguese. However, there are three other languages recognized by law: Nheengatu (C), Tukano (D) and Baniwa (E). The region has the highest concentration of different indigenous ethnic groups in the country, which are: Arapaço, Baniwa, Barasana, Baré, Desana, Hupda, Karapanã, Kubeo, Kuripako, Makuna, Miriti-tapuya, Nadob, Pira-tapuya, Siriano, Taiwano, Tariano, Tukano, Tuyuka, Wanana, Werekena and Yanomami^{12,13}.

From the idealization of a region with such characteristics, we created expectations of finding a socioeconomic infrastructure without the influence of the white man; the image of the “sign of the Indian race” was conceived linked to characters subjectively charged with media stereotypes, which simplify and generalize cultures, languages, beliefs and singular individuals of the diverse indigenous ethnicities. This sign evokes stigmas of superstitious cosmologies, of delayed cultural development, and alien to interculturality¹⁴.

In this sense, at first, we found it strange to find so much white cultural representation in the city, such as shops with Christian names, products of foreign brands and a significant number of Catholic and Evangelical churches in a city with a predominantly indigenous population. This strangeness can be understood as a result of the social imaginary constructed about indigenous peoples - objects of discrimination and reduced to

stereotypes¹⁵. In addition to the media space, the invisibility of diverse knowledge developed around different ethnicities, which form the Brazilian identity, denotes a place of little democratic indigenous speech in the narrative of Brazilian history¹⁶. From this perspective, we began to assimilate the historical, political, and economic circumstances, which symbolically perpetuate the colonizing ideology and sustain this indigenous invisibility^{17;18}.

During the internship, amid so much white cultural representation, we were privileged to visit an institution of resistance, which represents the indigenous social movement in the region, known as the Federation of Indigenous Organizations of the Upper Rio Negro (FOIRN). Founded in 1987, it represents the 23 indigenous peoples of Rio Negro, in an area that covers the cities of Barcelos, Santa Isabel do Rio Negro and São Gabriel da Cachoeira, in Amazonas. It is a non-profit civil association and one of the leading organizations of the indigenous movement in Brazil, being a world reference on the defense of indigenous peoples in Latin America.¹⁹.

During the visit, we were introduced to one of the ex-presidents of the Federation, of the Tukano ethnicity, who explained the role and importance of all departments. In the end, he explained that new challenges arise for the movement in the face of constant uncertainties and threats to the constitutional rights conquered. Besides, in the following week, we participated in the 32 years of FOIRN, where the local leaders exposed it: the history of the movement, the question of the demarcation of Indigenous Lands, in addition to discussions of the achievements, challenges, and perspectives of health in the region. As an indigenous social movement of struggle and resistance for the Land, Health, and Culture, it is an institution that suffers harsh criticisms, mainly in the current political situation that we live in this moment in the history of Brazil.

These diverse considerations served as a basis for understanding the marginalization of ancient cultures during the “progress” of the nation and the reflections of the national policy of integrating or isolating indigenous peoples²⁰. We also had the opportunity to get to know the organization of indigenous health services through, first, a technical visit to the Alto Rio Negro Indigenous Special Sanitary District (DSEI - ARN).

The DSEI-ARN is organized by nuclei of primary health care, such as health promotion, prevention, control of diseases and conditions, the health of women and children, and planning, work management and continuing education²¹. During the visit, it was possible to experience the organizational structure and fundamental principles of indigenous health in the country, in addition to understanding the importance of guaranteeing indigenous rights to the preservation of their lands and natural resources, as it is recognized that their food, medicine, well-being and the joy of living come from the land(F)²². During the visit, we were introduced to a Tukano indigenous woman, who reported the challenge of her participation in the exchange of 50 indigenous people from the Upper Rio Negro to study medicine in Cuba in the 90s—contributing to the reflection on the flow of professionals from health of other states and countries, as well as the start of the construction project of the Amazonas State University with the mission of training professionals for the interior of Amazonas.

At a later moment, we were taken by DSEI-ARN to visit the facilities of the Indigenous' Health House (CASAI) and the staff responsible for the services. It was possible to observe how the blocks and dormitories are organized and the assistance services provided to the different ethnic groups of the Upper Rio Negro.

We were invited to follow two calls from DSEI-ARN, in the local communities called Itacoatiara Mirim and Amazonino. When we arrived in the communities, we had to ring a bell to announce our presence, and we had to organize ourselves in an open area. It is a reactive strategy contact(G). The DSEI-ARN team was already known, and we realized that their presence there was valued, as many were already looking for their younger children to receive childcare (H), or any other family members who needed assistance and/or medicines for chronic diseases. We noticed that there was significant adherence by the community to the vaccines and the therapeutic approaches proposed by the team. Some residents reported that the drugs for hypertension and/or diabetes were running out. Others had clinical complaints common to primary health care, ranging from diarrhea, common cold, scabies, superficial skin mycoses, and vaginal discharge. When someone did not speak

Portuguese, they had the help of a translator (I). However, even so, this was a limiting factor in our process of communication.

There was a particular complaint of sadness associated with a situation of lack of appetite and willingness to live. We suspected that it was a case of depression, and we did not have a psychologist on the team, and we had no experience in mental health.

The reports involved political and social issues, such as the difficulty of retiring and having to perform manual labor under the sun at an advanced age.

This community lived in vulnerable economic conditions, even though they worked with agriculture, crafts, fishing, raising chickens, among other activities. In this sense, we understand the importance of health teams moving to these communities, many of them inserted in contexts of difficult geographical and economic mobility.

In the city, we met some doctors who reported difficulties in dealing with some cultural issues, as it "limited their therapeutic approaches,"; and they intended to "save lives" and felt "frustrated". We followed up with a case of thrombocytopenic purpura (J) in an advanced stage.

Given the seriousness of the case, we had to refer to a specialized service. The team requested transportation. However, the patient had already escaped from the hospital. A few weeks later, we returned, and the situation was worst, and they reported having a treatment performed by a local Shaman, with the improvement of the condition for a few days. As she was in a severe condition, the white doctors criticized this attitude negatively, and we, as spectators, were reflective at the time

Final Considerations

From then on, we started to question and deconstruct the hierarchy of the doctor and user relationship. We understand that we were taught to "save lives" and to be "imposing" about treatment; under this biomedical perspective, we say the treatment and the user must follow it. Although in our society, imposing communication is naturalized, it prevents the establishment of dialogue itself, that is, an exchange in the deep inter-human sense, which accesses the being-in-the-world, the fundamental community values that constitute us as social beings²³.

We understand that in addition to making our relationships more complicated, this type of approach could not make sense from the relationship of freedom of indigenous peoples with their bodies. At that moment, we stripped ourselves of the idea of "saving lives" traditionally incorporated into white coats, because, under this hierarchical premise, it is not possible to respect the protagonism of the person who seeks assistance²⁴.

During the internship, a different therapeutic practice was revealed from that used by the white man's medicine *. This practice is imbued with ancient indigenous knowledge about plants with medicinal properties. It is an ethno-knowledge that spans generations and is widely respected by the residents of the city. We believe that this study gave rise to relevant information for academics and professionals, recognizing the importance of valuing and including ancient knowledge in their work practices, especially regarding indigenous health. Just as it is also a way of sharing a common therapeutic language, which allows us to get closer to the population; and encourages the transmission of knowledge about the proper use of medicinal plants to the community.

We could not fail to report that when we went to a bar in the city, we met an anthropologist, a philosopher, and a professor who were working and researching in partnership with the Instituto Sócio Ambiental (ISA). The dialogues with them, which we can affectionately call friends, helped us to understand that indigenous peoples have different ontological conceptions about the body, illness, healing, life, and time; and these are related in a more sensitive way than our conception of them. It helped us to assimilate health disparities, which must not only be respected but also understood so that responsibility for therapeutic choices can be shared. In addition to being an attempt to encourage the recognition, appreciation, emancipation, and decolonization of ancient indigenous knowledge.

Finally, we can say that the knowledge gained at this stage filled many gaps in Brazil's history that we were taught in schools. We see the dimension of the secular process of persistent colonization and in contrast, the resistance of indigenous peoples to assert their fundamental rights. Much remains to be done, but the effective implementation of their rights certainly depends on the decolonization of our thinking, on the awareness of the historical debts we have towards them, from organizations such as FOIRN, and, above all, on a true democracy that grants them a legitimate place to speak and listen. All these exchanges of knowledge and experiences have provided us with the critical appropriation of practices in health, which, above all, questions, resists, and seeks to change colonial patterns of being, knowledge, and power. As medical doctors assimilate their singularities, break with hierarchies, use non-imposing communication, consider that there are other medicines besides white modern, and be willing to relate to them, it is a way of guaranteeing dignified assistance to indigenous populations in the area of health.

Additional information

(A)- We chose the term decolonial - decolonization instead of decolonial - decolonization as suggested by author Catherine Walsh, in order to mark a distinction with the Castilian meaning of “des” which can be understood as a simple disarm, undo the reversal of the colonial. The author shows that there is no null state of coloniality.

(B) Confluence of different social subjects (Amerindians of the floodplain and / or terra firma, blacks, Northeasterners, and Europeans of different nationalities).

(C) Known as nhengatu, ñe'engatú, nhangatu, inhangatu, it is a general Amazonian language, derived from the Tupi trunk. It belongs to the Tupi-Guarani language family.

(D) language of the Upper Rio Negro region.

(E) Arawak language spoken by the Baniwa people.

(F) Worldview built over many years by the highland peoples of the Andes, who have become invisible in the face of colonialism, patriarchy and capitalism. Thus, the term is used to relate quality of life to spirituality, nature, ways of life and consumption, politics, ethics.

(G) Strategy conceptualized by William A. Corsaro in his ethnographic studies, in which the population reacts to the presence and comes spontaneously to contact, without any other type of intervention or presentation.

(H) Set of notions and techniques aimed at medical, hygienic, nutritional, psychological care, etc., for young children, from pregnancy to four or five years of age

(I) Some relative or friend who could translate.

(J) Autoimmune disease, characterized by low levels of platelets, which are blood cells that prevent bleeding. series of rituals that the indigenous shaman performs on certain occasions with a specific goal of healing or magic.

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Using the ABC costing system - Activity-based costing to calculate costs in the public sector

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Abstract

The calculation of costs in the public sector translates into a way of assessing management efficiency. However, there are great difficulties encountered in implementing this system. With the regulation of the Price Registration System - SRP, there is now the possibility for an agency to buy or contract for its own use and allow other agencies to participate (or ask for a ride) in the same bidding instrument, as long as it is of interest. homogeneous. This article presents a study that measured the cost of purchasing inputs at a university hospital in the city of Manaus by adhering to price registration procedures using the ABC cost. A case study was carried out and the data were collected through documentary research, mapping the acquisition process and unstructured interviews. Subsequently, the ABC costing method was used to measure the cost of the service performed (object of the study) for the acquisition of these inputs. The results of the study indicate that the ABC costing method is the most adequate to measure the costs of services performed in the public sector, since it avoids the arbitrary nature of the apportionment, allocating

the values referring to the human and material resources applied in the acquisition process.

Keywords: Cost Systems; Adhesion, ABC - Activity-Based Costing, Public Sector.

1. Introduction

With the growth of the scale of industrial activity that occurred from the 18th century onwards with the Industrial Revolution, the evaluation of products became more complex, the production costs were shared with more than one product and the concepts of General Accounting were no longer sufficient to determine the value of finished products and business results (Carioca, 2012), in addition to the need to obtain more inventory control, changing the preparation of financial statements. From these challenges, the first specialized cost accounting tests emerged (Crepaldi & Crepaldi, 2017; Souza & Silva, 2019).

Among the functions of Cost Accounting, three main ones can be highlighted: Planning, Control and Management for Decision Making (Hansen & Mowen, 2013), which made him leave his role of only assisting in the assessment of stocks and global profits, passing to be a tool for management decision control (Oliveira, Carvalho & Correa, 2010), being increasingly used in non-industrial companies and institutions, such as banks, finance, commerce, consultancy and the public sector (Bertó & Beulke, 2013; Martins, 2018).

In this context, the Public Sector seeks to control and determine its expenses and results in order to optimize decision-making and management processes. In addition to the management issue, the use of cost information in the public sector is configured as a mandatory requirement in the legislation (Costa, et al., 2018), an obligation imposed since the 1960s with the advent of Federal Law No. 4,320, of March 17, 1964. Considering that the Administration is also obliged to observe a series of procedures and to act in accordance with the law for the purchase or contracting of services (Bittencourt, 2015; Barbosa, 2012), the bidding presents itself as an indispensable and prior administrative procedure, aiming to guarantee the same conditions to all those interested in formalizing a contract with a public entity (Palaveri, 2005; Law nº 8.666/93), being governed, above all, by the administrative principles that guide public management acts (Borges & Bernardes, 2014).

In this perspective, this work aims to measure the cost of services performed for the purchase of inputs at a university hospital in the city of Manaus, by adhering to the minutes of price registration using the methodology of calculating ABC - Activity Based Costing.

2. Theoretical Foundation

2.1 Cost Accounting

Cost accounting is a branch of accounting that was initially used by the sector that needed assistance to determine the value of products (Martins, 2018). Over time, Cost Accounting started to perform other functions, highlighting three main ones: planning, control and management for decision making, ceasing to be a simple verification aid for an important organizational management tool (Hansen & Mowen, 2013).

2.1.1 General Principles and Concepts of Costs

Costs cannot be confused with expenses, which is what usually occurs, because expenses are directly linked to administrative expenses and costs to the production of goods and / or services (Martins, 2018; Osni, 2018).

In addition to differentiating costs from other expenditures, costs must also be observed and classified according to the identifications with the production of goods and services, attributing to the separation of Direct Costs, Indirect Costs, they can also, from the volume of production be classified between Fixed Costs and Variable Costs (Bertó & Beulke, 2013). Figure 1 summarizes the concepts of costs.

Spending
• All occurrences of payments or receipts of assets, costs or expenses is a general term of expenditure (PADOVEZE, 2011).
Investments
• They are expenses incurred on assets or expenses and costs that will be fixed, that is, expenses incurred according to their useful life or future benefits (CARIOCA, 2012).
Costs
• They cannot be confused with investments or expenses, as they are expenses related to products directly or indirectly (BERTÓ and BEULKE, 2013).
Expenses
• These are the expenses related to the administrative and commercial area, it can be said that they are the expenses necessary to sell and send products (KOLIVER, 2010; GOUVEIA, 2001).
Payments
• It is the financial execution of the company's expenses and investments (MARTINS E ROCHA, 2015).
Losses
• Facts that occurred in exceptional situations that are outside the normality of the company's operations, considered non-operational, are not part of the production costs (OSNI, 2018).
Losses
• It results from the calculation of the result of a period, when expenses exceed revenues (MEGLIORINI, 2012).

Figure 1: Terminologies used in Costs

2.1.2 General Principles and Concepts of Costs

Martins (2018) states that a system is not just a set of flows, routines, norms, but is also composed of people, and that depends on them for it to work and achieve the goal of its creation / application.

The first step before starting the implementation of costs in an organization is the definition of the Costing System that will be used, as it interferes in the results (Dias & Padoveze, 2007). Bonacim & Araujo (2010) argue that even though there are some alternatives of using costing methods, it is possible to adopt more than one method simultaneously and harmoniously, aiming to subsidize the cost systems, since it has common characteristics, having specific information to the functions of control and planning of the activities of an entity. A demonstration with the characteristics of the main Costing Systems or Methods will be shown below in Figure 2.

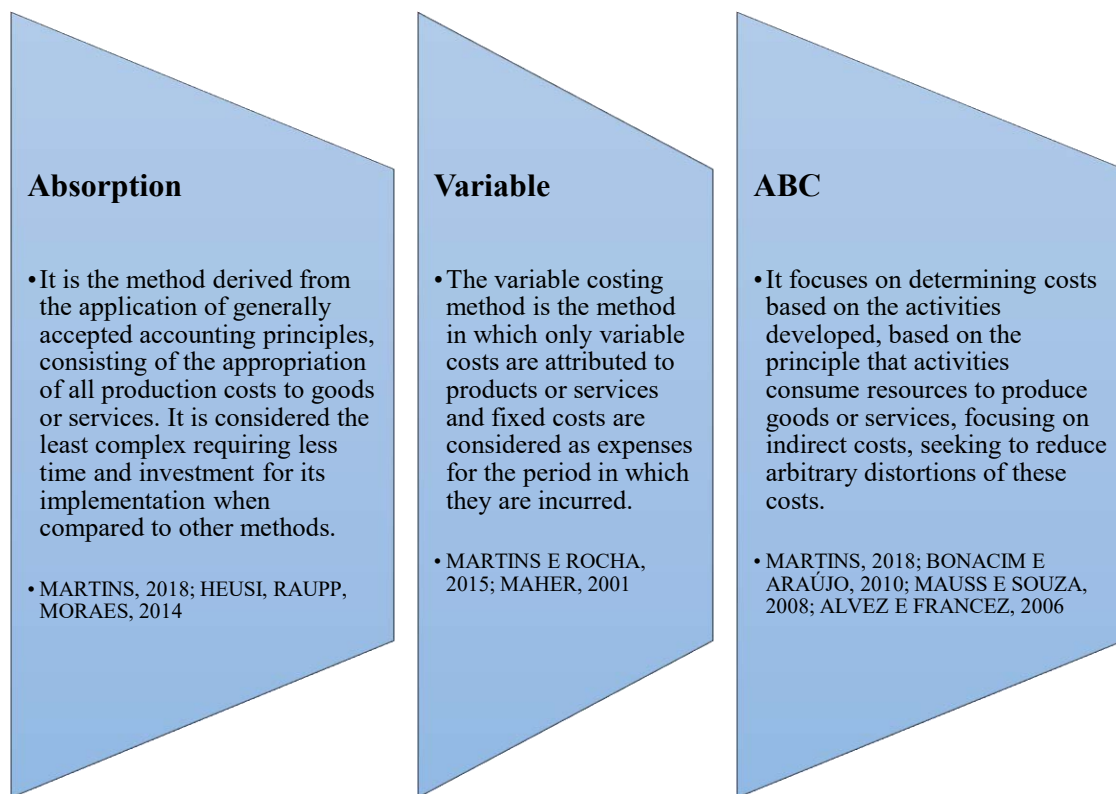


Figure 2 - Main Costing Systems or Methods

2.1.2 Activity Based Costing

Developed from the dissatisfaction of cost data determined by traditional methods (Brimson, 1996), methods that were developed in another time, where labor and applied materials were predominant factors of production and indirect costs did not contribute significantly to the cost total (Kaplan & Cooper, 2000), ABC Costing was developed to systematically distribute these costs (Silvestre, 2002; Bornia, 2010; Megliorini, 2012).

Corroborating with the authors above, Alves & Francez (2006) and Martins (2018), state that ABC is the method that seeks to reduce distortions caused by arbitrary allocation of indirect costs, and can also be applied to direct costs. In this sense, the activity-based costing method focuses on indirect costs, making the cost composition more robust, allowing a more accurate calculation of the economic result (Mauss & Souza, 2008). Figure 3 illustrates how to allocate costs to products through ABC.

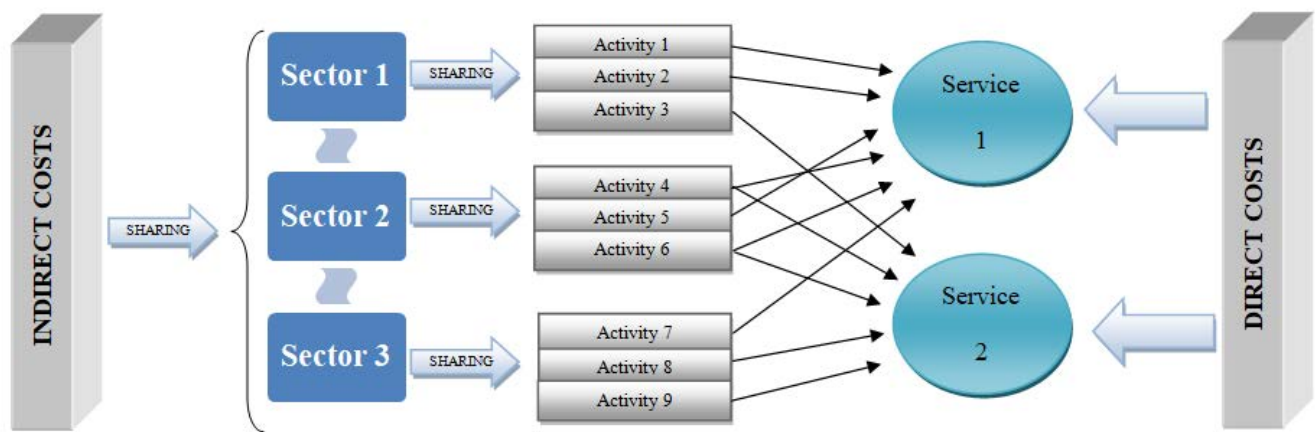


Figure 3 - ABC Costing Scheme - Activity Based Costing

2.2 Calculation of costs in the public sector

Because it is of great importance and for providing fundamental content to support more efficient government allocation decisions, facilitating sustainability and economic development, cost information must be disseminated throughout the public sector (Machado & Holanda, 2012). One of the main discussions regarding the implementation of cost systems in the public sector is the definition of costing objects and the method for calculating costs that become complex due to the lack of the profit factor, which makes the definition of the cost object more difficult (Tres & Silveira, 2013). As evidenced by Martins & Rosa (2014), the most viable and appropriate costing method for use “is one that produces consistent information and this should allow an analysis regarding the choice regarding the production or purchase of products and services, as well as the execution or outsourcing of certain activities”. In this sense, each unit will be able to choose the method that best meets its reality and characteristics, paying attention to the issue of consistent information and that helps in management (Costa & Raupp, 2018). In this scenario, the ABC costing method is the most discussed and suggested for the calculation of costs in the public sector (Carneiro et al. 2012; Cordeiro & Alves, 2016).

2.3 Bidding Process in the Federal Government

As established in Art. 37 of the 1988 Federal Constitution, Public Administration, unlike private individuals, is obliged to adopt a preliminary procedure when contracting the execution of works, services, purchases or disposals with third parties (Palaveri, 2005; France, 2013). As general rules, we have Law n°. 8.666/93 entitled Law of Public Bids and Administrative Contracts, as well as the Law of Trading Floor, n° 10.520 of 2002, which basically figure as the existing legislation on public tenders. Regarding the bidding modalities, five are traditionally described in Art. 22 of Law 8.666 / 93, namely: competition, price taking, invitation, tender and trading floor. The trading floor was introduced among the existing modalities, being extended to all Federative entities as of Law 10.520 / 2002 (Rodrigues, 2012). Among the procedures resulting from Law 8.666 / 93 we have the use of the Price Registration System - SRP, which consists of allowing public management to contract services or purchases without having to carry out a new bid for each contract, and from that system, the adhesion arose. Thus, unlike the bidding process, membership does not generate a contracting commitment, but a commitment to keep the quantities of products available

for the duration of the price registration (Fernandes, 2007).

3. Methodology

To achieve the proposed objective, a case study was carried out as conceptualized by Yin (2015) in a University Hospital located in the city of Manaus (AM), also using the documentary methods that according to Appolinário (2012) is part of all work of research, and unstructured interviews that are well outlined and defined by Marconi & Lakatos (2009). The survey began with the mapping of four (4) completed acquisitions. From this mapping, all the essential elements were identified for the calculation of costs, which were: identification of the sectors and their respective activities, demonstration of the resources used by these sectors; calculation of the hourly value of the server in each sector and the time of each activity; allocation and cost calculation. This path can be best demonstrated in Figure 4.

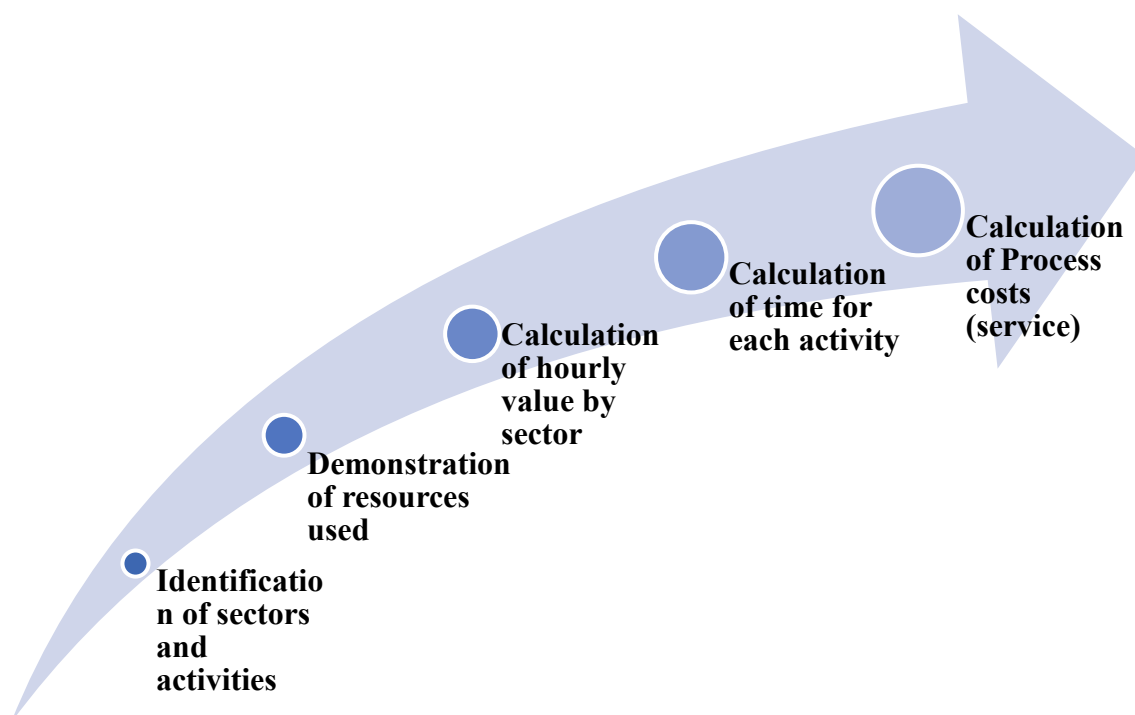


Figure 4 - Methodological Path

4. Results and Discussion

4.1 Sectors and activities involved

The identification of the sectors and activities involved was carried out through interviews and documentary research, which made it possible to elaborate the flow of the materials acquisition process carried out at the university hospital, as shown in Figure 5.

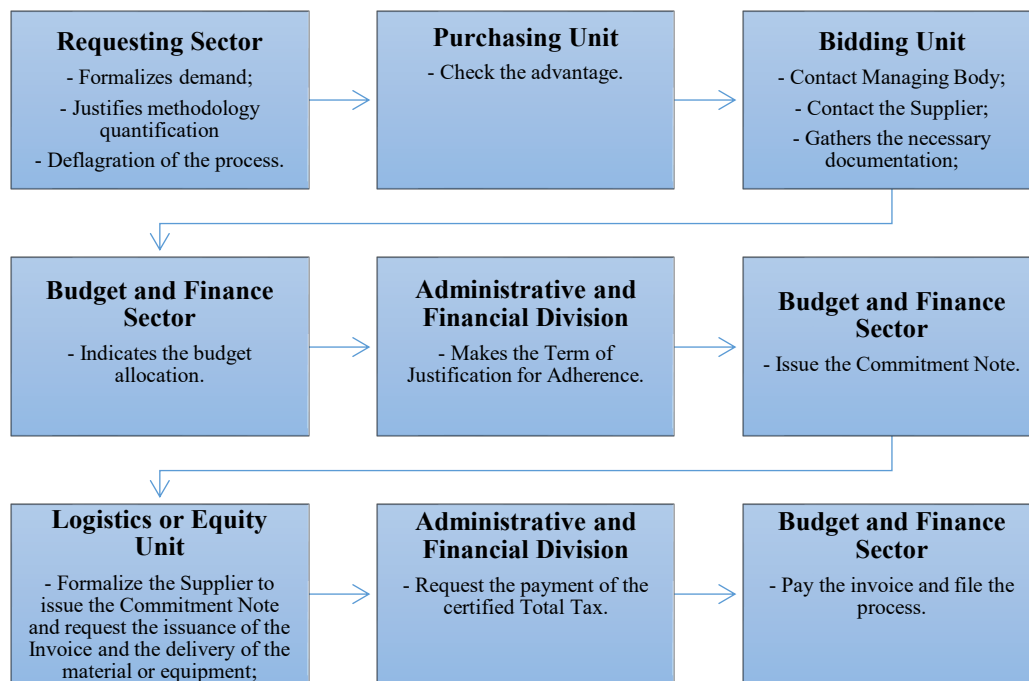


Figure 5 - Flow of the acquisition process

The acquisition process involves 6 (six) departments and, based on this information, surveys were carried out with those involved in the process to, from then on, identify the resources used and the time that each one uses for the activity.

4.2 Resources Used

Through information extracted from the Transparency Portal, it was possible to identify the remuneration and benefits (transportation, meals, etc.) of the employees involved, demonstrated in full, as shown in Table 1.

Table 1 - Monthly Compensation and Benefits by Department

Sector	Remuneration Monthly	Benefits
Bidding Unit	R\$10.751,06	R\$2.277,08
Purchasing Unit	R\$ 8.859,43	R\$ 963,81
Equity Unit	R\$ 8.326,87	R\$1.115,06
Budget and Finance Sector	R\$21.159,26	R\$1.351,93
Logistics Sector	R\$16.675,82	R\$1.096,51
Administrative and Financial Division	R\$17.900,73	R\$1.430,33

Considering that the university hospital is managed by a Public Company governed by the Consolidation of Labor Laws - CLT, social and labor charges were calculated based on the percentage shown in Table 2.

Table 2 - Percentage for calculating Social and Labor Charges

Burden Breakdown	(%)	(%)
Labor benefits		
13th salary		8,33%
Vacation		11,11%
Social charges		
INSS	20,00%	
SAT	3,00%	
Education Salary	2,50%	
INCRA/SENAI/SESI/SEBRAE	3,30%	
FGTS	8,00%	
Total Social Security		36,80%
Social Security on 13th and Vacations		7,15%
Total		63,39%

Other features that can be considered in the process are:

- A4 paper cost: they are purchased for the price of approximately R \$ 14.00 (fourteen reais) per ream, which generates a cost of R \$ 0.03 (three cents) per sheet;
- Printing cost: the entity has a contract with a supplier that costs R \$ 0.12 (twelve cents) per impression;
- Process folder: costs around R \$ 1.50 (one real and fifty cents) per unit.

4.3 Calculation of the hour and time value of activities

Consolidating the consumed resources presented in the previous steps, the monthly values were obtained, and to determine the hourly cost, the remuneration was considered divided by 176 (one hundred and seventy-six) hours, taking into account 8 (eight) hours daily in 22 (twenty-two) monthly business days per year, reaching the results of the hourly values of each department, as presented in Table 3.

Table 3 - Cost per hour with personnel

Sector	Monthly Remuneration (Average)	Benefits	Social and Labor Charges	Total Cost /Monthly	Cost/Hour
Bidding Unit	R\$10.751,06	R\$2.277,08	R\$6.815,10	R\$19.843,24	R\$112,75
Purchasing Unit	R\$8.859,43	R\$963,81	R\$5.615,99	R\$15.439,23	R\$87,72
Equity Unit	R\$8.326,87	R\$1.115,06	R\$5.278,40	R\$14.720,33	R\$83,64
Budget and Finance Sector	R\$21.159,26	R\$1.351,93	R\$13.412,85	R\$35.924,04	R\$204,11
Logistics Sector	R\$16.675,82	R\$1.096,51	R\$10.570,80	R\$28.343,13	R\$161,04
Administrative and Financial Division	R\$17.900,73	R\$1.430,33	R\$11.347,27	R\$30.678,33	R\$174,31

4.4 Calculation of activity time

Through interviews and documentary analysis, it was possible to identify the time used for each activity, which, related to the hourly value of each sector shown in Table 3, achieved the results shown in Table 4, determining at that time the cost per activity.

Table 4 - Calculation of Activity Costs

Activity	Time in hours	Executing Sector	Cost of Activity	
Deflagration of the Process for acquisition of Consumable Material	08:00	Logistics Sector	R\$	1.288,32
Deflagration of the Process for acquisition of Permanent Material	08:00	Equity Unit	R\$	669,12
Check advantage (price estimate)	16:00	Purchasing Unit	R\$	1.403,52
Contact Governing Body	02:00	Bidding Unit	R\$	225,50
Contact winning company	02:00	Bidding Unit	R\$	225,50
Obtaining documents for the adhesion event	08:00	Bidding Unit	R\$	902,00
Budget Allocation Indication	01:00	Budget and Finance Sector	R\$	204,11
Preparation of Terms of Justification for Adherence	04:00	Administrative and Financial Division	R\$	697,24
Issue of Commitment Note	00:30	Budget and Finance Sector	R\$	102,06
Contact Supplier for delivery of goods (Consumption Material)	01:00	Logistics Sector	R\$	161,04
Contact Supplier for delivery of goods (Permanent Material)	01:00	Equity Unit	R\$	83,64
Receiving the material (Material Consumption)	02:00	Logistics Sector	R\$	322,08
Receiving the material (Permanent Material)	01:30	Equity Unit	R\$	125,46
Request for Payment of the Good (Material Consumption)	01:00	Logistics Sector	R\$	161,04
Request for Payment of Goods (Permanent Material)	01:00	Equity Unit	R\$	83,64
Payment authorization	04:00	Administrative and Financial Division	R\$	697,24
Settlement of the process expense	02:00	Budget and Finance Sector	R\$	408,22
Payment of the process expense	02:00	Budget and Finance Sector	R\$	408,22
File Provisions	03:00	Budget and Finance Sector	R\$	612,33

4.5 Calculation of Process costs (Service)

After identifying the cost per activity (Table 4), it is possible to calculate the costs of services, reaching the end of the ABC costing methodology cycle, as previously illustrated in Figure 3. The application of this methodology in the present study can be demonstrated through the Figure 6.

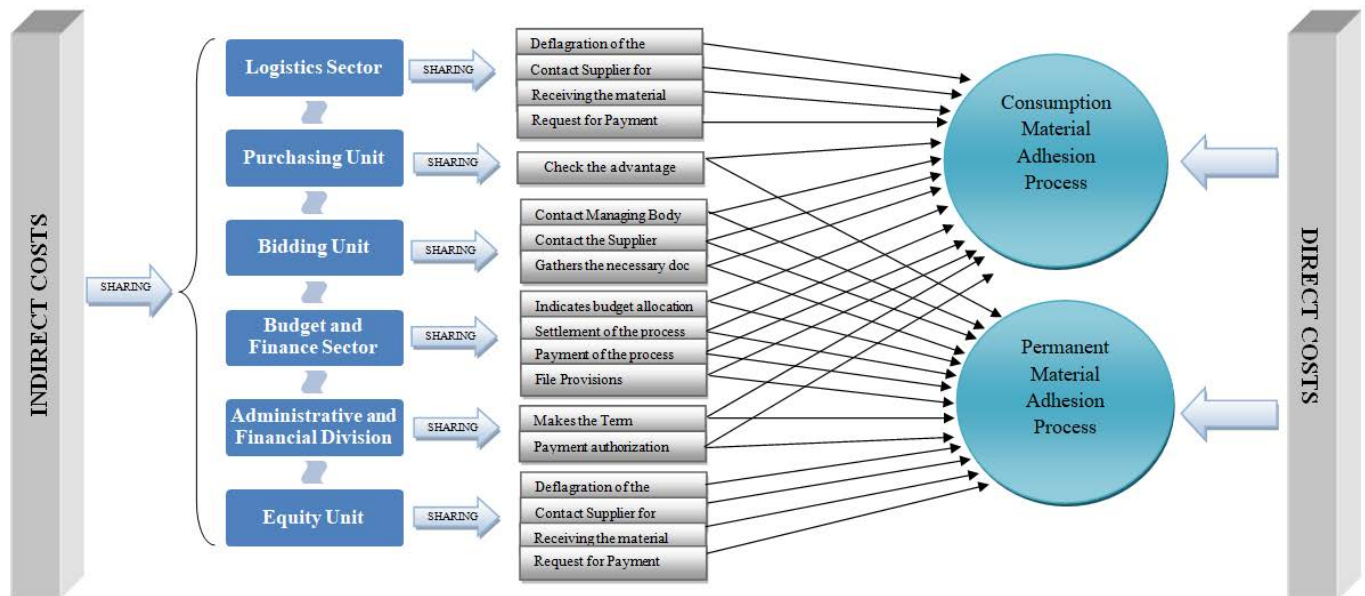


Figure 6 - ABC cost calculation process

As described in the methodology, 04 (four) material purchase processes already completed at the university hospital were analyzed. The service to complete this acquisition is the cost object of this work, which was divided into 02 (two) for the purchase of consumable material and 02 (two) for permanent material. The 02 (two) processes of consumable materials presented the costs shown in Table 5.

Table 5 - Cost of material consumption

Sector	Monthly Remuneration (Average)	Benefits	Social and Labor Charges	Total Cost /Monthly	Cost/Hour
Bidding Unit	R\$10.751,06	R\$2.277,08	R\$6.815,10	R\$19.843,24	R\$112,75
Purchasing Unit	R\$8.859,43	R\$963,81	R\$5.615,99	R\$15.439,23	R\$87,72
Equity Unit	R\$8.326,87	R\$1.115,06	R\$5.278,40	R\$14.720,33	R\$83,64
Budget and Finance Sector	R\$21.159,26	R\$1.351,93	R\$13.412,85	R\$35.924,04	R\$204,11
Logistics Sector	R\$16.675,82	R\$1.096,51	R\$10.570,80	R\$28.343,13	R\$161,04
Administrative and Financial Division	R\$17.900,73	R\$1.430,33	R\$11.347,27	R\$30.678,33	R\$174,31

The 02 (two) processes of permanent material, presented the results in Table 6.

Table 6 - Cost of Permanent Material

Object	Value Acquisition	Physical Details Other Costs	Cost with Folks	Others Costs	Total Costs	% over the value acquisition
Machine acquisition Hemodialysis	42.000,00	112 sheets/188 prints/ 01 Process Folder	R\$ 6.847,80	R\$ 57,66	R\$ 6.905,46	16,44%
Microscope Acquisition for the Ophthalmology Service	75.000,00	115 sheets/199 prints/ 01 Process Folder	R\$ 6.847,80	R\$ 59,88	R\$ 6.905,46	9,21%
Average					R\$ 6.906,57	12,83%

The data presented, verified that the total average cost of the service of acquisition of Consumable Material was R\$ 7.861,11 (seven thousand eight hundred and sixty-one reais and eleven cents), corresponding on average to 21.71% of the value of materials acquired, while the service for the acquisition of Permanent Material was R\$ 6.906,57 (six thousand nine hundred and six reais and fifty-seven cents), corresponding on average to 12.83% of the value of the acquired equipments.

5. Final Considerations

This work aimed to demonstrate the application of the ABC costing methodology to determine the costs of the procurement process carried out in the public sector. The research was carried out at a university hospital in the city of Manaus / AM.

The survey results showed the cost of purchasing consumables and permanent materials, which generated a cost to the public government of R \$ 7,861.11 and R \$ 6,906.57, respectively, representing up to approximately 21% of the acquired value.

The research makes it evident that the use of the ABC Costing method to determine service costs in the public sector was successful. ABC also proved to be the most appropriate tool for cost management in the public sector, due to the more robust treatment in the distribution of indirect costs.

From the results achieved, it is clear that bureaucracy burdens the procurement process in the public sector, as well as all other processes, which require many procedures and paths to be followed in order to comply with the rite imposed by the legislation that governs the acts of public administration.

The measurement of costs in the public sector, in addition to serving as accounting information, appears as an essential management tool for the public manager, who can use this information as indicators of efficiency and governance for example, demonstrating the managerial contribution of this research.

The economic contribution of this research is in the field of resource management, making it possible to

identify which processes are more costly, enabling the evaluation of alternatives that make services within the public sector less expensive.

As a social contribution, this work presents the disclosure of costs in the public sector, taking into account the prerogatives of transparency, making public information on the application of public resources.

For future work, it is recommended to consider the costs of electricity, water, and outsourced services, which are not considered in this work because the team involved in the service surveyed is running a home office due to the social distance experienced because of the pandemic (Covid-19).

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Bayesian Approach to the Assessment of Geological Risk in Oil and Gas Exploration

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Abstract

When assessing undiscovered oil resources, an important step is the assessment of geological risk, which is usually defined as the probability that there will be no accumulation of hydrocarbons. Some important authors have traditional ways of obtaining this probability, but these classic models are not developed on a rigorous basis. Therefore, they may present conflicting results, which are not always compatible with reality and are not able to take into account historical data from similar situations already studied. This article aims to propose a Bayesian approach to the determination of geological risk with advantages over classical approaches. The positive aspects and limitations of the Bayesian approach are discussed and an illustrative application using fictitious data is presented.

Keywords: Undiscovered Oil Resources Assessment; Risk Analysis; Geological Risk; Bayesian Approach.

1. Introduction

The oil industry has many high-risk investments (Ribeiro, Inacio Jr., Ly, Furtado, & Gardin, 2020), and this is one of its main characteristics. These risks are mostly from geological, economic, and engineering nature. As a result, it takes place a necessary meticulous probabilistic analysis of the decisions. The use of adequate proper probabilistic methods for the risk quantification process can increase the quality of available information as well as the managers' capability of making decisions.

The exploration process of oil and gas involves, in few words, the understanding of geological structure to be explored pointing to the hydrocarbons' existence and the volume of the hydrocarbon evaluation. For hydrocarbon exploration to proceed, most firms need their explorers to estimate the geological risk to segments and prospects for exploration (Zhu, et al., 2018).

The main step in the oil and gas obtaining process is exploration (Stabell & Sheehan, 2001) and the greater possibility of making value is in this phase. This occurs because of the high level of geological uncertainties, even in the presence of seismic and other tests. Another reason for this large uncertainty is the high cost of exploratory wells (Jones, 2018). It is not uncommon that 90 percent of exploratory wells result in dry wells

(Hyne, 2001).

The largest portion of the oil and gas reserves in Brazil is deposited in high deep-water fields (Li, Yun, Dufen, Jiexin, & Tao, 2016). Therefore, the exploration costs increase and so the risks. The use of probabilistic methods for decision analysis in Brazil and several countries in the world is quite incipient. Thus, it is a research product of an exceptionally good direction for the improvement of the making decisions process in the petroleum industry.

The exploration process is supported by the results of awfully expensive tests. Consequently, the decision-makers appeal to experts' opinions about indirect tests, especially seismic and other geological pieces of evidence.

Unsurprisingly, the experts' opinions are affected by biases and miscalibration (Lucena, 2006). A large literature discusses how to deal with those problems (Spetzler & Stäel von Holstein, 1975; Kahneman, Slovic, & Tversky, 1982; Hora, 2004; Daneshkhah, 2004).

After the analysis of indirect tests, the experts, supported by theories, own experience, and information about analogous oil fields; establish a model to the geological structure assessed. The next step is the economic evaluation of the oil prospects to compose a project portfolio.

A prospect evaluation involves the calculation of the geological risk and the volume of recoverable oil (Rose P. , 2017). Many relevant papers treat the calculation of the volume of the recoverable hydrocarbons (Otis & Schneiderman, 1997; Schuenemeyer, 2002; Rose P. , 2004).

The existence of a proper geological structure does not assure the hydrocarbons' occurrence (Zhu, et al., 2018). Therefore, it is necessary to define the probability that the hydrocarbons are present in the evaluated prospect; this probability is called the probability of geological success (Rose P. , 2004) and is used as a parameter to measure the geological risk.

The determination of the probability of geological success is the central subject of this paper. Even being in the base of the whole exploration process, the geological success is surprisingly not much discussed in specific literature.

The available literature suggests that geological success is a function of geological factors. However, no method rigorously justified in combining the probability of occurrence of these factors, in particular, doesn't seem any reason to affirm that the occurrence of a determined geological factor has a deterministic weight in the geological risk estimation.

We found some methods in use (Otis & Schneiderman, 1997; Rose P. , 2004), that do not consider the interrelationship between the geological factors, this is the major contribution of this paper.

This paper proposes a Bayesian methodology for determining the probability of geological risk as an alternative to the existent restricted models and, considering some restrictions, more accurate.

2. Geological Risk: Classical Approach

The geological risk (Gr) is that one which should be considerate in the process of evaluation of hydrocarbons' existence in a play.

A play is the elemental part of a petroleum system and has one or more accumulation of hydrocarbons [8] with geological common characteristics. These potential hydrocarbons accumulations are called prospects.

The probability of the geological risk is the probability of hydrocarbons occurrence in a prospect [8,10]. This probability is calculated considering that certain geological factors are present. These factors may differ according to the authors. Based in Rose (2004) and Schneiderman (1997), some geological factors are determinant to the existence of hydrocarbons accumulations, as:

- a) A **source rock** that can generate the oil.
- b) A **reservoir rock** that can keep the hydrocarbons.
- c) A **trap**, that's a rock that seals the reservoir.
- d) And the **timing**, that is the necessary time to generating the hydrocarbons e its migration.

All these factors are essentials to hydrocarbons occurrence, i.e. if someone of these probabilities is zero, there is no possibility of hydrocarbons occurrence.

Once these probabilities are estimated, they must be combined to compose the probability of hydrocarbons occurrence. To Otis and Schneidermann (1997) the probability of geological success is calculated by the product of the probability elicited of the factors, that is, the occurrence of the geological factors is considered unrelated. To Rose (2004), perhaps guided by his experience, recommends considering the probability of geological success as the lowest probability of the factors. To illustrate these models, we present the table 1 below.

Table 1. Models of Probability of Geological Success

Author	Model
Otis and Scheneidermann (1997)	$P_g = \prod_{i=1}^n P_i$ (1)
Rose (2004)	$P_g = \text{Min}[P_i]$ (2)

Source: Otis and Scheneidermann (1997) and Rose (2004)

Note that both models are compatible with the premise that the impossibility of the occurrence of one of the factors determines the non-existence of hydrocarbon accumulation.

Some publications assist the geologist in determining the probability of the occurrence of each of the factors. However, this is not a topic covered in this paper.

Typically, each of these factors is divided into subfactors presented in checklists. Otis and Schneidermann (1997) present a checklist that can be used to analyze all the subfactors relevant to each of the characteristics needed to evaluate. The table 2 below shows an example of how such lists are presented:

Table 2. Example of checklist to geological factor analysis

Factor A - Reservoir rock
1. Presence
a. Lithology
b. Distribution
c. Depositional Model
2. Quality
a. Lateral continuity and extension
b. Vertical thickness and cyclicity
... (so on)

Source: Adapted from Otis and Scheneidermann (1997)

After evaluating each of the elements presented in the list, the geologist should code the concepts in terms of probabilities, that is, from the evaluation of the sub-factors, he should qualify them as: unfavorable, questionable, neutral and encouraging, and with that identify the range of probabilities you are in. An example is shown in table 3.

Rose (2004) and Otis and Schneiderman (1997) indicate different qualitative concepts about the evaluator's certainty and semantic scales that help him to associate his ideas with a probability. An important point of convergence between the authors is that the probability of the geological factor will be equal to the lowest probability among its sub-factors.

In practice, a form for assessing the probability of the factors that result in the value of the geological risk takes the following appearance:

Table 3. Example of Geological Factors Probability Assessment Form

A. Reservoir Rock	Unfavorable	Questionable	Neutral	Encouraging	Favorable
1. Presence					X
2. Quality			X		
3. Other				X	
Range of probabilities	0.1 to 0.3	0.3 to 0.4	0.4 to 0.6	0.6 to 0.7	0.7 to 0.9

Source: Otis and Scheneidermann (1997)

In the case presented above, the probability of the reservoir factor is associated with the probability of the quality subfactor, that is, 0.5.

After estimating the probability of all geological factors, the probability of success is calculated using the selected model and, consequently, the geological risk. With the determination of the geological risk, the appraiser goes on to a coherence analysis that depends strictly on the appraiser's knowledge regarding the geological formation under study. If any inconsistency is found, the evaluator redoes the steps to determine where bias may have occurred.

The result of this process will be called geological risk or geological risk factor and will be interpreted qualitatively based on the indications of the model proponent. Table 4 below presents the qualitative interpretation for the result found in the models presented according to the risk range, note that the risk scale does not show the compatibility of magnitude. This difference is a result of the model applied, for example, if the probability of estimated occurrence of all geological factors is equal to $P_i = 0.8$ in the model (1) the probability $P_g = 0.41$ which is equivalent to low risk and in the model (2) $P_g = 0.8$, which represents a scenario of probable occurrence of hydrocarbons.

Table 4. Qualitative Interpretation of Geological Risk

Pg Range	Model (1)	Model (2)
1.0 ± 0.9	Very Low Risk	Virtual Certainty
0.9 ± 0.8		Reasonable Geological Confidence
0.8 ± 0.7		Occurrence Probable
0.7 ± 0.6		
0.6 ± 0.5		Significant Uncertainty
0.5 ± 0.4		
0.4 ± 0.3	Low Risk	Higher Probability of Absence
0.3 ± 0.2		
0.2 ± 0.1	Moderate Risk	Geological Factor of High Risk
	High Risk	
0.1 ± 0.0	Very High Risk	Impossible to Occur

Source: Otis and Scheneidermann (1997) and Rose (2004)

Incompatibilities in these models can occur when there is a large difference between the probabilities of the factors since the model (2) strictly considers the lowest probability of occurrence among the geological factors.

The following section presents an alternative approach to the calculation of Pg, based on the principles of Bayesian statistics.

3. Bayesian Approach to the Definition of Geological Risk

Before presenting the Bayesian approach, it is important to verify some assumptions used about the geological risk. (1) The geological risk depends on predetermined geological factors; (2) the mathematical expression that relates the probabilities of occurrence of these factors is not important for the application of the Bayesian model; (3) some information about past events (analogous fields in the case of undiscovered oil resources) is necessary for the model to perform well; (4) the probabilities of occurrence of the geological factors are considered to be uncorrelated (which is an approximation). Also, the determination of the qualitative description of the geological factor remains subject to the process presented in table 5. However, the combination of these factors starts to be performed using the well-known Bayes 'theorem (3) presented as follows:

$$P(\theta | F_1 = Q_1, F_2 = Q_2, F_3 = Q_3, F_4 = Q_4) = \frac{P(F_1 = Q_1, F_2 = Q_2, F_3 = Q_3, F_4 = Q_4 | \theta) \cdot P(\theta)}{P(F_1 = Q_1, F_2 = Q_2, F_3 = Q_3, F_4 = Q_4)} \quad (3)$$

With,

$P(\theta)$ – Probability of hydrocarbons occurring

F_i – i-th geological factor

Q_k – the expression that qualifies the i-th factor, e.g. (favorable, neutral, unfavorable, etc.).

This update scheme can be used for numerous types of information (Clemen & Winkler, 1999). The Bayesian approach presents the difficult task of obtaining the joint probability of the geological factors conditionally on the occurrence of the event, $P(F_1 = Q_1, F_2 = Q_2, F_3 = Q_3, F_4 = Q_4 | \theta)$, which is necessary to obtain the relationship between the event and the geological factors. As we consider the occurrences of independent geological factors, we can perform the following transformation:

$$P(\theta | F_1 = Q_{k_1}; \dots; F_n = Q_{k_n}) = \frac{\prod_{i=1}^n P(F_i = Q_{k_i} | \theta)}{\prod_{i=1}^n P(F_i = Q_{k_i} | \theta) + \prod_{i=1}^n P(F_i = Q_{k_i} | \bar{\theta})} \quad (4)$$

For the Bayesian approach to have a satisfactory result, there must be a reasonable history of observed events. The example presented in table 5 supposes a history for the occurrence of each geological factor, in past geological explorations, in three qualitative classes: unfavorable, neutral, and favorable.

Table 5. History of Occurrence of Geological Factors (example)

Factor A	θ	$\bar{\theta}$	Factor B	θ	$\bar{\theta}$	Factor C	θ	$\bar{\theta}$	Factor D	θ	$\bar{\theta}$
Unfavorable	5	25	Unfavorable	6	23	Unfavorable	7	25	Unfavorable	6	24
Neutral	20	20	Neutral	22	18	Neutral	22	20	Neutral	24	18
Favorable	30	18	Favorable	31	20	Favorable	27	17	Favorable	29	18
Totals	55	63		59	61		56	62		59	60

Source: Authors

In terms of probability we have those presented in table 6:

Table 6. Probability of Occurrence of Geological Factors (example)

Factor A	θ	$\bar{\theta}$	Factor B	θ	$\bar{\theta}$	Factor C	θ	$\bar{\theta}$	Factor D	θ	$\bar{\theta}$
Unfavorable	0.09	0.39	Unfavorable	0.10	0.37	Unfavorable	0.12	0.40	Unfavorable	0.10	0.40
Neutral	0.36	0.31	Neutral	0.37	0.29	Neutral	0.39	0.32	Neutral	0.40	0.30
Favorable	0.54	0.28	Favorable	0.52	0.32	Favorable	0.48	0.27	Favorable	0.49	0.30
Totals	1	1		1	1		1	1		1	1

Source: Authors

Using the above historical data, if we calculate the probability of hydrocarbon discovery using expression 3, given that the geological factors were evaluated as A = Favorable, B = Neutral, C = Favorable and D = Neutral, using 4, we express by:

$$P(\theta | A = F; B = N; C = F; D = N) = \frac{0,545 \cdot 0,373 \cdot 0,482 \cdot 0,407}{0,545 \cdot 0,373 \cdot 0,482 \cdot 0,407 + 0,285 \cdot 0,295 \cdot 0,274 \cdot 0,300} = 0,85$$

In this example, the probability of hydrocarbons occurs given the historical data is 85%. The main virtues

of the Bayesian approach are to avoid biases, despite (in the same way as the others) considering the factors as probabilistically independent (when, in fact, they are not) and also making it possible to adjust the final probability for a coherent solution, even that experts have been systematically biased in their assessments of geological factors.

The main problem with using this approach in the oil exploration activity is the difficulty of generating reliable historical data since the formation of a play does not necessarily have to do with others evaluated by the team. However, the use of this methodology in a field already under development or with existing analogous fields can bring more satisfactory results than the subjective incorporation of analogies.

In recent years, the application of the Bayesian approach has been growing, mainly in areas where subjective probability is used, but in real applications for the calculation of geological risk, the approximate classical approach is still much more present, mainly due to its practicality. However, it is intuitively perceived that the Bayesian approach is more adequate to deal with the biases of specialists and its complexity is very reduced if it is properly implemented on a computer.

4. Conclusions

The estimation of geological risk in the process of assessing undiscovered oil resources plays a fundamental role in the composition of the oilfield exploration project portfolio. Over the years, new methodologies and procedures have been developed to increase the credibility of this type of assessment. This article aims to contribute to stimulating research on this subject.

Many oil companies today develop their methods and algorithms for carrying out risk analysis, seeking to maximize the value of their exploration and production portfolio. However, the competitive advantage that such methods can provide makes them little known.

Most of the known and adopted methods for risk assessment have important limitations. The methods described as classic, do not take into account the bias of expert evaluators that are already reflected in data from previous evaluations of analogous situations. The Bayesian approach presupposes the existence of a history of assessments, which is not always possible to obtain, but which can exist, or be accumulated, for large oil basins. In it, the specialist has as the main concern the evaluation of certain geological characteristics, and the model conveniently combines these evaluations with the information present in the evaluation history of geologically similar areas.

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Effects of Environmental Exposure to Tobacco on Modulation of Color Vision

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Abstract

The chronic use of cigarettes causes toxic and oxidative effects on the visual system, which can cause changes in color vision. Although there are studies on the harmful effects of tobacco in active smokers, the literature on secondhand/passive smokers (or environmental tobacco smoke) is still scarce. Therefore, the aim of this study was to investigate the ability of color vision in active and passive smokers. This is a cross-sectional observational study in which 103 individuals were divided pseudorandomly into 3 groups: control group (CG) n = 44 individuals (72 eyes), with a mean age of 28.65 ± 7.90 ; group of passive smokers (GPS) n = 28 (56 eyes), mean age 28.74 ± 9.42 ; group of active smokers (GAS) n = 31 (60 eyes), mean age 34.91 ± 11.30 . The psychophysical evaluation of color vision was performed using the Ishihara pseudoisochromatic plates, the computer program of the Freiburg Visual Acuity & Contrast Test, version 3.7, and the desaturated Lanthony D15 ordering test. The results indicate that there was no correlation in GAS and GPS with age, time of exposure to tobacco and daily consumption. It was observed that both GAS and GPS showed changes in visual acuity ($P < 0.05$), and only GPS showed changes in color vision ($P < 0.05$); GFP showed a deficit in visual acuity and worse color vision when compared to GAS ($P < 0.05$). These results are discussed in relation to the biochemical and pathophysiological effects that exposure to cigarettes may have on the visual system, which would explain the functional changes observed. We conclude that passive and active smokers have impaired color vision and that the psychophysical methods used in this study are effective for the subclinical tracking of changes in color vision.

Keywords: smoking; color vision; environment; active and passive smokers.

1. Introduction

The World Health Organization estimates that approximately 6 million people die each year as a result of the harmful effects of tobacco consumption, however, only 5 million are active users, the rest are passive

smokers (or environmental tobacco smoke), which makes tobacco one of the largest threats to public health [1,2].

Cigarettes have about four thousand types of substances, including benzene, polonium 210, hydrogen cyanide, formaldehyde, xylene, dichloro-diphenyl-trichloroethane (DDT), phosphorus P4 and P6, phenol and nicotine. [2, 3, 4]. Among the top five risk factors for mortality, smoking is one of the preventable causes of death. It is estimated that approximately 10 million deaths will occur in the year 2030 if global control measures are not adopted [5, 6, 7].

In Brazil, 23 people die every hour due to problems related to smoking, which affects 17.2% of the population over 15 years of age [8, 9].

The age range for starting smoking and becoming a smoker is estimated to be between 18 and 24 years, which makes smoking an important socioeconomic problem and is a serious health warning [10, 11].

Cigarette smoking is a risk factor for several diseases including cardiovascular and respiratory diseases [10, 11]. In addition to smoking affecting the entire organism, its consumption is also associated with neuro-ophthalmological changes such as age-related macular degeneration, cataracts, shortening of the time to break the tear film, itching, burning in the eyes and dryness suggestive of dry eye syndrome [7, 10]. Some authors also suggest that chronic cigarette use is related to toxic neuropathy linked to smoking that affects color vision both on the green-red axis [12, 13, 14] and on the blue-yellow axis [15, 16].

Many of the changes in visual functions resulting from intoxication can happen before other more serious neurological disorders. These manifestations can occur subclinically, making the assessment of visual function to be used as a signal that the intoxication process is happening [17, 18]. To investigate visual functions, there are several methods, including psychophysics, which has tests and non-invasive instruments capable of detecting early changes, indicating losses before the appearance of more harmful signs and symptoms [19].

Given the above, the general objective of this study was to investigate the effects of environmental exposure to tobacco on color vision. More specifically, the experiments carried out investigated (1) possible differences in color vision performance in active and passive smokers and; (2) possible relationships between the performance in color perception with time and the intensity of cigarette consumption.

2. Material and Methods

This is an observational, analytical cross-sectional study carried out in the city of São Luís-MA, whose research protocol was approved by the Ethics Committee for Research with Humans at the CEUMA University (registration # 3.115.352). All volunteers signed an informed consent form to participate in the research.

2.1 Sample

171 subjects were recruited, of these 68 were excluded due to the exclusion criteria, thus leaving 103 subjects who remained in the study and were divided into three groups: group of active smokers, group of passive smokers and control group (Figure 1).

The group of active smokers (GAS) consisted of 31 subjects who were smokers on average for 16 years and smoked on average 7 cigarettes per day. The average age of this group was 34 years.

The group of passive smokers (GPS) was composed of 28 subjects who had been cohabiting with active smokers for at least 1 year (mean of 17 years and standard deviation of 11 years). The average age of this group was 29 years.

The control group (CG) consisted of 44 subjects who were neither exposed to active nor passive smoking. The average age of this group was 29 years.

The recruitment of volunteers took place through an invitation to participate in the research published on social networks, posters posted in schools and health centers. Inclusion criteria were health and age over 18 years, with smoking being the criterion for the experimental group. The exclusion criteria were chronic diseases, such as diabetes and systemic arterial hypertension, psychiatric and neurological diseases, such as depression, anxiety, schizophrenia and epilepsy, eye diseases such as cataracts and glaucoma, infections such as toxoplasmosis and malaria and a history of exposure to chemical agents such as heavy metals, organic solvents and agrochemicals.

All study participants underwent rigorous medical history and medical evaluation. Then they performed a battery of psychophysical tests evaluating visual acuity and color vision. The flowchart below illustrates the sample selection and the composition of the groups.

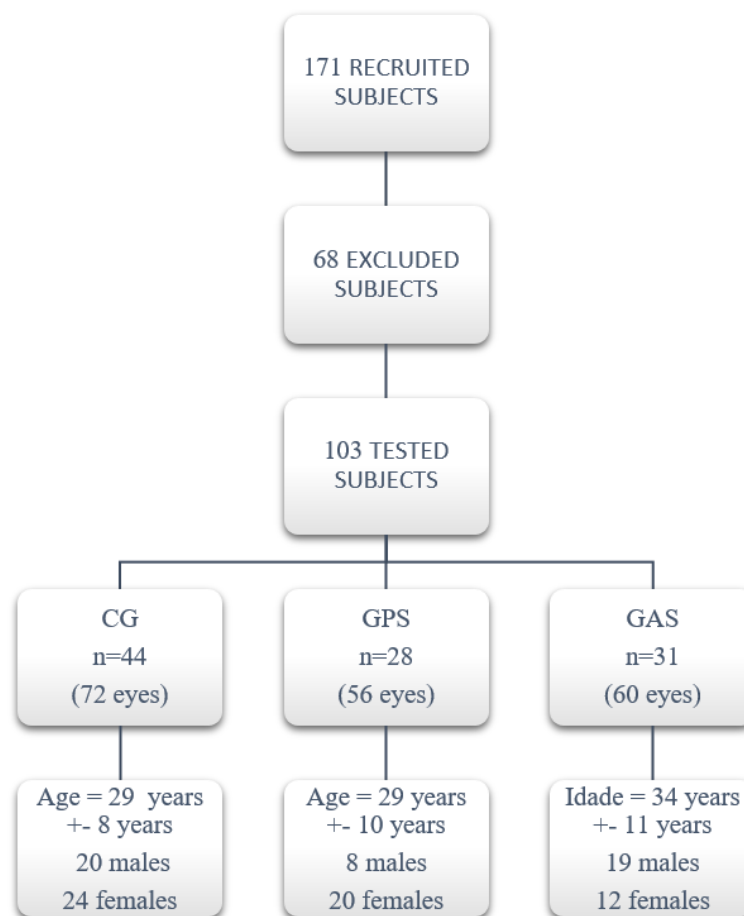


Figure 1. Flowchart of the studied sample.

2.2 Tests and instruments for visual assessment

2.2.1 Ishihara Pseudoisochromatic Plates

The assessment of color vision was performed using the Ishihara pseudoisochromatic plates widely used in studies of visual psychophysics because they have high sensitivity and specificity [20, 21]. In addition, studies show that this test is effective for the rapid identification of congenital and acquired deficiencies. The Ishihara test contains boards that differentiate protanomalias from deuteranomalias [21]. The test was carried out with a book containing the pseudoisochromatic plates - Ishihara's Test for Color Deficiency, edition of 24 plates (2009, Kanehara Trading Inc., Japan), under lighting of approximately 67000 Kelvin to 25 candles of the Illuminant, which is a Richmond Illuminator Flat Tray Tru-Daylight.

In the test the target is composed of a group of circles that form numbers and that differ from the background only by the difference in chromaticity. For this study, 17 plates were used; the first stimulus presented to the subject was a control stimulus that can be viewed by healthy subjects with dyschromatopsies. It does not have a pseudoisochromatic configuration and serves to verify if the subject understood the command. Another 14 plates contain stimuli for evaluating protans and deutans dysromatopsies; and 2 plates are for making a differential diagnosis between protan-type dyschromatopsia and deutan-type dyschromatopsia. These plates were presented (for 3 seconds each) at a distance of 75 cm from the subject's eye, and the subject was instructed to answer which number he could see. The test was performed on both eyes in a monocular form.

As a result, the number of errors and the plates on which the confusions took place were considered. Thus, the results of each tested subject could be compared with the reference values indicated in the test manual. For the screening of altered color vision, the tested subject was considered normal if there was a maximum of 6 errors in the response.

2.2.2 Freiburg Visual & Contrast Test (FrACT)

This test consists of the computer program Freiburg Visual Acuity & Contrast Test, version 3.7, which aims to assess visual acuity. The test was performed in a photopic environment with the computer monitor light used to present the stimuli.

The test stimulus consists of the shape of the letter "C" by Landolt in high contrast of luminance in relation to the background. The opening of the "C" was presented to the subject in 4 different orientations (above, below, right and left) and the individual should inform the direction in which the stimulus is being presented. With each presentation, the program automatically increases or decreases the size of the letter "C" according to the responses obtained, totaling 30 presentations of the stimulus.

The stimulus presentation follows a random sequence and the computer program records the minimum stimulus size that the subject can detect (inform). To perform the test, the subject was positioned at a distance of four meters from the screen of a 15" computer monitor, according to the Freiburg Visual Acuity & Contrast Test manual (version 3.7). The test was performed in both eyes of each subject in a monocular form. The test result was plotted from data made available by the evaluation program itself considering decimal values.

2.2.3 Desaturated Lanthony D15 hue ordering test

The Lanthony D15 desaturated tint ordering test (number 4428, Richmond Products Inc., USA) was performed under lighting of approximately 67000 Kelvin at 25 foot-candels of the Illuminant, which is a Richmond Flat Tray Tru-Daylight Illuminator.

The test consists of 16 pieces that have 2 degrees of visual angle with constant saturation of 2 and varied hue. The stimulus (piece) was presented at a distance of 75 cm from the subject's eye.

At first, the tested person had a minute to view the pieces correctly arranged on a table according to the color gradation. Then, the experimenter dispersed the pieces leaving only the first piece of the fixed organization (piece number 0) to serve as a reference for the ordering.

The subject was instructed to reorder (position) the pieces as presented in the first moment, taking into account pieces with a similar hue next to each other. Each piece is internally numbered from 0 to 15 so that only the experimenter has control of the correct order to be followed.

At the end of the reorganization of the pieces, the subject was able to make the adjustments he deemed necessary for the best ordering. The test was performed in both eyes of the tested subject, monocularly, twice in each eye, with the first attempt in each eye being used only for training and discarded afterwards. For the analysis of the results, the Color Confusion Index (CCI) was calculated, which takes into account the number of pieces placed in the wrong position and the distance it was from its proper position. The results were quantitatively evaluated using the CCI, which indicates that the worse the vision, the greater the number of pieces placed in the wrong position [22]. Also analyzed were the parameters of the C-Index, which takes into account the magnitude of the error made, the S-Index, which takes into account how far the error was made, and the Angle, which takes into account the location where the error it was more persistent [3].

2.3 Statistical design

Initially, the data were analyzed for normality using the D'Agostino Pearson test. For all the visual parameters studied, a comparison was made between active and passive smokers with control subjects and between them using ANOVA one way with Tukey post test.

To analyze the relationship between variables raised (age, consumption time in years, number of cigarettes per day) in the interviews with subjects and the results observed in the visual tests, the linear correlation coefficient in a correlation matrix was used. In all cases, an $\alpha = 0.05$ value was considered.

3. Results

The CG showed better visual acuity when compared to the GAS and GPS groups ($p < 0.05$ and $p < 0.01$, respectively). Interestingly, the GPS group showed lower results when compared to the GAS ($p < 0.05$) (Figure 2).

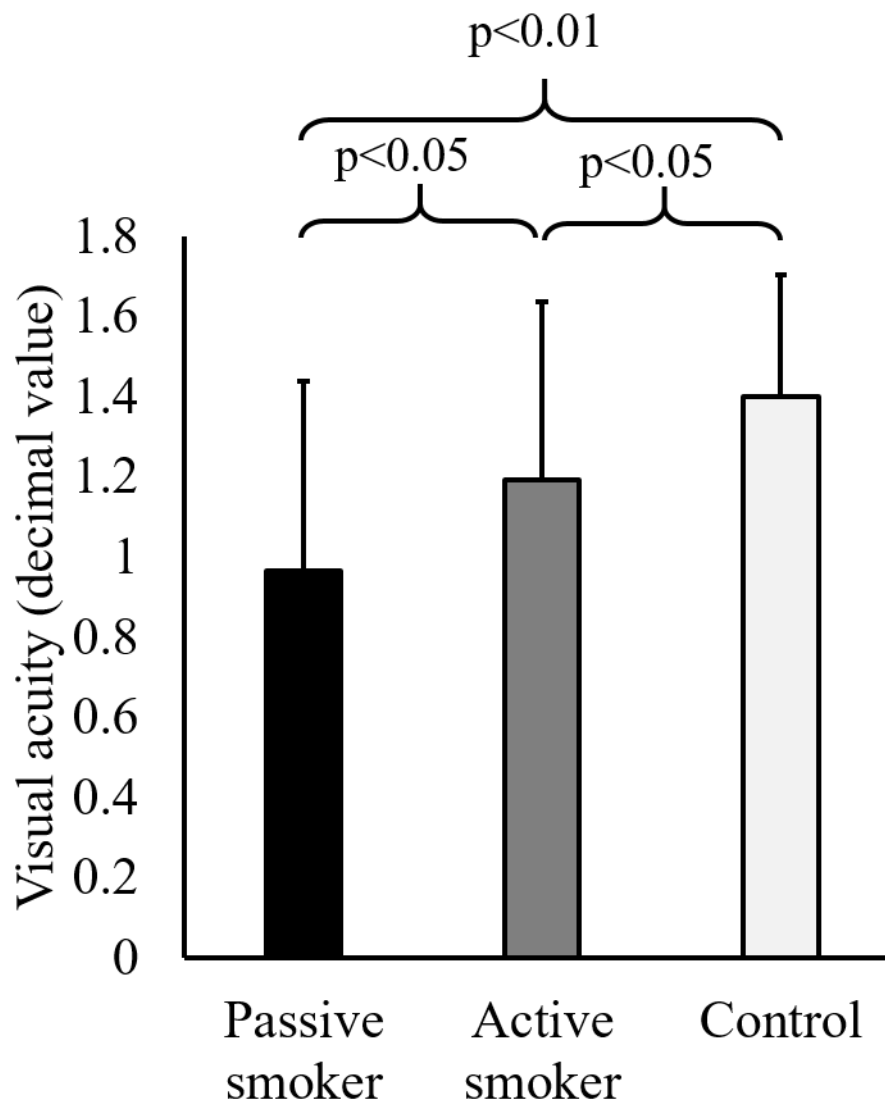


Figure 2. Visual acuity of the three studied groups: passive smokers, active smokers and control group. The vertical columns indicate the average visual acuity in decimal value and the bars indicate the standard deviation. The horizontal bracket indicates statistical difference between the groups with the significance value of $p < 0.05$ for the one-way ANOVA.

GPS subjects showed, on average, lower values for CCI when compared to CG ($p < 0.01$) and C index ($p < 0.05$). There was no difference between GAS and GC. For all other color vision assessment parameters, there was no difference between groups (Figure 3).

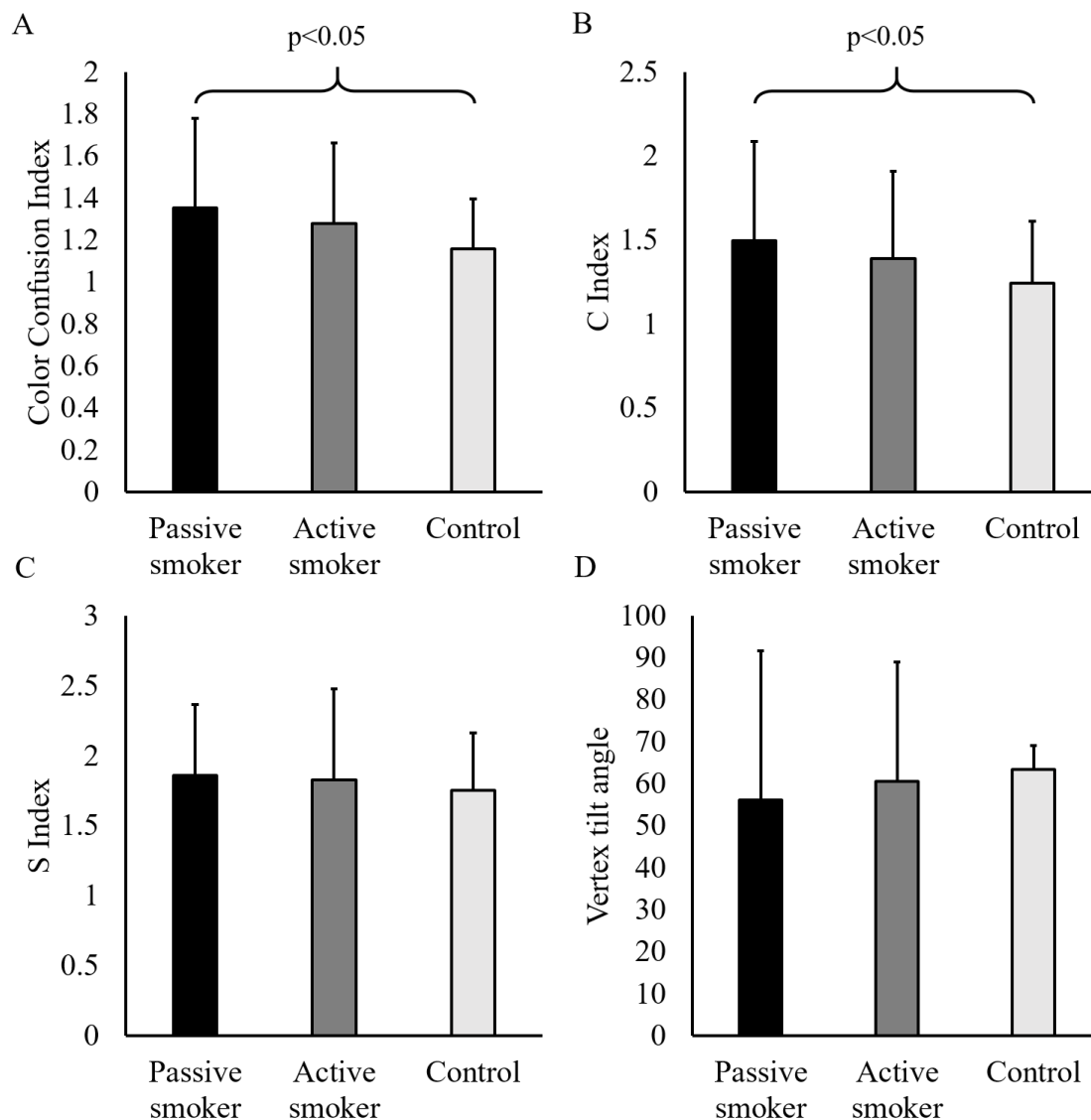


Figure 3. Color vision analysis performed by the Lanthony D15 test desaturated for the three groups studied. (A) Analysis of the Color Confusion Index with $p < 0.01$. (B) Analysis of the C index with a value of $p < 0.05$. (C) Analysis of the S. (D) index of the Tilt angle analysis of the color vector. The vertical columns indicate the average of each studied parameter and the bars indicate the standard deviation. The horizontal bracket indicates statistical difference between the groups with the p significance value for one-way ANOVA.

There was no significant correlation between age and visual performance of active and passive smokers in the tests used (Table 1). In addition, there was no correlation between the time of exposure to tobacco and the visual performance of active smokers in the tests used (Table 2) and there was no correlation between exposure time and visual performance of passive smokers (Table 3).

Table 1. Correlation between groups of active, passive smokers and age.

Age vs GAS and GPS						
GAS	Erros Ishihara	Visual Acuity	CCI	C-Index	S-Index	Tilt Angle
n (pairs)	53	53	53	53	53	53
r(Pearson)	-0,0703	-0,0103	0,1905	0,1907	0,1643	0,1689
R2	0,0049	0,0001	0,0363	0,0364	0,027	0,0285
t	-0,503	-0,0732	1,3859	1,3873	1,1892	1,224
(p)	0,6171	0,9419	0,1717	0,1713	0,2398	0,2265

GPS						
n (pairs)	49	49	49	49	49	49
r(Pearson)	-0,0371	-0,2785	0,0376	0,0461	0,1224	0,0234
R2	0,0014	0,0776	0,0014	0,0021	0,015	0,0005
t	-0,2543	-1,9882	0,258	0,3161	0,8452	0,1603
(p)	0,8004	0,0525	0,7975	0,7533	0,4023	0,8734

CCI= Color Confusion Index.

Table2. Correlation between the group of active smokers and time of exposure to tobacco.

Time of exposure vs						
Erros Ishihara	Visual Acuity	CCI	C-Index	S-Index	Tilt Angle	
n (pairs)	53	53	53	53	53	53
r(Pearson)	-0,0708	-0,0516	0,1737	0,1631	0,1645	0,1856
R2	0,005	0,0027	0,0302	0,0266	0,0271	0,0344
t	-0,5072	-0,3693	1,2598	1,1806	1,1909	1,3488
(p)	0,6142	0,7134	0,2134	0,2432	0,2391	0,1833

CCI= Color Confusion Index.

Table 3. Correlation between the group of passive smokers and time of exposure to tobacco.

Time of exposure vs						
Erros Ishihara	Visual Acuity	CCI	C-Index	S-Index	Tilt Angle	
n (pairs)	49	49	49	49	49	49
r(Pearson)	-0,1466	-0,0866	-0,013	-0,0528	-0,1456	-0,0599
R2	0,0215	0,0075	0,0002	0,0028	0,0212	0,0036
t	-1,0159	-0,5959	-0,0889	-0,3624	-1,0093	-0,4114
(p)	0,3148	0,5541	0,9295	0,7187	0,318	0,6827

CCI= Color Confusion Index.

4. Discussion

This study demonstrated that there are statistical differences between the visual performance of active, passive smokers and the control group. Visual changes were observed for visual acuity and color vision. According to the experimental design that excluded from the sample all subjects with suspected eye changes or visual changes resulting from health conditions and changes due to pre-established diseases, we consider that the visual changes found may be due to changes in the neuro-ophthalmological functions involved in the visual processing.

Since the worsening of visual performance with age represents a physiological condition of the visual system, the age of the volunteers could be an important bias for the subjects' visual performance, however our analysis showed that it did not show a correlation with the results, demonstrating no interfere with the results of present sample.

Thus, our results corroborate the literature that reports harmful effects of tobacco on the visual system. Even if the retinal tissue is not directly and morphologically affected [23], from a chemical and molecular point of view, chronic smoking reduces the production of oxygen and collagen in the tissues during healing, which would be related to ocular hypoxia caused by ocular hypertension and consequent decrease in corneal thickness [1].

The literature suggests that cigarette users are at an increased risk of developing diabetic retinopathy, glaucoma, severe ophthalmopathy and optic neuritis, in addition to nuclear cataracts [7, 11, 24, 25, 26], hyperopia and dry eye [27]. As any of these findings was the reason for exclusion from the sample, we suggest that the changes observed in this study could be caused by less severe subclinical conditions of affections such as those mentioned above.

Cigarette consumption is also related to the decrease in color vision involving both the green-red axis and the blue-yellow axis [15, 16]. As in our results, smokers who had their color vision assessed by a method similar to the desaturated Lanthony D15 test, the Farnsworth-Munsell 100 test, showed a lower Color Confusion Index, compared to those who did not smoke [15, 28, 29]. Additionally, these studies did not find statistical differences between smokers and non-smokers in relation to the red-green and blue-yellow sectors, which corroborates our findings in the S Index and tilt angle, suggesting a diffuse loss of color vision in chronic smokers [15]. That is, a diffuse impairment in processing that includes the magnum and parvocellular pathways in the subjects of the groups of active and passive smokers studied.

Toxic neuropathy related to smoking, especially affecting red-green color vision and carbon monoxide in cigarette consumption, may be the cause of this dyschromatopsia [12, 13]. It is also suggested that the saturation of the cones, alter the amplification of signals that reach the visual cortex or toxic action in the parvocellular pathway, resulting in changes in color discrimination [28]. These toxic and oxidative effects are believed to play an important role in eye changes and are considered one of the risk factors for many disorders [27, 28, 30].

The toxins in cigarettes cause a decrease in blood flow, helping to form clots within the eye capillaries, preventing the arrival of essential nutrients for eye health, increasing free radicals and promoting macular degeneration and ischemia, as well as decreased flow retinal blood pressure and reduced retinal vessel self-regulation ability after smoking [7, 11, 27, 28, 31].

The toxins and irritants present in cigarette smoke cause a reaction of the conjunctiva and redness of the eye, increasing the vulnerability of the optic nerve and modifying its blood supply; this can alter the histological structure of the conjunctiva and the characteristics of tears, indirectly exposing the corneal endothelial cells to ischemia [6, 7, 23, 32, 33].

Cigarette smoke contains approximately 1017 molecular oxidants. Free radicals cause changes in cell membranes that increase oxidative stress and, according to the literature, smoking causes low concentrations of antioxidants in plasma [6, 32]. This metabolism is indirectly affected by the chronic use of cigarettes through this decrease in plasma levels of antioxidants [31, 32].

A change in choroid thickness in short-term smokers and a decrease in choroid thickness in chronic smokers has been reported [34, 35]. It is also believed that smoking causes an imbalance in the neurotransmission of acetylcholine, dopamine and glutamate and deficiencies in the functioning or conformation of receptors, thus being able to modify visual processing [28, 36].

One study suggest that chronic smokers had fewer hexagonal cells than in the non-smoking group. This may be caused by hypoxia in chronic smokers, which changes the number of hexagonal cells. These results imply that the morphological characteristics of the corneal endothelial cells were affected by smoking [37]. The present study demonstrated that the visual performance of passive smokers was also compromised, and in all analyzes performed, the rates were lower than those observed for active smokers. To the best of our knowledge, this is the first study to demonstrate changes in color vision in passive smokers and that the damage may be greater in this group than in active smokers.

Studies reveal that the visual performance of smokers who consume more than 20 cigarettes a day is worse than smokers who consume less than that, suggesting that the intensity of exposure may be related to the severity of visual damage [38]; this analysis cannot be replicated in the present study since the maximum number of cigarettes consumed per day by our sample was 20. However, this relationship with intensity could be explained by the fact that passive smokers may be exposed to more than one active smoker, which would cause that their contact with smoking was greater. In addition, passive smokers generally begin their exposure at a very early age, many of them when they are still children, at a time when the visual system is still developing, which causes intoxications in this period of life can have a greater impact on individual's health [39].

Our results did not show correlation between time and intensity of exposure with visual performance. This is a common result whenever trying to compare functional losses with absolute values of exposure time. This may be due to the existence of genes that encode enzymes responsible for the metabolism of chemical substances and that the polymorphism modifies absorption and the risk of neurotoxic effects among individuals [40]. Susceptibility factors including age and inter-individual differences in the pattern of chemical substance absorption are involved in metabolism and compensatory processes, which also explains the difference in results between subjects exposed to chemical substances [41].

5. Conclusion

The results of this study indicate that tobacco consumption by active and passive smokers produces deficits in color vision processing that are probably caused by the neurotoxic effects of substances in cigarettes.

However, additional studies are needed to elucidate what are the neurobiological mechanisms underlying, directly or indirectly, this neurointoxication and why the observed changes are greater in secondhand/passive smokers.

The analysis also suggests that passive smokers had greater performance deficits than active smokers, indicating that their exposure to smoking shows more aggressive results than is usually imagined.

Moreover, the results obtained in the present study reinforce the usefulness of psychophysical methods such as those used in this study for tracking possible changes in the visual system even if a subclinical level.

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Teacher Written Feedback in EFL Classroom: Abu Hayyan al-Tawhidi High School- Kenitra, Morocco- as a Case Study

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Abstract

This paper is an empirical and analytical study of the uses of written feedback by Moroccan high school EFL teachers. It tries to investigate how EFL teachers in Abu Hayyan al-Tawhidi high school respond to students' compositions. Strong emphasis is laid on the types of teacher written feedback, with a focus on integrated feedback (form and content) as an effective way to respond to students' written work. The ultimate goal of this paper is to ascertain the types and forms of teacher written feedback prevalent amongst Moroccan EFL high school teachers. In this light, the study seeks to investigate the following research questions: (1) Which types of written feedback do Moroccan high school EFL teachers employ to respond to students' compositions? (2) Which forms of written feedback do Moroccan high school EFL teachers' employ to respond to students' compositions? To answer these questions, the present study used a mixed method approach that included: classroom observation checklist, document analysis of corrected writing productions and students' questionnaire. The key findings illustrated that teachers at Abu Hayyan al-Tawhidi high school relied heavily on form-focused feedback. It also revealed that teachers opted for correction symbols and commentary.

Keywords: English as a Foreign Language (EFL), Written Feedback, Writing skill, Baccalaureate students.

1. Introduction

The English language has got a considerable role in fields such as politics, business, and education. So, it is important to learn such a language for different purposes, especially education. In fact, learning English as a foreign language (EFL) is a complex and demanding process. One should acquire its four skills namely, speaking, reading, listening and writing. The latter is probably the most difficult skill amongst the foregoing four skills. The process of writing requires a great deal of efforts, time and practice. As a matter of fact, writing in a foreign language requires knowledge of vocabulary, grammar, organization and so forth. In addition, the writer needs a great deal of comments and responses about his/her performance. Thus, it is important that the instructor should constantly provide feedback so as to help the learner acquire the writing skill.

1.1. Research Problem, Questions and Hypothesis

Teacher written feedback is essential to help students enhance their writing skills. Students, to a great extent, value teachers' comments and remarks; thus, teachers should make efforts to ascertain the types and forms of written feedback conducive to students' improvements. In fact, some teachers think that a good piece of writing is hinged only on the form of the language. Herein emerged the academic need to ascertain the types of feedback teachers at Abu Hayyan al-Tawhidi high school provide. Thus, the research questions are as follows:

- Which types of written feedback do Moroccan high school EFL teachers employ to respond to students' compositions?
- Which forms of written feedback do Moroccan high school EFL teachers' employ to respond to students' compositions?

In an attempt to investigate the type of feedback used on students' writing, it is hypothesized that Abu Hayyan al-Tawhidi English teachers so heavily use form-focused feedback to respond to their students' compositions.

1.2. Research Purpose

The overall purpose of this descriptive study is to investigate the types of teacher written feedback used to respond to students' compositions in a Moroccan EFL classroom. The data is obtained through observation, document analysis and questionnaire at Abu Hayyan al-Tawhidi high school.

1.3. Research Significance

This study is an important endeavour to ascertain the types and forms of teacher written feedback used in Abu Hayyan al-Tawhidi High school. Generally, it tries to give Moroccan high school EFL teachers an idea about the appropriate written feedback they should adopt to respond to students' compositions. In fact, it is crucial that teachers should investigate which types and forms are most effective.

2. Related literature review:

2.1. The Written Feedback

This section defines teacher written feedback and discusses its different types and forms with focus on which is the most effective one amongst them. It also discusses students' reaction to teacher written feedback.

2.2. Defining Feedback

Generally, Dulay, Burt and Krashen (1982) describe the notion feedback as "the listener's or reader's response given to the learner's speech or writing" (p. 34). That is, both productive skills are hinged on the reader's or listener's response in order to be ameliorated. Specifically, in teaching context, Richards and Schmidt (2010) defines feedback as "comments or other information that learners receive concerning their success on learning tasks or tests, either from the teacher or other persons" (p. 217). K. Hyland (2003) regards feedback as a pivotal element in enhancing students' writing skills and contributing to students' learning. It is worth stating that Vygotsky (as cited in, K. Hyland, 2003) discusses a stage in cognitive growth named "the zone of proximal development" where skills are extended through the guidance and response of expert others" (p. 177). In fact, the teaching of writing must go hand-in-hand with providing feedback, because it is crucial to enhance students' performance in writing.

2.3. Teacher Written Feedback

Teacher written feedback is still considered pivotal for improving students' writing in an EFL classroom. Teachers and students recognize the importance of teacher written feedback; thus, teachers feel that they are compelled to comment on students' paper, justify their grades, and so forth (K. Hyland, 2003). Similarly, F. Hyland (as cited in K. Hyland, 2003) states that second language students exceedingly value their teachers' written feedback and try to make use of it. Despite the large amount of research that has concluded that teacher written feedback is ineffective as a way of improving students writing, it is still conducive to improving students' writing if it is employed appropriately (K. Hyland, 2003). As regards research on L1

writing, Sommers (1982) states that “teachers' comments can take students' attention away from their own purposes in writing a particular text and focus that attention on the teachers' purpose in commenting” (p. 149). That is to say, students' attention is on teacher written feedback rather than on their writing; therefore, they neglect their initial purpose which is writing. He adds that several examples of teacher-written feedback are irrelevant to the text in a sense that they can be ‘interchanged’ and ‘rubber-stamped from one text to another. That is, most teachers' comments are not specifically designed to students' texts; if they are moved from one text to another and would still make sense. For instance, comments such as “think more about [their] audience, avoid colloquial language, avoid the passive, avoid prepositions at the end of sentences or con-junctions at the beginning of sentences, be clear, be specific, be precise, but above all, think more about what [they] are thinking about” (p. 152). Therefore, Sommers (1982) suggests that teachers should be precise and thoughtful with their comments in order to help students concentrate solely on the purposes of their writing.

Concerning research on second language (L2) writing, Cumming (as cited in Zamel, 1985) points out the techniques ESL teachers implement to comment on students' texts. Chief amongst them is error identification. This technique seems to be widely adopted by English as a Second Language (ESL) teachers since they maintain that their sole task is to identify language problems rather than to develop students' cognitive abilities. It is worth noting that error identification is not workable. Zamel (1985) seems to agree with research carried in L1 writing (e.g., Sommers, 1982). She argues that ESL writing teachers constantly misread students' compositions and therefore fail to give accurate and thoughtful comments; they rather provide a myriad of abstract rules, write arbitrary corrections, respond to students' compositions as final products and focus on the form more than content. Zamel stresses that ESL teachers often pay attention to the form of the text rather than its content, because they “overwhelmingly view themselves as language teachers rather than writing teachers” (1985, p. 86). As a reaction to the phenomena of form-related versus content-related correction, Williams adroitly puts forward, as a reaction to the phenomena of form related versus content-related correction, that:

It is the difference between reading for typographical errors and reading for content. When we read for typos, letters constitute the field of attention; content becomes virtually inaccessible. When we read for content, semantic structures constitute the field of attention; letters-for the most part-recede from our consciousness (As cited in Zamel, 1985, p. 86).

That is to say, ESL teachers are often distracted by form-related problems, and thus fail to attend to meaning-related problems in students' writing. In fact, there are three types of teacher written feedback, namely, form-focused feedback, content-focused feedback and integrated feedback.

2.4. Types of Teacher Written Feedback

Teacher written feedback can target different aspects of language. It can be designed to comment on either the form or content of students' compositions, and sometimes it can comment on both aspects at the same time. Thus, three different types of teacher written feedback are discussed in this subsection.

2.4.1. Form-focused Feedback

Truscott (1996) claims that form-focused feedback (or grammar correction) is ineffective as a way of responding to students' writing. He adds that grammar correction could also be harmful and therefore ESL teachers should avoid it all at once. Such a radical conclusion could be accurate, since there has been scant

research, which fails to provide any solid theoretical ground or critically and thoroughly study the drawbacks of form-focused feedback. It is worth noting that Truscott sees that ESL teachers mistime grammar correction. That is, L2 learners normally acquire certain grammatical structures in a certain order; nevertheless, teachers correct some grammatical errors, which learners have not acquired yet. In fact, Truscott's article ignites a great deal of debate on the effectiveness of form-focused feedback in L2 settings. Chief amongst these debates is Ferris' (1999), who argues that Truscott's conclusions about error correction is rather premature and strong. She notes a number of limitations; firstly, Truscott's definition of grammar correction is vague. He (as cited in Ferris, 1999) defines error correction as "correction of grammatical errors for the purpose of improving a student's ability to write accurately." Later on, he adds, "correction comes in many different forms, but for present purposes such distinctions have little significance" (p.4). Such a definition, to Ferris, is deemed vague, and forms of error correction can be either careful and clear; or ineffective and misleading to students. Secondly, she observes that Truscott tends to advocate for previous negative research and dismiss positive research on form-focused feedback. However, Ferris admits that research which advocates for the effectiveness of form-focused feedback is inadequate, and Truscott's article, in fact, draws teachers and scholars' attention to rethink the effectiveness of such a type of teacher written feedback. Subsequently, other research tries to exhibit the benefits of grammar correction. Fathman and Whalley (1990) state that teachers should correct students' grammatical errors, because it improves students' accuracy.

2.4.2. Content-focused Feedback

Previous research on content-focused yields positive results. In an examination of four groups using different types of feedback, Semke (1984) states that the group that receives comments on content has scored better than the other groups. He finds out that commenting on content only is more effective than correcting errors only; correcting errors and commenting on content; or forcing students to correct their own errors. Zamel (1985) also states that teachers should give content-based feedback on the first, and point out grammatical errors later. She suggests this type of teacher written feedback, because students, if given both content-based and form-based feedback at the same time, may be perplexed to ascertain which type of feedback deserves more attention. It is worth noting that a great deal of research prioritizes content-focused feedback over form-based feedback. For instance, Kepner (1991) believes that meaning-focused feedback is more effective than form-focused feedback. She concludes that the former is conducive to enhance students' language accuracy and the level of thinking in L2 writing. Whereas the latter is deemed ineffective to develop neither aspect of L2 students' compositions. However, Lee (As cited in Park, 2006) seems to disagree with previous research, he maintains that correcting grammatical errors is easier than correcting meaning and ideas. Therefore, he sees that form-focused feedback is workable than content-focused feedback. Despite Lee's conclusion, many researchers agree that meaning-focused feedback is more effective than form-focused feedback.

2.4.3. Integrated Feedback

Song (as cited in Park, 2006) endeavours to ascertain which type of teacher written feedback (content-focused feedback or integrated feedback) yields better results. He finds out that integrated-focused feedback is conducive to enhance students' writing skills. To illustrate, the study's results show that students who have received integrated feedback gain higher grades than those who have received content-focused feedback in aspects such as content, organization and mechanics; whilst they score similar grades in aspects such as vocabulary and style. It is worth noting that integrated feedback yields better results. Ashwell's experiment (as cited in Park, 2006) proves the effectiveness of integrated feedback. It concludes that

integrated feedback is the most effective type of responding to students' writing, because it has helped students demonstrate a good mastery of writing skills. Such a conclusion urges Ashwell to respond to Zamel's (1985) argument that teachers should give content-based feedback on the first, and point out grammatical errors later. He also refutes Fathman and Whalley; Ferris' (as cited in Park, 2006) arguments that integrated feedback can be a harmful and ineffective practice by stating that integrated feedback is innocuous, and can lead to improvements on both levels: content aspect and grammatical accuracy. These types of teacher written feedback are typically given in a certain form.

2.5. Forms of Teacher Written Feedback

Teacher written feedback may take different forms. K. Hyland (2003) sketched out the most common forms. Chief amongst them are commentary, rubrics, correction symbols and electronic feedback.

2.5.1. Commentary

Commentary feedback is seen as the most common practice amongst ESL teachers. K. Hyland (2003) states that this technique takes the form of handwritten commentary on students' composition. This form of teacher written feedback is often written at the margin and the end at the same time. The former is more effective in a sense that they indicate the place of the problem immediately and show students how teachers progressively correct their writing, whereas, the latter, can only summarize the teachers' overall remark about students' texts. In fact, commentary is "best seen as responding to students' work rather than evaluating what they have done, stating how the text appears to us as readers, how successful we think it has been, and how it could be improved" (K. Hyland, 2003, p. 180). It is worth pointing out that this form of teacher written feedback is effective to provide students with comments on different level; it is not restricted to form-focused feedback, but it can include comments on content as well.

2.5.2. Rubrics

K. Hyland (2003) defines rubrics as "the use of cover sheets which set out the criteria that have been used to assess the assignment and how the student has performed in relation to these criteria" (p. 181). Normally, this form of teacher written feedback is handed to the student in order to have an idea how the teacher assesses and evaluates their compositions. K. Hyland also states that rubrics show "students what the teacher values in a particular piece of writing" (p.181). A sample of rubric adopted from K. Hyland (2003) is attached (see appendix A).

2.5.3. Correction Symbols

Correction symbols (also known as minimal marking) "refers to a type of in-text, form-based feedback" (K. Hyland, 2003, p. 181). Harmer (2007b) describes the use of correction symbols by stating that it involves underlining and using symbols accordingly to indicate students' mistakes. Oshima and Hogue (1997) provide the most common correction symbols used by teachers (see appendix B). Many researchers highly recommend the importance of using symbols or codes in correction, because writing a myriad of comments can be demotivating for students on the one hand, and time-consuming for teachers on the other. Therefore, K. Hyland (2003) observes that such a technique is "neater and less threatening than masses of red ink and helps students to find and identify their mistakes (p. 181). Harmer (2007b) also states that correction symbols "makes correction look less damaging" (p. 120). It is worth pointing out that, in order to use correction symbols effectively, teachers should explain what these symbols and codes stand for beforehand; otherwise, they would confuse students. However, there are some disadvantages of using correction symbols. K. Hyland (2003) states that "it is not always possible to unambiguously categorize a

problem, particularly when it extends beyond a sentence boundary” (p. 181). For instance, when teachers try to categorize a content problem; they find it quite difficult, since correction symbols technique is used merely as form-based rather than content-based feedback. Harmer (2007b) points out correction symbols are used only to respond to students’ writing as a final product rather than a process one. He adds that teachers should point out both form and content problems.

2.5.4. Electronic Feedback

Nowadays, students can receive feedback from their teachers through electronic mediums such as Facebook, emails, and to name but a few. This form of teacher written is workable, since through which:

Teachers can provide comments on electronic submissions by email or by using the comment function, which allows feedback to be displayed in a separate window while reading a word-processed text. Feedback on errors can also be linked to online explanations of grammar or to concordance lines from authentic texts to show students examples of features they may have problems using correctly (K. Hyland, 2003, p. 183).

It is worth noting that teachers can immediately provide students with invaluable online links showing them the correct usage of a certain grammatical structure, or providing them with more information about a factual point. In other words, teachers can provide both form-focused feedback and content-focused feedback.

2.6. Students’ Reaction to Teacher Written Feedback

Students’ preference for types and forms of teacher written feedback varies considerably; thus, teachers should consider what students pay attention in their revision. F. Hyland (as cited in K. Hyland, 2003) observes that “the effect of written feedback on student revisions in subsequent drafts has not been extensively studied, although it seems that students try to use most of the usable feedback they are given” (p. 179). That is to say, students value teacher written feedback and see it useful to their improvements. Hedgcock and Lefkowitz (1994) state that English as a foreign language (EFL) learners favour form-focused feedback, whereas ESL learners attend to content-focused feedback. They argue that the underlying reason for this predilection is students’ needs. For instance, EFL learners use English as a form of language practice, whereas ESL learners need the language in their daily practices. However, Enginarlar (1993) sees that EFL learners attend not only to form-focused feedback, but also to content focused feedback; he therefore states that such finding is a reminder for EFL teachers who overuse the red pen. To illustrate, this is a comment which an EFL student have made to respond to teachers’ way of responding to his/her composition; he/she says that:

I think you waste too much time with dots, commas, date on paper or where you write your name. You should concentrate more on the context (content?) of writing. First, I think you should read the composition without considering gr/sp/p and then correct it. Sometimes, I feel my paper is being graded only in terms of gr and sp (emphasis added) (Enginarlar, 1993, p. 199).

The student’s comment above, should urge EFL teachers to use content feedback rather than form focused feedback alone. However, according to a number of research (Chandler; Ferris, cited in Park, 2006) it is concluded that “when students received only meaning-related feedback, they tend to feel their teachers

don't pay much attention to their writing or even regard that teachers lack sincerity" (p.7). In other words, teachers should use integrated feedback which provides comments on two levels: content and form. In fact, Radecki and Swales (as cited in, K. Hyland, 2003) notes that "in contexts where they are asked to write multiple drafts, however, students claim to prefer comments on ideas and organization in earlier drafts and on grammar in later drafts, perhaps influenced by process oriented feedback practices" (p. 179). That is to say, the process approach is convenient for such types of feedback where teachers provide comments on both grammar and content.

3. Methodology

This section is going to present the methodological procedure designed to answer the research questions and hypothesis. It consists of research design, target population and sampling, data collection and analysis procedure.

3.1. Research Design

Generally, this research is a mixed method one which lends itself to answer the research questions enlisted in the introduction of this paper. In other words, this research is going to present both qualitative and quantitative ideas regarding the researched phenomenon. By definition, quantitative approach "involves the generation of data in quantitative form which can be subjected to rigorous quantitative analysis in a formal and rigid fashion" (Kothari, 2004, p. 5), whereas qualitative approach to research is concerned with "subjective assessment of attitudes, opinions and behaviour" (Kothari, 2004, p. 5). In fact, Kitchenham (2010) states that the use of mixed methods fit well in a case study research. Based on these, this case study is going to describe the types and forms of teacher written feedback used in Abu Hayyan al-Tawhidi high school. As far as research design is concerned, this research has employed a descriptive research design. The latter is defined as "those studies which are concerned with describing the characteristics of a particular individual, or of a group" (Kothari, 2004, p. 37). Accordingly, this research will describe the data using mixed methods to ascertain the types and forms of teacher written feedback in the aforementioned high school.

3.2. Target Population and Sampling

The populations of this study are Moroccan high school EFL teachers and students in Kenitra. Moroccan high school EFL teachers normally teach different streams, namely, arts, humanities, science and economics; students selected for this study also belong to the foregoing streams. Since it is not practically feasible to observe, question or analyse all these populations (teacher/student), a sampling method is highly needed in this respect. Namely, a convenience sampling method is employed to choose samples from Moroccan high school EFL teachers and students. This sampling method "involves purposive or deliberate selection of particular units of the universe for constituting a sample which represents the universe. When population elements are selected for inclusion in the sample based on the ease of access" (Kothari, 2004, p. 15). In fact, this study, which is a part of teaching training, takes place in Abu Hayyan al-Tawhidi high school situated in Saknia, Kenitra, Morocco. Before it became a high school, it had been two primary schools which were later conjoined in 2008 and named Abu Hayyan al-Tawhidi. This high school consists of 36 classrooms. It consists of 35 administrative staff and 70 teachers. Besides, the levels and streams in this high school are as follows: 8 Common Core groups, 5 Arts groups and 3 Science groups; 11 First Year Baccalaureate groups, 6 Arts groups and 5 Science groups; 23 Second Year Baccalaureate groups, 5 Arts groups, 8 Humanities groups, 5 Science groups, and 2 Economics groups. In fact, this research concentrates

on 5 high school EFL teachers and 62 second Baccalaureate students from two streams, namely arts and economics.

3.3. Data Collection Procedure

The instrumentation used in this research differs from one approach to another. In the qualitative phase, classroom observation and then document analysis are used to collect data about the researched phenomenon. The former according to Cohen, Manion and Morrison (2005) state that such data “afford the researcher the opportunity to gather ‘live’ data from ‘live’ situations” (p. 305). It is stated that the observer should bear the following questions in mind: “What should be observed? How should the observations be recorded? Or how the accuracy of observation can be ensured?” (Kothari, 2004, p .96). besides, this study has used a structured observation; that is to say, “the observation is characterised by a careful definition of the units to be observed, the style of recording the observed information, standardised conditions of observation and the selection of pertinent data of observation” (Kothari, 2004, p .96). In fact, a checklist is used to record how writing is taught, and which type and form of teacher written feedback is used in Abu Hayyan al-Tawhidi high school. This study also tries to find out which type and form of teacher-written feedback by collecting students’ corrected compositions from the seven EFL teachers at Abu Hayyan al-Tawhidi high school. In the quantitative phase, the instrument used is questionnaire. It is distributed to 62 students from different streams. It consists of eight closed questions about the frequency, type and form of teacher written feedback they receive, and their reaction toward it. items in this questionnaire are variegated in terms of scales: 3- point, 4-point and 5-point scales.

3.4. Data Analysis Procedure

Given the nature of this research, quantitative data (questionnaires) and qualitative data (observation/document analysis) is collected to answer the research questions. Thus; the analysis nature is going to be based on description and quantifying frequencies. Firstly, based on the checklist made for observation, a description of how writing takes place in an EFL classroom in general, and how teacher written feedback is provided to students in particular. Secondly, content analysis methods are used to find out how teachers respond to students’ compositions and what form(s) they adopt. Based on these descriptive findings, we are going to see if they match with the questionnaire administered to 62 second baccalaureate students in order to give an in-depth analysis as regards the researched issue. The questionnaire is going to be interpreted using Microsoft (MS) Excel.

4. Finding and Discussion:

4.1.Findings:

4.1.1. Classroom Observation

The checklist (see appendix C) was used to record how the teacher would normally teach the writing skill in general, and use written feedback to respond to students writing in particular. The first unit of “Ticket to English” textbook is entitled “The gifts of Youth” and the type of writing in this unit is a descriptive one. Students are normally asked to write a paragraph about a famous person. In fact, I recorded the 3 stages of the writing process namely, pre-writing, writing and post-writing. The checklist I used is a 3-point scale: (1) not observed, (2) more emphasis recommended and (3) accomplished very well.

The Pre-Writing Stage

- Item no. 1: According to item one in the checklist, the teacher seems to be aware of the importance of activating students' prior knowledge about the writing topic.
- Item no. 2: it is recorded that the teacher does not stress the importance of considering the target audience. Therefore, such elements are missing in their compositions.
- Item no. 3: It is recorded that the teacher, to some extent, encourages students to work in pairs but not in groups, because the tables are not arranged in a manner which facilitates such practice.
- Item no. 4: it is recorded that the teacher does not provide students with any strategy for generating ideas or organizing them. Such practice is not observed in the pre-writing stage.
- Item no. 5: it is recorded that the teacher does not encourage students to use any visual images such as graphic organizers and webs to organize their ideas.
- Item no. 6: it is recorded that the teacher does integrate the reading skill or allow students to take notes from previous text so they have ample vocabulary (ex: in descriptive writing, students are exposed to a number of adjectives and verbs related to size, height and so forth.) to express themselves freely.
- Item no. 7: it is recorded that the teacher analyses a text model related to the writing topic so as to allow students see how the text is built and organized.

The Writing Stage:

- Item no. 1: According to item one in the checklist, it is recorded that the teacher does lead students into building awareness of discourse organization. He explains how a piece of writing is organized: introduction, body and conclusion.
- Item no. 2: it is recorded that the teacher models how the parts of a text are linked through cohesive devices.
- Item no. 3: it is recorded that the teacher does not illustrate how sentence structure can vary to develop the meaning of students' compositions.
- Item no. 4: it is recorded that the teacher, to a great extent, helps students use correct spelling, punctuation, word form and so forth.
- Item no. 5: it is recorded that does not help students' correct facts and meaning related to the topic.

The Post-Writing Stage:

- Item no. 1: According to item one in the checklist, it is recorded that the teacher does mark areas to be improved in students' compositions.
- Item no. 2: it is recorded that the teacher encourages self-correction by underlining the mistake without providing correction and also encourages peer correction since it creates an interactive atmosphere in the classroom.
- Item no. 3: it is recorded that the teacher uses correction symbols to denote types of errors.
- Item no. 4: it is recorded that the teacher does not use marginal comments and ask the students to locate the errors by oneself.
- Item no. 5: it is recorded that the teacher does not share with students the rubrics used to assess their written work.
- Item no. 6: it is recorded that the teacher often uses form-focused feedback to respond to students' written work.
- Item no. it is recorded that the teacher does not provide content-focused feedback or integrated feedback at all.

4.1.2. Document Analysis:

While analysing the pieces of writing, focus is laid on the types and forms of written feedback which teachers opt for. Five corrected compositions are going to be analysed and described.

Sample 1: Teacher (1) emphasises, to a greater extent, on the composition form. A number of comments addressing accuracy problems permeates the student's composition, and incessant repetition of remarks addressing mechanics of writing make the student's paper look as if it should be rewritten from the topic sentence to concluding sentence. The teacher seems to overcorrect students' papers. For instance, the student writes: "we make fire" which is correct and meaningful; however, the teacher underlines it with no mention of the problem. Besides, the teacher seems to adopt both indirect and direct comments; that is to say, he/she sometimes provides corrections and others he/she underline mistakes. Teacher (1) tends to give both marginal and ends comments. It is deduced that the teacher use, to a great extent, form-based feedback.

Sample 2: Teacher (2) uses form-focused feedback to respond to the student's composition. A number of comments addressing mechanics of writing is formed as end comments. This is somewhat ineffective, because marginal comments tend to be proximate and immediate in a sense that they indicate what the teacher wants to correct immediately. Besides, the teacher seems to correct word by word without looking at the whole sentence. For instance, she changes "are" to "is" and "something" to "things" to stress that the following sentence: "there is things that one must do" is the correct form. It is worth noting that the teacher only crosses out and sometimes provides correction. It is deduced that the teacher does not read the composition as a meaningful whole, but rather as separate segments.

Sample 3: Teacher (3) focuses partially on the composition form. She/he tries to give relatively less comments on form, claiming that too much correction may demotivate students. As a solution, the teacher suggests that it is advisable to mention the mistakes, being overlooked, in class. It is worth noting that correction symbols permeate the text. Besides, the teacher uses only end comments to provide feedback.

Sample 4: The teacher (4) opts for form-focused feedback to respond to the student's composition. He/she uses a number of correction symbols as a form to respond to students writing; no marginal or end comments is used. In fact, the teacher uses confusing symbols and unclear handwriting, which would definitely be difficult for students to understand. It is worth noting that the teacher is distracted by accuracy problems, forgetting that there are content problems which could be pointed out. For instance, the student writes "in the camping must wear my jeans and I go to shopping with my brother" here the teacher should have asked the student to focus only on camping and suggest some ideas so as to help the student write a meaningful text. In fact, sometimes teachers do not pay heed to content problems.

Sample 5: The teacher (5) excessively focuses on the composition form. Several comments addressing accuracy problems permeate the student's composition, and incessant repetition of remarks addressing mechanics of writing may distort the student's initial sequencing of ideas. The teacher (5) adopts direct comments; that is to say, he/she sometimes provides correction. It is worth noting that the teacher (5) tends to give only end comments, summarizing the type of mistakes the student has made.

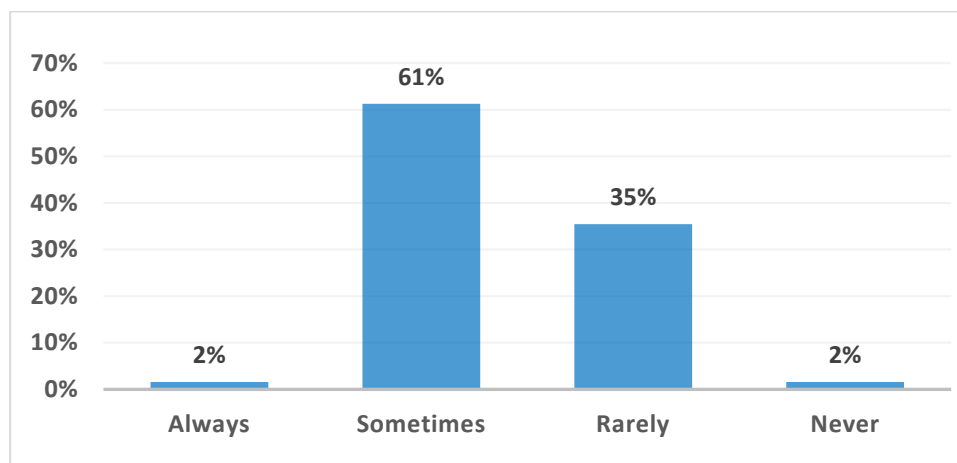
4.1.3. Students' Questionnaire

The questionnaire distributed to 62 Second Baccalaureate students is going to be presented in tables, graphs and comments.

Question 1: How do you often receive written feedback from teachers?

Options	Response	Percentage
Always	1	2%
Sometimes	38	61%
Rarely	22	35%
Never	1	2%

Table 1 The amount of time students receive teacher written feedback



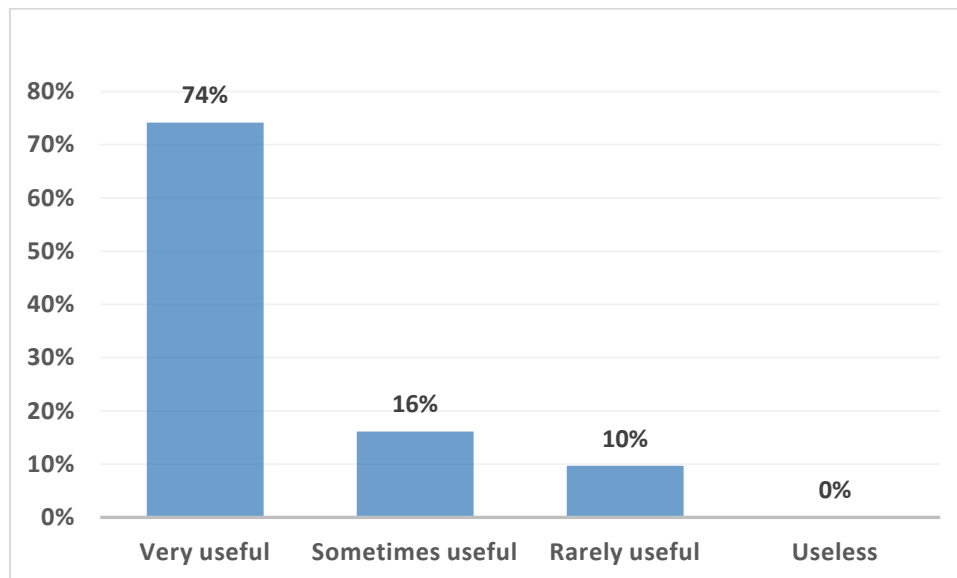
Graph 1 The amount of time students receive teacher written feedback

The two highest proportion 61% and 35% of the surveyed students, reflect that their teachers sometimes or rarely provide written feedback. Whilst only 2% say their teachers always or never provide written feedback.

Question 2: How useful is written feedback in improving your writing?

Options	Response	Percentage
Very Useful	46	74%
Sometimes Useful	10	16%
Rarely Useful	6	10%
Useless	0	0%

Table 2 The usefulness of teacher written feedback



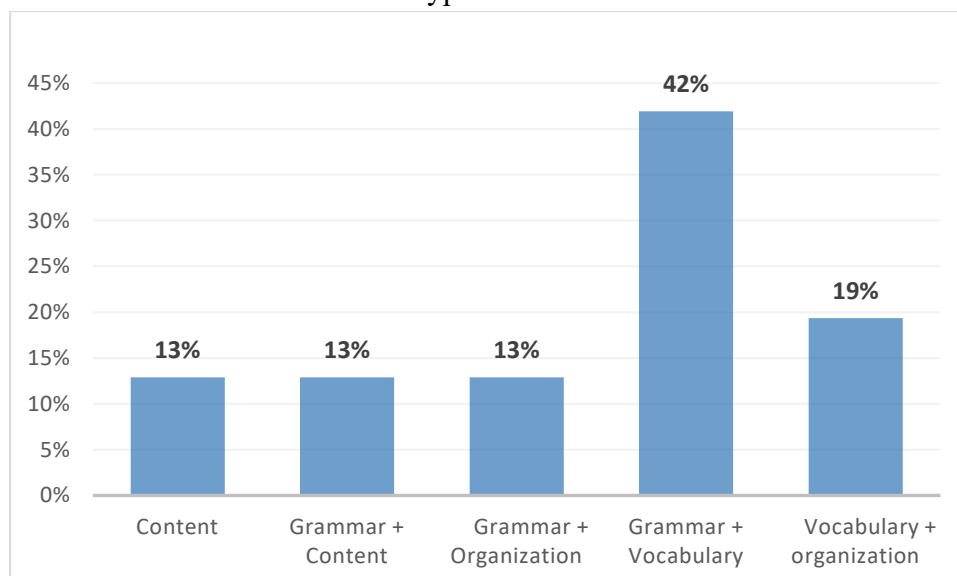
Graph 2 The usefulness of teacher written feedback

The highest proportion 74% representing the surveyed students' responses as to whether they think teacher written feedback is useful to improve their writing, reflects the very high degree of the students' belief in the usefulness of teaching written feedback. Only 16% of students believe that it is sometimes useful and 10% believe it is rarely useful. It is worth noting that 0% of the surveyed students believe that it is useless.

Question 3: What is important for your teacher?

Options	Number of Responses	Percentage
Content	8	13%
Grammar + Content	8	13%
Grammar + Organization	8	13%
Grammar + Vocabulary	26	42%
Vocabulary + Organization	12	19%

Table 3 Types of teacher written feedback



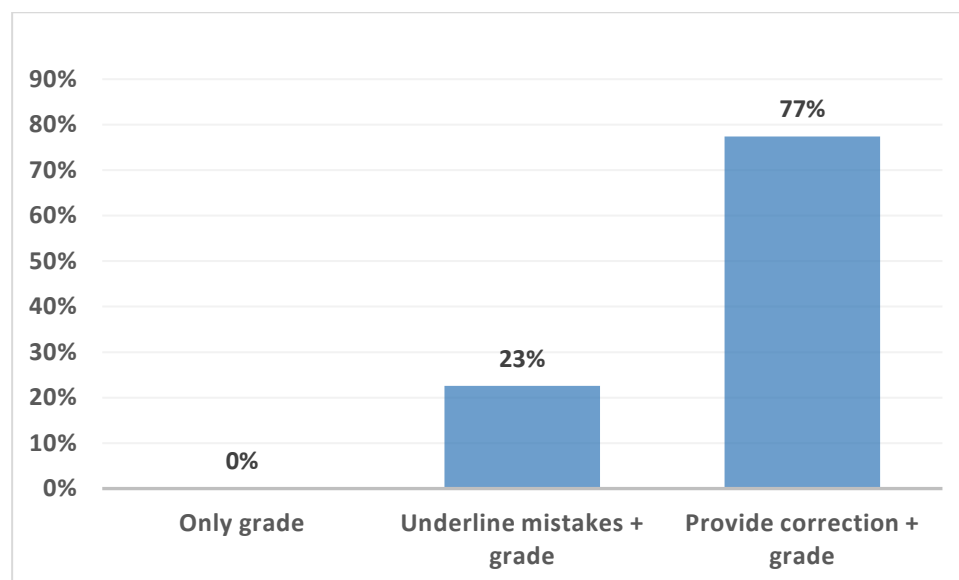
Graph 3 Types of teacher written feedback

The two highest proportions 42% and 19 representing the surveyed students, reflect that teachers focus on form-based feedback (grammar + vocabulary) and (vocabulary and organization). The second two highest proportions 13% go to content-focused feedback (content) and integrated feedback (grammar + content). It is worth noting that content-focused and integrated feedback is equal in terms of responses. Another aspect of form-focused feedback (grammar + organization) gains 13% of students' responses.

Question 5: What do you want your teacher to provide?

Options	Number of Responses	Percentage
Only grade	0	0%
Grade + Underline mistakes	14	23%
Grade + providing correction	48	77%

Table 4 Students' preference to teacher written feedback



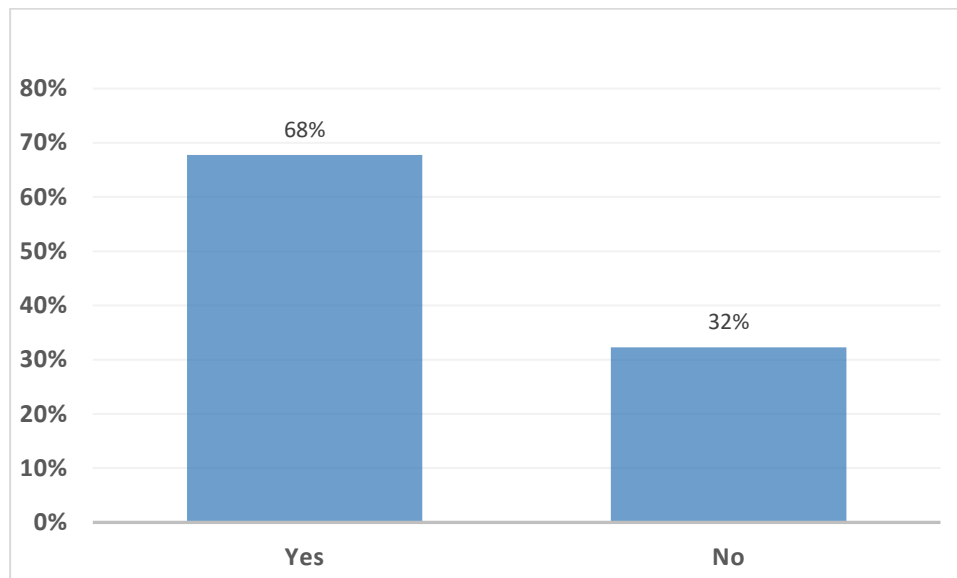
Graph 4 Students' preference to teacher written feedback

The highest proportion 77% representing the surveyed students' responses as to whether they prefer grade, underline mistake (indirect feedback) + grade or providing correction + grade, reflect that students highly prefer direct feedback and only 23 % of the surveyed students prefer indirect feedback. In fact, according to the questionnaire, none of the students prefer grades alone.

Question 5: Does it demotivate you to have all your mistakes corrected by your teacher?

Options	Number of Response	Percentage
Yes	42	68%
No	20	32%

Table 5 Students' attitudes towards overcorrection

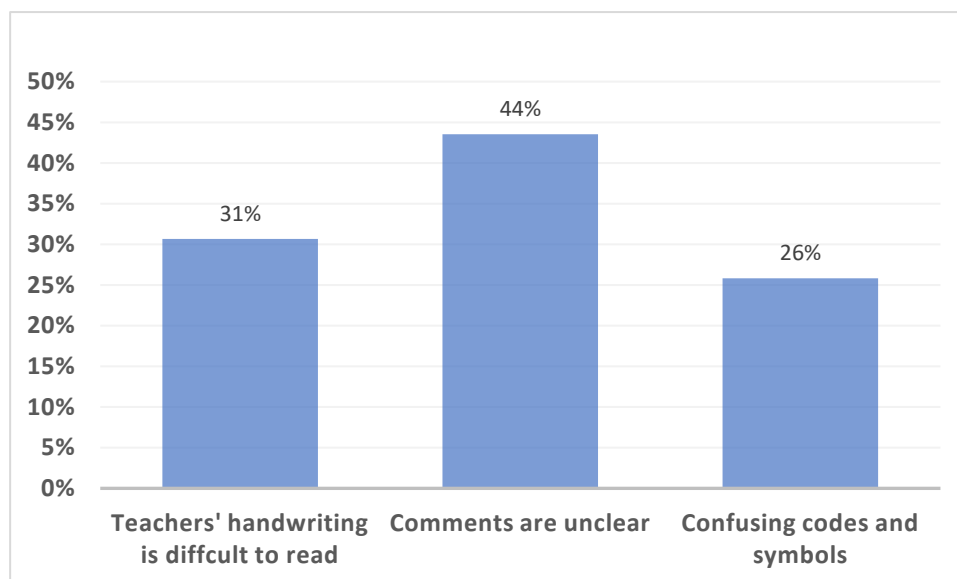


Graph 5 Students' attitudes towards overcorrection

The highest proportion 74% representing the surveyed students' responses as to whether too much correction is demotivation, reflect that they feel that it is demotivating to see the red colour permeating their compositions. In fact, only 32% of them say no to the question presented.

Options	Number of Response	Percentage
Teachers' handwriting is difficult to read	19	31%
Comments unclear	27	44%
Confusing codes and symbols	16	26%

Table 6 Forms of teacher written feedback



Graph 6 Forms of teacher written feedback

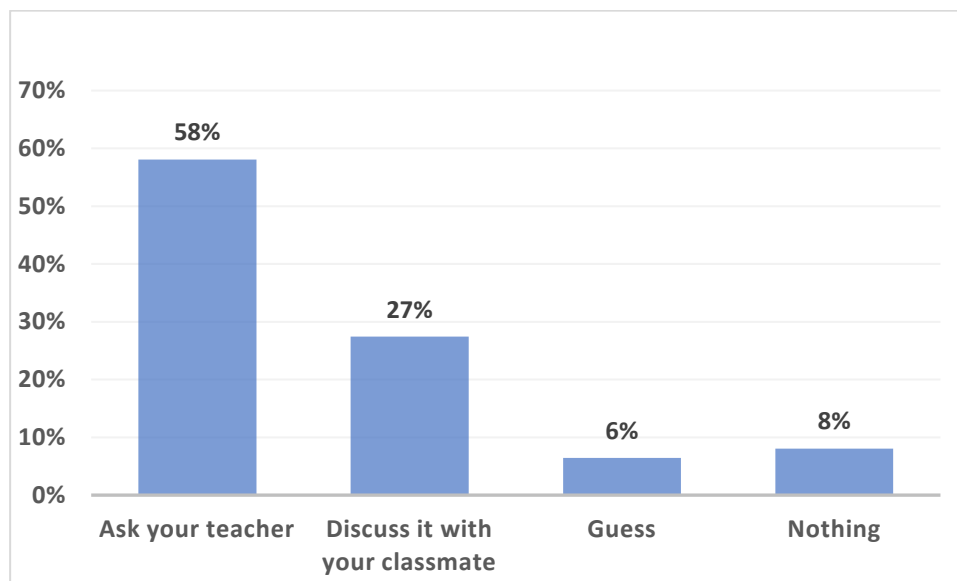
The highest proportion 44% representing the surveyed students' responses as to why they do not understand teachers' feedback, reflect that students do not understand teachers' comments in general. 31% of the

surveyed students' say that they find difficulty understanding teachers' handwriting and 26% of them say that teachers use confusing symbols and codes.

Question 7: When you do not understand your teacher's feedback, what do you do?

Options	Number of Response	Percentage
Ask your teacher	36	58%
Discuss it with your classmate	17	27%
Guess	4	6%
Nothing	5	8%

Table 7 Students' reactions to teacher written feedback



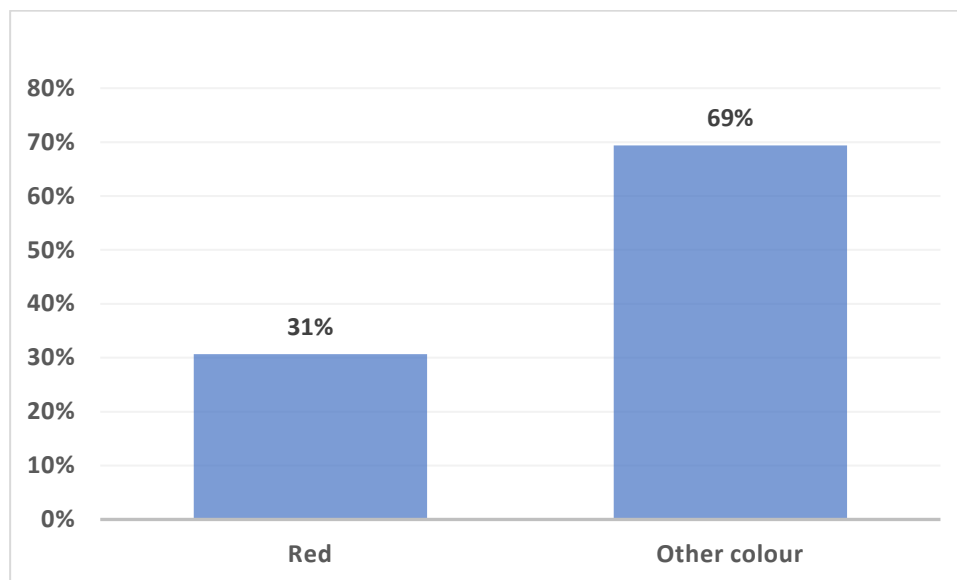
Graph 7 Students' reactions to teacher written feedback

The highest proportion 58% representing the surveyed students' responses as to what they normally resort to when they find difficulty understanding teachers' feedback, reflect that they mostly tend to ask the teacher personally. 27 % of the surveyed students tend to do peer-correction, 8% do nothing at all, and 6% only guess what the comments mean.

Question 8: What colour do you prefer to see in your paper?

Options	Number of Response	Percentage
Red	19	31%
Other Colour	43	69%

Table 8 Students 'preference to attribute of correction



Graph 8 Students 'preference to attribute of correction

The highest proportion 69% representing the surveyed students' responses as to what colour they prefer to see in their papers, reflect that students believe that the red colour is very demotivating and daunting, for this reason only 31% of them prefer red colour.

4.2. Discussion

The present research gives an idea about the types and forms of teacher written feedback employed by Moroccan high school EFL teachers. In this section, the results in the present, including classroom observation, Students' corrected compositions and students' questionnaire, is going to be discussed using descriptive statistics. It is worth restating the research questions of this study.

- Which types of written feedback do Moroccan high school EFL teachers employ to respond to students' compositions?

Before starting the discussion of the results of classroom observation, corrected samples of students' compositions and students' questionnaire, it is significant to laconically summarise what the literature review has concluded as far as teacher written feedback is concerned. In fact, it has shown that there are alternatives to form focused feedback, namely content-focused feedback and integrated feedback. The latter is deemed the most effective since it focuses on both aspects: form and content.

The question above is to shed light on the types of teacher written feedback used in a Moroccan EFL classroom. Throughout the results of the field work (classroom observation, corrected samples of students' compositions, and students' questionnaire) it can be asserted that Moroccan high school EFL teachers use form-focused feedback to respond to their students' writing. In other words, the different instruments used to collect data have come up with the following statement: Moroccan high school EFL teachers focus solely on the students writing, neglecting its content. It is worth stressing that students are also aware of the fact that their teachers exceedingly focus on grammar and vocabulary; this has been deduced from the questionnaire distributed to students at Abu Hayyan al-Tawhidi high school.

- Which forms of written feedback do Moroccan high school EFL teachers' employ to respond to students' compositions?

The question above is to ascertain the forms teacher-written feedback used in a Moroccan EFL classroom. Throughout the results of the field work (classroom observation, corrected samples of students' compositions, and students' questionnaire), it can be asserted that teachers mostly use commentary and correction symbols to respond to students' compositions. To put it differently, teachers use marginal and end comments, which tend to be either direct or indirect comments, they also use correction symbols and codes to respond to students' compositions. It is worth noting that students prefer direct comments which tend to locate their mistakes rather than indirect ones which tend to be ambiguous to them. Similarly, according to the questionnaire distributed to students at Abu Hayyan al-Tawhidi high school, students find correction symbols unclear, and believe that the quality teacher's handwriting is significant as far as teacher written comments are concerned. In addition, according to the observation checklist, teachers do not provide students with rubrics; thus, the students may not have the slightest idea how their written work is assessed. Besides, teachers should use ICT to give students feedback. In fact, the English textbook "Ticket to English" includes email writing; therefore, it would be beneficial to use information and communication technologies ICT as a platform to show students how to practice email writing on the one hand, and also use it to respond to students writing, on the other.

5. Conclusion

Generally, the present study accepts the hypothesis stated at the introduction. It is concluded that EFL teachers at Abu Hayyan al-Tawhidi high school so heavily use form-focused feedback to respond to their students' compositions. It also sheds light on the form of teacher written feedback, and concludes that EFL teachers at the aforementioned high school use different forms namely, correction symbols, commentary, but never make use of other forms such as electronic feedback and rubrics. To sum up, it seems that writing never floats free from teacher written feedback, thus, teachers should attend to the types of written feedback they adopt.

5.1. Limitations of the study

Although this research has reached its aims, there were some ungainsayable limitations. Firstly, the time of the training was not appropriate to collect data, since teachers had not done any writing task before. In fact, the host teacher started writing after two weeks of the training. Secondly, this study involved only 5 teachers and 62 students (Arts and Economics students) from Abu Hayyan al-Tawhidi high school. In fact, it would not be plausible to generalise the findings of this paper on all Moroccan high school EFL teachers. Finally, this paper would have been better if it had tested the most effective teacher written feedback and proposed a treatment regarding the researched phenomenon.

5.2. Recommendations for Further Research

On the basis of the finding and conclusions of this study, the following recommendation are sketched out below:

- In-depth investigation of the effectiveness of integrated feedback (form and content);
- Thorough investigation of the effectiveness of electronic feedback (social media, emails, and so forth);
- Expanding the scope of investigation: involving a larger number of teachers and students in future research;
- The field work should be done in the first months of the second semester so as students are acquainted with teacher written feedback.

5.3. Pedagogical Implications

There is a need for interested teachers to ascertain the most effective type of written feedback and identify which one works better. As stated in the literature review above, there is no harm if teachers provide form-based feedback and content-based feedback. In this case, students can be able to write accurate and meaningful compositions. Besides, teacher written feedback can be more effective if it is delivered through electronic media; such provides teachers with avant-garde, comprehensive and effective ways of responding to students' written work.

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Appendices

Appendix A: Writing Rubrics

Name	Title		Group			
Content	Excellent	VG	Good	S	Weak	Unacceptable
• The piece is engaging and alive • It contains valuable information and insights • Writer shows good understanding of topic • Details are clear and helpful • Voice of narrator is honest and convincing						
Reader Awareness						
• The piece has clear organization • Writer relates topic to reader's knowledge • Effective lead, engaging the reader • Satisfying ending • Clear transitions and signposts						
Style						
• Language is clear and precise • Sentences are varied and effective • Unnecessary words are eliminated • Style is consistent and appropriate						
Mechanics						
• Grammar • Spelling • Punctuation • Proofreading						
Process						
• Presentation (double-spacing, legibility) • Effective revision • Peer response and self-evaluation • Paper is on time						
Your Strengths:		Possible Improvements:			Grade:	

Appendix B: Correction Symbols

Meaning	Incorrect	Correct
<i>p.</i> punctuation	I live ^{<i>p.</i>} and go to school here ^{<i>p.</i>} Where do you work ^{<i>p.</i>} ?	I live and go to school here. Where do you work?
<i>○</i> word missing	I ^{<i>○</i>} working in a restaurant.	I am working in a restaurant.
<i>cap.</i> capitalization	It is located at ^{<i>cap.</i>} main and ^{<i>cap.</i>} baker ^{<i>cap.</i>} streets in the ^{<i>cap.</i>} City.	It is located at Main and Baker Streets in the city.
<i>v.t.</i> verb tense	I never ^{<i>v.t.</i>} work as a cashier until I ^{<i>v.t.</i>} get a job there.	I had never worked as a cashier until I got a job there.
<i>agr.</i> subject-verb agreement	The manager ^{<i>agr.</i>} work hard. There ^{<i>agr.</i>} is five employees.	The manager works hard. There are five employees.
<i>○</i> make one word or sentence	Every ^{<i>○</i>} one works hard. We work together. ^{<i>○</i>} So we have become friends.	Everyone works hard. We work together, so we have become friends.
<i>sp.</i> spelling	The ^{<i>sp.</i>} maneger is a woman.	The manager is a woman.
<i>pl.</i> plural	She treats her employees like ^{<i>pl.</i>} slave.	She treats her employees like slaves.
<i>○</i> unnecessary word	My boss ^{<i>○</i>} she watches everyone all the time.	My boss watches everyone all the time.
<i>w.f.</i> wrong word form	Her voice is ^{<i>w.f.</i>} irritated.	Her voice is irritating.
<i>w.w.</i> wrong word	The food is delicious. ^{<i>w.w.</i>} Besides, the restaurant is always crowded.	The food is delicious. Therefore, the restaurant is always crowded.
<i>ref.</i> pronoun reference error	The restaurant's specialty is fish. ^{<i>ref.</i>} They are always fresh. The food is delicious. Therefore, ^{<i>ref.</i>} it is always crowded.	The restaurant's specialty is fish. It is always fresh. The food is delicious. Therefore, the restaurant is always crowded.

W	wrong word order	Friday <u>always is</u> our busiest night.	Friday is always our busiest night.
RO	run-on	Lily was fired she is upset.	Lily was fired, so she is upset.
OR	OR		Lily was fired; therefore, she is upset.
CS	comma splice (incorrectly joined independent clauses)	Lily was fired, she is upset.	Because Lily was fired, she is upset. Lily is upset because she was fired.
FRAG	fragment (incomplete sentence)	She was fired. <u>Because she was always late.</u>	She was fired because she was always late.
T	add a transition	She was also careless. She frequently spilled coffee on the table.	She was also careless. For example, she frequently spilled coffee on the table.
S.	subject	<u>Is</u> open from 6:00 PM until the last customer leaves.	The restaurant is open from 6:00 PM until the last customer leaves.
V.	verb	The employees <u>on</u> time and work hard.	The employees are on time and work hard.
prep.	preposition	We start serving dinner <u>at</u> 6:00 PM.	We start serving dinner at 6:00 PM.
conj.	conjunction	The garlic shrimp, fried clams, <u>and</u> broiled lobster are the most popular dishes.	The garlic shrimp, fried clams, and broiled lobster are the most popular dishes.
art.	article	Diners expect <u>a</u> glass of water when they first sit down <u>at</u> table.	Diners expect a glass of water when they first sit down at the table.
¶	Symbol for a paragraph		

Appendix C: Observation Checklist**Observation Checklist**Class: 2nd B.C.EDate: 28/10/2015

1 = Not observed

2 = More emphasis recommended

3 = Accomplished very well

Items for Observation	1	2	3
I-The Pre-writing Stage			
1-Teacher (T, henceforth) activates students' prior knowledge about the writing topic.	1	2	3
2- T helps students (ss, henceforth) to develop a sense of audience.	1	2	3
3-T encourages Ss to work in pairs and / or groups	1	2	3
4- T provide ss. with strategies for generating ideas through, organizing them and planning.	1	2	3
5- T encourages Ss to use visual and sensory images such as graphic organizers and webs to organize main ideas and supporting or related ideas	1	2	3
6- T enables Ss to collect information from reading, taking notes ..etc	1	2	3
7-T helps Ss analyze a model text related to the writing topic.	1	2	3
II-The Writing Stage			
1-T lead ss. into building awareness of discourse organization	1	2	3
2-T models how the parts of a text are linked through cohesive devices	1	2	3
3-T illustrates how sentence structure can vary to develop meaning.	1	2	3
4-T helps Ss use correct punctuation, word form, structuresetc.	1	2	3
5-T helps ss correct facts and meaning of the topic	1	2	3
III-The Post Writing Skills			
1-When assessing Ss' work, T marks areas for improvement	1	2	3

2-T uses encourages self and peer correction.	1	2	3
3-T locates errors and gives them symbols to denote types of errors (using a coding system)	1	2	3
4-T indicates in the margin that there is an error of a particular kind somewhere on that line and asks Ss. to locate it and correct it	1	2	3
5-T shares with Ss. the grading criteria that is to be used to assess their written work.	1	2	3
6-T provides form-focused feedback	1	2	3
7-T provides content-focused or integrated feedback.	1	2	3

Switching from face-to-face to electronic-mediated education caused by COVID-19 pandemic: An analysis of student perceptions

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Abstract

Mozambique, like several other countries in the region and all over the world, faces the dilemma of the need to guarantee the minimum learning conditions for students during the state of emergency due to COVID-19. It is in this sense, which the present study aimed to analyze the perceptions of students of the Pedagogical University of Maputo (UP-Maputo) in the use of electronic platforms as a resource to support classroom teaching during the State of Emergency. The research had a quanti-qualitative character, where the analysis and control of the different variables was foreseen. It consisted of collecting information on the objectives of operationalizing the teaching and learning process in the face of the COVID-19 pandemic, through the application of an electronically administered questionnaire. A sample of 1787 students was obtained, corresponding to 13.61% of the universe of students enrolled in the year 2020. The survey showed that most of the students, around 64% used some electronic platform to support their teaching and on-site learning process, after the declaration of a state of emergency the percentage of users of electronic platforms increased to 100%, highlighting the use of WhatsApp to the detriment of the others (SIGIUP, MOODLE® Institutional, Google Classroom and ZOOM®). The device they use, because 95% of the students access the platforms using their mobile phones, justifies the massive use of WhatsApp. Regarding the use of different electronic platforms, most of the students revealed a platform usage that varies from "Many Times" and "Always". Students refer to the need for training in the use of the different platforms made available to them to support their teaching and learning process. The research made it possible to conclude that students are aware of the need to appropriate the new form of teaching they are subject to, despite having significant financial difficulties in the acquisition of internet packages and in the use of some of the electronic platforms made available for learning.

Keywords: COVID-19; Electronics platforms; State of Emergency; Teaching and Learning.

1. Introduction

In Mozambique, the National Education System (SNE), as in many other countries all over the world, was challenged regarding the emergency measures imposed by COVID-19. The perspective of implementing Distance Learning in Mozambique is referenced in the Strategic Plan for Distance Education (PEED) which defines Distance Education as being “the teaching model that is distinguished by the separation between students and teachers, use of technology to mediate learning, bidirectional communication that allows interaction between students, teachers and tutors and the possibility of face-to-face meetings for tutorials.” (PEED, 2013).

UNESCO (1998) refers to the need for Higher Education Institutions (HEIs) to adapt to the Knowledge Society through the adoption of different ways of teaching and learning taking into account a profound impact in terms of methodologies, practices and paradigmatic, organizational approaches, pedagogical and social aspects of each one.

The declaration of the State of Emergency drastically changed the face-to-face teaching system, with Higher Educational Institutions defined as a result of Presidential Decree No. 11/2020 of 30 March, the continuation of Teaching and Learning Processes through the use of electronic platforms. In this sense, each of the HEIs has defined one or a set of electronic platforms in order to guarantee the effectiveness of the teaching of classes during that period. It was from the above that this research was developed, aiming to analyze the perception of students from the Pedagogical University of Maputo (UP-Maputo) in the use of electronic platforms as a resource to support teaching and learning during the term of the State of Emergency.

2. Digital Platforms and Learning

Digital learning platforms are virtual environments created from Information and Communication Technologies (ICTs), which use the Internet as a means of diffusion and communication. The digital platforms offer a range of resources, which allow the management of academic activities, through the creation of classes, provision of communication tools between participants and the creation, in real time, of immersive and interactive environments (DELGADO; HAGUENAUER, 2010).

The use of digital platforms in learning is a challenge due to the lack of planning for its use in the Mozambican context. Ceccim and Feuerwerker (2004) draw attention to the fact that the prevalence of protagonism from the teacher, which in the traditional model, acts by reproducing a teaching model centered on the massive transmission of content, in which students are seen as recipients of technical-scientific information about a given content in a perspective where they are unaware of the active role in the teaching and learning process.

The current context requires changes in the teaching and learning process, characterized by the redefinition of the roles and places occupied by the different subjects involved in this process. Thus, it is up to the teacher to offer the respective distance from the position of sole holder of knowledge and also assume the role of apprentice (FREIRE, 1996). On the contrary, it is up to the student to assume a more active role, resigning the attitude of being a mere recipient of content and seeking autonomously the relevant knowledge to the problems and learning objectives. This stance implies, on the one hand, greater

responsibility on the side of the actors and particularly, greater autonomy in the construction of knowledge by the students (PALÁCIO; STRUCHINER, 2016). On the other hand LIMA, et all (2016), refer that users can develop the learning of the contents if they develop and believe that the system can contribute to improve their performance.

3. Methodology

This research was carried out at UP-Maputo. UP-Maputo is a Mozambican public higher education institution whose statutory mission is the higher education of teachers for all levels of education and other professionals in the field of education and related areas, research and extension. The research had a quanti-qualitative character, where the analysis and control of variables was made, which made it possible to access the degree of compression of the students regarding the use of electronic platforms to assist the teaching and learning processes.

Methodologically, the present research consisted of gathering information about the objectives of the operationalization of the teaching and learning process due to COVID-19 pandemic, through the application of a questionnaire that aimed to assess the perception of UP-Maputo students in relation to the use of electronic platforms to support the teaching and learning process.

The survey was conducted electronically, using Google Forms. The invitations to reply were sent by WhatsApp during April 2020, a period characterized by the implementation of the Presidential Decree and the validity of the State of Emergency due to COVID-19. The questionnaire was sent to WhatsApp groups in all classes of the University, that is, the questionnaire was sent to 13,127 students, which corresponds to the total number of students from the Pedagogical University of Maputo and we had 1787 questionnaires answered, which corresponds to a rate of responses of 13.61%. This response rate is considered excellent considering that for the size of the population in question (13,127 students enrolled in the academic year 2020) with a 95% confidence level and a margin of error of 5%, a sample of 374 respondents was sufficient.

The observation presented above is supported by the verification of representativeness of groups. For this purpose, considering a finite population (in this case 13,127 students), the following formula was used, considering the margin of error of 5% and the confidence level of 95%:

$$n = \frac{N \cdot \hat{p} \cdot \hat{q} \cdot Z^2}{\hat{p} \cdot \hat{q} \cdot Z^2 + (N - 1) \cdot e^2}$$

Where:

N - Number of people in the study population

n - Sample size

e - Margin of error (%). Smaller error margin requires larger samples.

Z - Confidence level (%). The higher the confidence level, the larger the sample (Confidence level of 90% - Z = 1.645; Confidence level of 95% - Z = 1.96 and, Confidence level of 99% - Z = 2.575).

$\hat{p}$ - Estimation of the proportion of the population.

When there is no idea of the estimate of the population proportion, that is, what values of p and q the

research will reveal, it is assumed, hypothetically, $p = 50\%$ and $q = 50\%$, $\hat{p} \cdot \hat{q} = 0.25$.

$$n = \frac{13127.0,25.1,92^2}{0,25.1,92^2 + (13127 - 1) \cdot 0,05^2} = 373,26$$

According to the sample size presented in the calculation above ($n = 373.36$), it is concluded that the sample used in the research is representative of the population ($n = 1787$).

The questionnaire had 8 questions between open and closed. It was divided into three parts: (1) identification, (2) use of electronic platforms to support the teaching and learning process before the declaration of a state of emergency due to Covid-19 and, (3) use of electronic platforms to support the teaching and learning process after the declaration of a state of emergency due to Covid-19.

In the first part, data were collected regarding the faculty that each student attends.

The second part sought to assess whether students had already used electronic platforms to support face-to-face teaching before the COVID-19 decree of emergency came into effect.

In the third part, students were asked about the electronic platforms they use during the state of emergency due to COVID-19 and about the devices they use to access these platforms as well as the frequency with which they use them under different prisms. They were also asked about the benefits and difficulties they encountered in using these platforms used by teachers to teach the subjects.

For the analysis of the research results, considering that the quantitative approach was chosen and that the questions in the third part of the questionnaire used the Likert scale, the Average Ranking (AR) was used to measure the degree of agreement of the students who answered the questionnaires. According to Malhotra (2011) and Laranjeiras, Albuquerque & Fontes (2011), in order to find the Average Ranking of each researched variable, based on the Liker scale analysis method, the calculation considers the division of the weighing average of each investigated category (item Likert) using the Likert scale, respectively presented (sum of responses for each Likert item).

$$\frac{P_1 \cdot X_1 + P_2 \cdot X_2 + P_3 \cdot X_3 + \dots + P_n \cdot X_n}{P_1 + P_2 + P_3 + \dots + P_n} = \frac{\sum_{i=1}^n (P_i \cdot X_i)}{\sum_{i=1}^n P_i}$$

Figure 1. Formula for calculating the Average Ranking.

In Figure 1, the element X_n refers to the value of each option of the item, which ranged from 1 to 5 (Totally Disagree to Totally Agree), and P_n is the number of students who chose the respective value. Therefore, there is a weighted average of the items in each investigated category divided by the number of students. The final value is the Average Ranking and can vary from 1 to 5. The Average Ranking shows the degree of agreement or disagreement of a particular item in the questionnaire on the Likert scale and is related to the frequency of the students' responses.

Cronbach's Alpha measure (Cronbach, 1951) was also used on questions six and seven of the questionnaire (Frequency of use of the different electronic platforms and electronic platforms adopted for the teaching of classes during the term of the State of Emergency due to Covid- 19). Cronbach's Alpha is

used to measure the reliability of a questionnaire applied in a survey. The alpha measures the correlation between responses to a questionnaire, by analyzing the profile of responses selected by the interviewees, that is, it is an average correlation between the questions (Hora, Monteiro & Arica, 2010).

According to Hora et al. (2010), using the same measurement scale, the coefficient is calculated from the variation of individual items and the variation of the sum of the items of each evaluator, using the following equation in figure 2:

$$\alpha = \frac{k}{k-1} \left(1 - \frac{\sum_{i=1}^k S_i^2}{S_t^2} \right)$$

Figure 2: Equation to calculate Cronbach's Alpha

The internal consistency of the questionnaire can be seen in the table below.

Table 1. Consistency of questionnaires according to the alpha value

Alpha value	Internal consistency
Greater than 0.80	Almost perfect
From 0.80 to 0.61	Substantial
From 0.60 to 0.41	Moderate
From 0.40 to 0.21	Reasonable
Less than 0.21	Little

Source: Landis e Koch (1977)

This metric was used to verify the reliability of the applied questionnaire, validate the questions asked and provide a greater degree of integrity to the research.

4. Presentations and Discussion of Results

This section presents and discusses, in a clear and detailed way, the results achieved by the research carried out, which was described in the previous section. For this, the data obtained in the questionnaire applied to students will be presented.

4.1 Cronbach's alpha

Cronbach's Alpha verifies the reliability that a questionnaire applied to users can achieve and thus ensure greater reliability to the results achieved. Based on this assumption, this metric was applied to questions 6 and 7. Question 6 of the questionnaire aimed to measure the frequency of use of the different electronic platforms. This question had 11 items with options for answers using the Likert scale (from Never - 1 to Always - 5). Similar to question 6, question 7 had 9 items with options for answers using the Likert scale (from Totally Disagree - 1 to Totally Agree - 5) and intended to gather the students' opinion regarding the electronic platforms adopted for the teaching of classes in the validity period of the State of Emergency due to Covid-19.

To obtain alpha, the variances of each item and the variances of the total scores of the items were calculated. To make these calculations, an Excel spreadsheet was used. The results are shown below.

For question 6, the results are as follows:

Number of items = 11

Sum of item variances = 1.4513769 + 1.624726112 + 2.347042888 + 1.778818546 + 1.866410678 + 1.887826931 + 1.511091891 + 1.938268957 + 1.998764941 + 2.02168243 + 1.698694388 = 20.12

Variance of the total scores of each respondent = 95.95

$$a_6 = \frac{k}{k-1} \left(1 - \frac{\sum_{i=1}^k S_i^2}{S_t^2} \right) = \frac{11}{11-1} \left(1 - \frac{20,12}{95,95} \right) = 0,87$$

For question 7, the results are as follows:

Number of items = 9

Sum of item variances = 1.458730889 + 1.766389039 + 1.989763789 + 1.909341514 + 1.797422722 + 1.867615049 + 2.120395106 + 1.852599559 + 2.06145923 = 16.82

Variance of the total scores of each respondent = 70.03

$$a_7 = \frac{k}{k-1} \left(1 - \frac{\sum_{i=1}^k S_i^2}{S_t^2} \right) = \frac{9}{9-1} \left(1 - \frac{16,82}{70,03} \right) = 0,86$$

It can be seen that the result of Cronbach's Alpha for question 6 is 0.87 and for question 7 is 0.86. According to the questionnaire consistency table for the alpha value of Landis and Koch (1977) and the classification scale based on values proposed by George and Mallery (2003), the values found are considered Excellent. This result shows that the questionnaire applied to users guarantees reliability to the results achieved.

4.2 Questionnaire results

The first question of the questionnaire sought to know the provenance of the students participating in the survey. The results are shown below in figure 3.

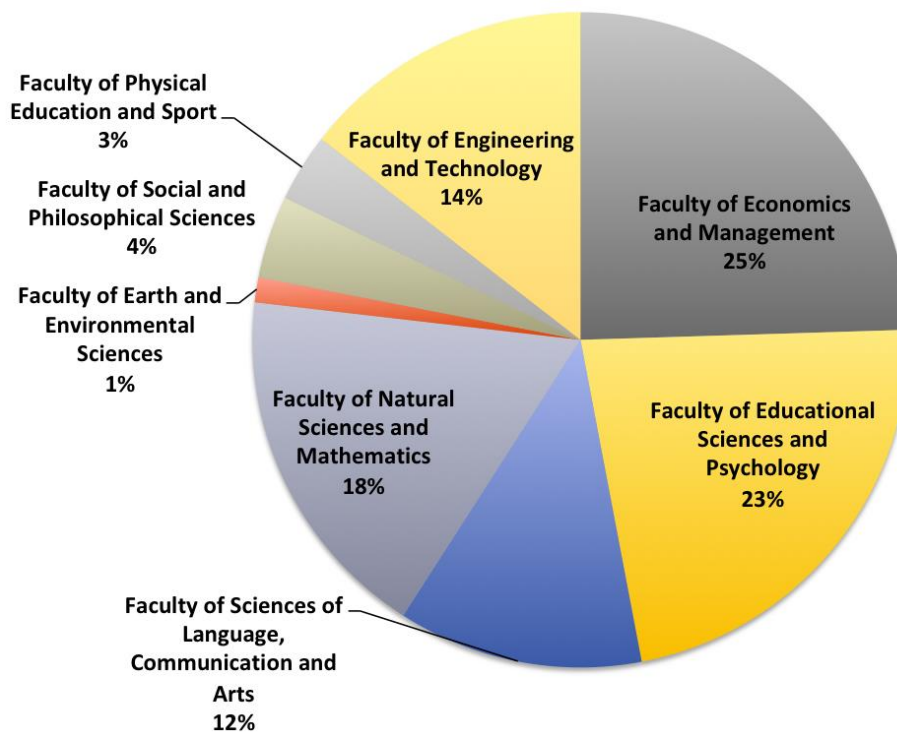


Figure 3: Distribution of students by Faculty

As can be seen in figure 3, the faculty that had the largest number of students participating in the research was the Faculty of Economics and Management with 25% of the total participants, followed by the Faculty of Educational Sciences and Psychology with 23%. The faculties with the lowest number of participants were the Faculty of Physical Education and Sport with 3% and the Faculty of Earth and Environment Sciences with 1%. These results are explained by the number of students that each faculty has. The Faculty of Economics and Management and the Faculty of Educational Sciences and Psychology contribute a total of 40.15% of the total number of students at the University while the Faculty of Physical Education and Sport and the Faculty of Earth and Environmental Sciences contribute only 10.25% (SIGUEP, 2020).

Students were asked if they had ever used an electronic platform to support the teaching and learning process before the Covid-19 pandemic broke out. If they answered Yes to the question, we tried to find out the platforms they used. The results are shown in the following figure.

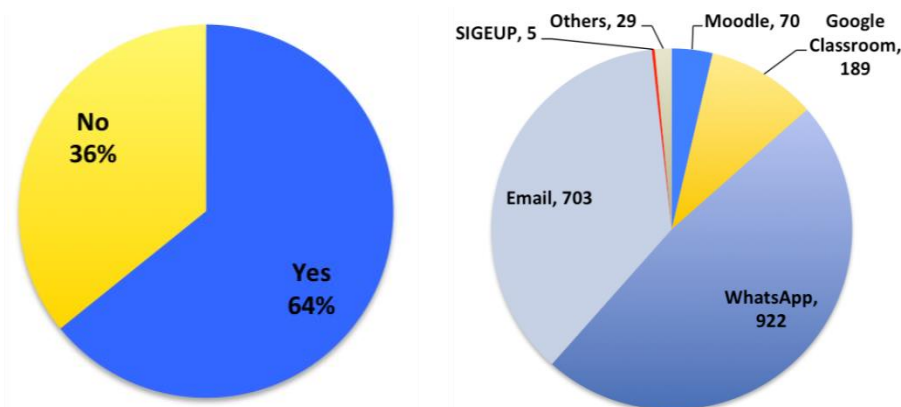


Figure 4: Distribution of students by Electronic Platforms used before the COVID-19 pandemic and the declaration of a state of emergency.

The results presented in figure 4 indicate that 64% of the students stated that they had used some electronic platform to support face-to-face teaching before the outbreak of the COVID-19 pandemic. Still, of the 64% of those who answered Yes, most of the students said they had used WhatsApp (48%) followed by Email (37%). Only 5 (five) students (0.4%) claimed to have used SIGEUP. With this question, a much higher percentage of students who answered SIGEUP were expected, since this platform is the official platform of the University and all students must be registered in it from the first moment they enter the University. According to Carvalho et al (2011), this reflects the fact that today students arrive at the university with good technological skills, which justifies the fact that most students have indicated WhatsApp and Email as the most used platforms. The students were then asked about the electronic platforms they were currently using after the outbreak of the COVID-19 pandemic and the declaration of a state of emergency. The answers are presented in the following figure.

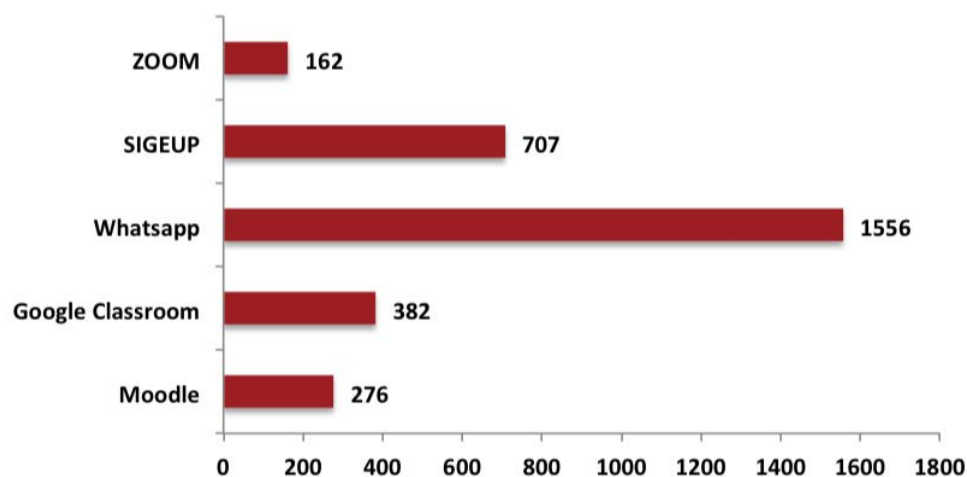


Figure 5: Distribution of students by Electronic Platforms used during the COVID-19 pandemic and the declaration of the state of emergency.

Similar to the results obtained in figure 4, the results presented in figure 5 show that about 87% of students answered that they are using WhatsApp as an electronic platform to participate in online classes. SIGEUP came in second with 39% of students stating that they are using this platform for classes. In last place were MOODLE® and ZOOM® with 15.4% and 9.06% respectively. This result shows that although the University suggested using MOODLE and SIGEUP, the financial condition of teachers and students determined the choice of WhatsApp for online classes. It should be noted that most students only have access to Internet using their cell phones.

This finding was confirmed by the answers to the following question in which we sought to know the devices used by students to access the educational resources made available by teachers on electronic platforms. The answers are shown below in figure 6.

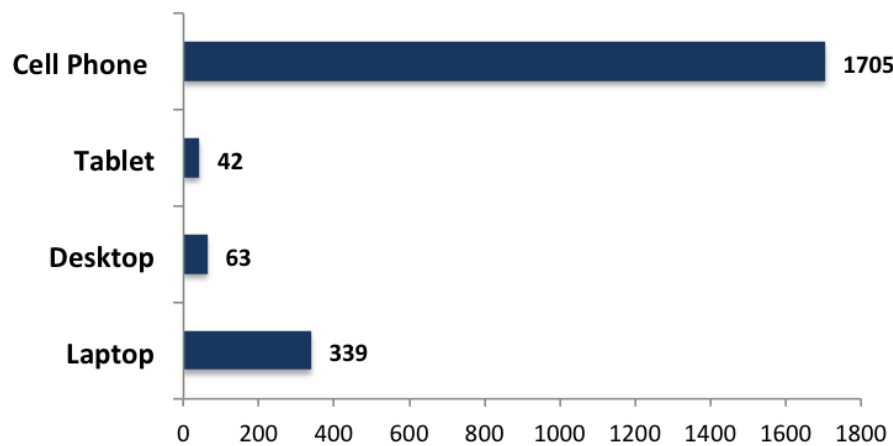


Figure 6: Distribution of students by device used to access electronic platforms

The data presented in figure 6 show that 95% of students access electronic platforms from their cell phones. Although this finding is associated with the students' financial condition, it is reinforced by the free internet packages for accessing WhatsApp offered by mobile operators. In addition, after the state of emergency came into force, mobile operators began offering free internet packages to students.

The following question aimed to measure the frequency that students use the different electronic platforms and was subdivided into 11 items using the Likert scale. Student responses can be seen in Figure 7 below.

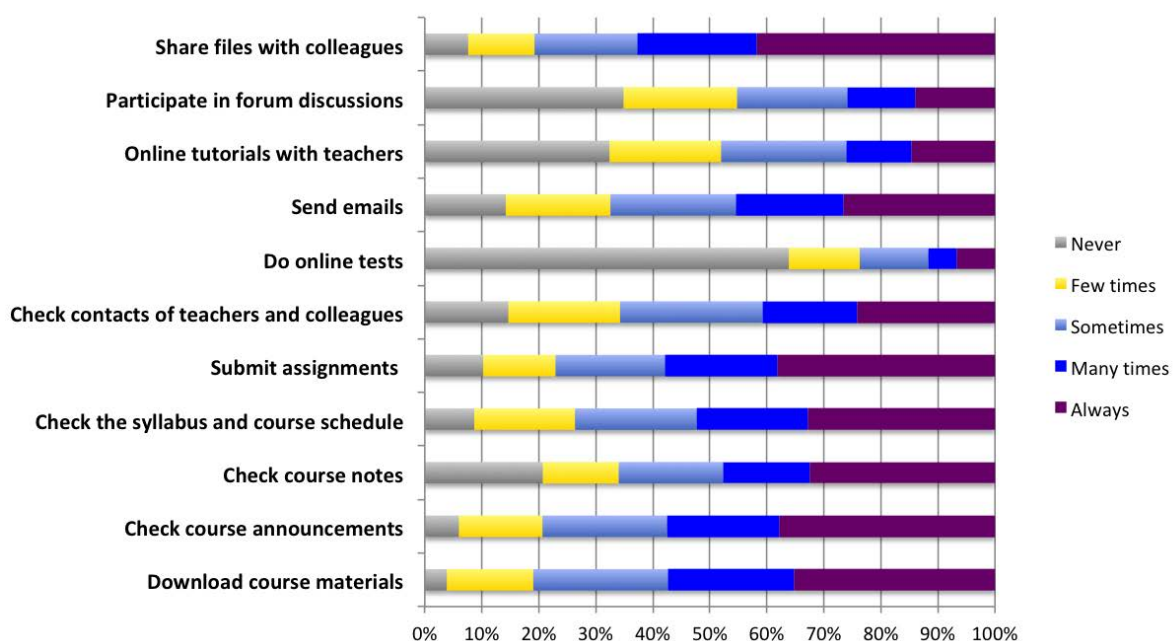


Figure 7: Frequency of usage of electronic platforms

For the analysis of the results of the students the method of analysis of the Average Ranking was used. This method was used to show the tendency of the students' answers in each item of the question. Table 2 presents the data obtained from the students' response to each of the five options, based on the Likert

scale for each item of the question.

Table 2: Average ranking of the items of frequency of use of electronic platforms

Item	Frequency of responses in each item					
	1	2	3	4	5	AR
1. Download course materials	69	271	423	394	630	3.697
2. Check course announcements	107	262	389	352	677	3.688
3. Check course notes	370	238	328	271	580	3.253
4. Check the syllabus and course schedule	155	316	380	351	585	3.501
5. Submit assignments	183	227	344	350	683	3.628
6. Check contacts of teachers and colleagues	262	350	447	297	431	3.159
7. Do online tests	1141	222	214	92	118	1.782
8. Send emails	254	328	395	336	474	3.251
9. Online tutorials with teachers	579	350	393	204	261	2.562
10. Participate in forum discussions	623	356	346	213	249	2.501
11. Share files with colleagues	136	208	324	373	746	3.775

For items 1, 2, 3, 4, 5, 6, 8 and 11, students have a frequency of use of electronic platforms that varies from “Many Times” to “Always”. This tendency of responses converges with the statement by Carvalho et al (2011) when he affirms that today's students arrive at the university with good technological skills. The items mentioned are characteristic of this type of students.

In items 7, 9 and 10, the frequency of responses pointed to “Few Times”. These items are largely related to the performance of teachers, who for the most part do not make the proper use of the concept of e-learning. Sending a set of PDFs on the Internet and answering students' questions by e-mail is not e-learning (Magano, Castro and Carvalho, 2008).

The next question was intended to collect the students' opinion regarding the electronic platforms adopted for the teaching of classes during the term of the State of Emergency due to Covid-19. The question comprised 9 items and the students' answers are shown in figure 8.

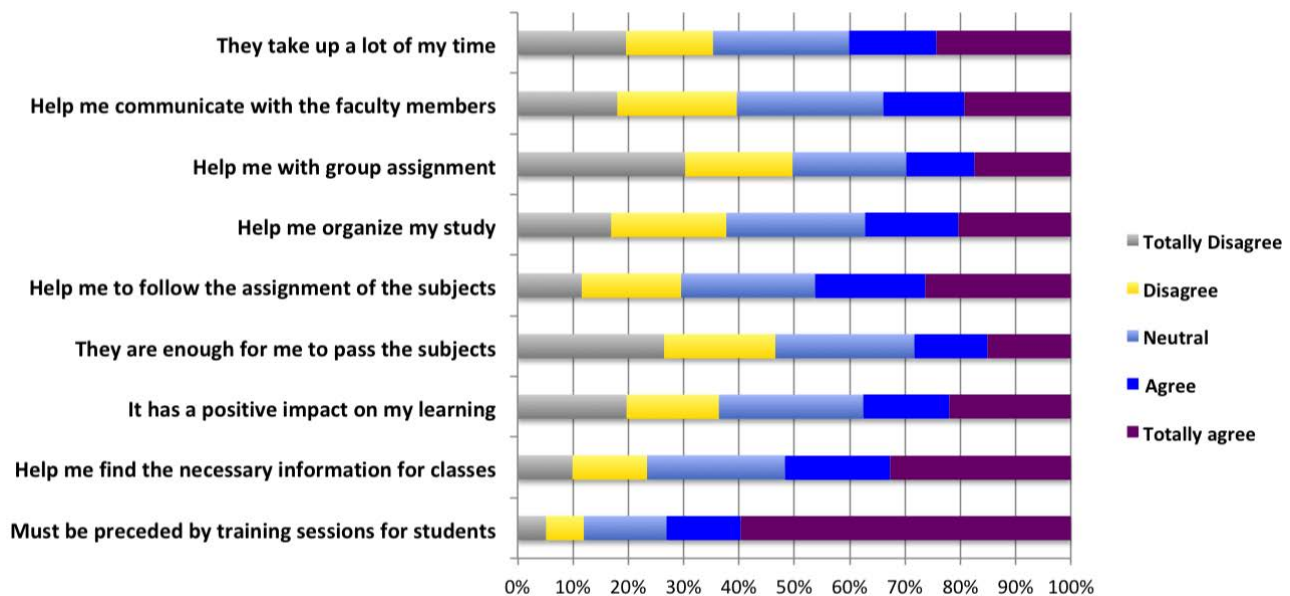


Figure 8: Students' perception of the use of electronic platforms

Similar to the previous question, the method of analysis used was Average Ranking. The analysis is shown in table 3.

Table 3: Average ranking of students' perception of the use of electronic platforms

Item	Frequency of responses in each item					AR
	1	2	3	4	5	
1. Must be preceded by training sessions for students	92	122	268	239	1066	4.156
2. Help me find the necessary information for classes	177	241	444	342	583	3.511
3. It has a positive impact on my learning	352	298	464	280	393	3.036
4. They are enough for me to pass the subject	473	359	448	237	270	2.705
5. Help me to follow the assignment of the subject	207	321	431	357	471	3.316
6. Help me organize my study	302	372	449	299	365	3.030
7. Help me with group assignment	541	347	366	221	312	2.673
8. Help me communicate with faculty members	322	386	471	264	344	2.956
9. They take up a lot of my time	350	281	439	283	434	3.095

In item 1 the students fully agreed that the use of electronic platforms for the teaching and learning process should be preceded by training sessions. These responses are reinforced by the position of Magano et al. (2008) when they state that the use of technology in the teaching and learning process must go through a high-level strategic and planned process involving the maximum levels of management and decision. It should be noted that in this specific case, the introduction of these platforms to support the

teaching and learning process was decided in a short time without giving preparation time to the various actors in the process.

In items 2, 3, 5, 6 and 9 the response trend was in agreement. Regarding items 4, 7 and 8, the students' responses tended to disagree. In these items, once again, the teacher plays a fundamental role that should be to guide students towards the effective use of electronic platforms in support of e-learning.

As a last question in the questionnaire, we sought to know from students what were the greatest difficulties they encountered in accessing the electronic platforms in use for the teaching of classes.

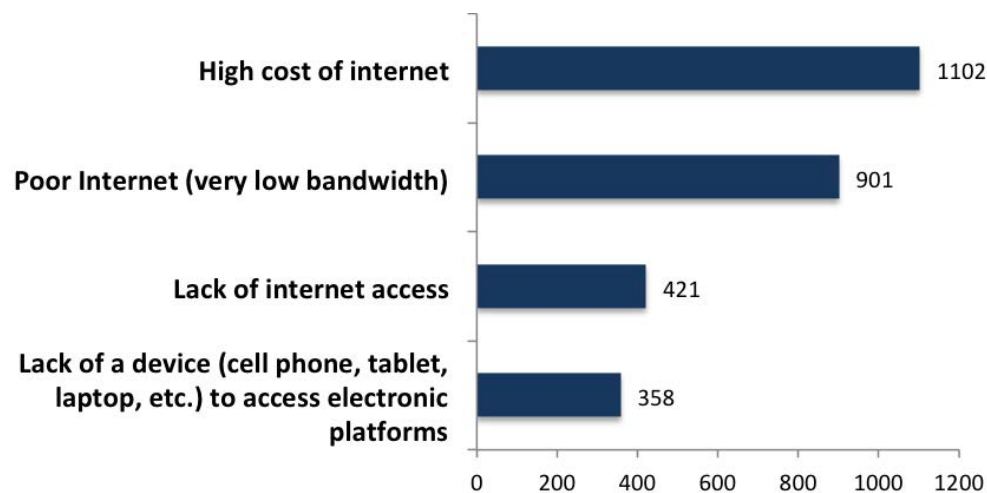


Figure 9: Distribution of students due to the greatest difficulties encountered in accessing electronic platforms

Regarding the difficulties of students to access electronic platforms, about 61.7% of them affirm that they face difficulties related to the high price of the internet. Considering the per capita income of the University's student population, this factor impacts the entire teaching and learning process. It is worth mentioning that mobile operators are, in this period, offering free internet packages to students. However, 50.4% of the students affirm that the internet offered by mobile phone operators has an exceptionally low bandwidth, which difficult activities related to the process of interaction and exchange of material for their learning. Approximately 23.55% of students have difficulty accessing the internet, which is basically justified by its cost. Few students have the lack of a device (cell phone, tablet, laptop, etc.) to access the different platforms available for learning.

5. Conclusion

The present research aimed to analyze the perception of UP-Maputo students in the use of electronic platforms as a resource to support face-to-face teaching during the State of Emergency due to the COVID-19 pandemic.

As a way to achieve the aforementioned objective, the research consisted of collecting data on the operationalization of the teaching and learning process in the face of the COVID-19 pandemic, through the application of a questionnaire for students. As a way of verifying and ensuring greater reliability of

the results achieved, Cronbach's alpha was calculated. For the analysis of the results of the collected data, the analysis method of the Average Ranking was used.

After analyzing the data collected during the research, it was possible to conclude that students use different electronic platforms in the current scenario for the teaching and learning processes. These platforms were already used by some students. However, with the scenario of COVID-19, there was an increase of 100% in the use of electronic platforms by students. This increase is a consequence of the absence of another way of student-teacher interaction and, access to learning materials in the University libraries.

It was also concluded that even with difficulties, students find alternatives to access the different platforms made available to them by the university, especially using WhatsApp. The main difficulty encountered by students is not related to the use of electronic platforms but to the costs of acquiring internet data packages, since more than 95% of students access instructional materials through cell phones. The students also report that the packages offered by the operators are characterized by being deficient for access to the different platforms as it is of short bandwidth. The study concluded that due to this set of difficulties, the use of electronic platforms does not help in the teaching and learning process, in the organization of their studies and does not improve or facilitate their learning in this context of the COVID-19 pandemic.

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Social Responsibility in The Food and Beverage Industry in Brazil

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ABSTRACT

Social responsibility is a growing theme, given the rapid and necessary transformations observed in corporate management in recent years towards sustainable development. Thus, the purpose of this research was to study the communication of social responsibility in the food and beverage sector in Brazil, as well as to characterize the link between social responsibility and business strategy. As for the research methodology, it is descriptive and explanatory, with a bibliographic and documental survey on corporate websites, with the purpose of knowing the projects and the results of social responsibility actions, which are communicated and published by the selected companies. The selection criteria of these companies is their position in the ranking of net revenue of the sector. The results indicate, for the studied companies, that investments in social responsibility are linked to the competitive strategy. However, there is scope for improvement through more detailed responsible business practices and the results of social responsibility projects, enabling it to meet stakeholder demands, strengthening reputation and increasing long-term sales and profits.

KEYWORDS: social responsibility; sustainability; communication; business strategy; food and beverage.

1. Introduction

The term social responsibility holds plenty of meanings. Therefore, in this initial chapter a promptly historical and chronological conception on the literature about social responsibility was adopted. Subsequently, this practice was connected to business strategy and, after that, the literature on social responsibility and strategy in the food and beverage sector was highlighted. Finally, the research problem was disclosed.

1.1. Social Responsibility Chronology

The term social responsibility holds many meanings. During the decade of 1950, Howard Bown (1953) stated that social responsibility refers to the expected actions related to the society's values and goals. Later in the 1960's, Keith Davis (1960) amplified this concept by arguing that companies need to be aware to the collective problems, since business decisions has social consequences, and for this reason, they cannot only focus on the economical aspect. Business decisions must be guided, as well, by the respect to the general interests of the society, considering that companies use their resources which, in return, expects to be favored by the use of these resources. Davis (1960) affirms that companies that disregard social responsibility may lose, in the long term, share in the market and profits.

Another author who contributed to the improvement of the theme was Willian Frederick (1960), which understood to be necessary to reconcile economic interests with those of society, so that production and distribution were in harmony with socioeconomic well-being. For Joseph W. McGuire (1963), corporations have social responsibilities to the population, which go beyond legal and economic obligations.

In the same decade, Clarence Walton (1967) argued that social responsibility concerns the relationship between companies and society, and that all parties must pursue their goals clearly and

transparently. However, to Friedman (1970), a liberal economist, the company's social responsibility, in a free market, with open competition and without fraud, should converge solely to profit maximization. Therefore, social practices are only justified for the company's interests.

Later, Carroll's (1979, 1991) conception gained importance, to whom social responsibility involves four dimensions: economic responsibility, legal responsibility, ethical responsibility, and philanthropy. According to this concept, it matters not only what the company does for itself, but also for others. In this way, even the company's economic responsibility is relevant to society, given that the generation of resources is fundamental for the development of social responsibility actions.

Melo Neto and Fróes (2001) define social responsibility as investments made by the company in the welfare of employees, the protection of the environment and responsible actions with society. Therefore, social responsibility is directed to both internal and external public of the company.

Naturally, the growing concern with social responsibility exists, as society demands companies' attention to the interests of all citizens affected by their actions, since being part of a larger system, they must contribute to the progress of society. In fact, Abramovay (2012) proposes the construction of a new economy, based on the rapprochement between the market and society, between ethics and economy. For the author, this new economy needs to be faced

... not by the state monopoly on business decisions or the elimination of markets, but, on the contrary, within a decentralized economy in which markets play a decisive, even though, evidently non-exclusive role (ABRAMOVAY, 2012, p. 22).

1.2. Social Responsibility and strategy

According to Prahalad and Hamel (1990), to a company obtain success, it is necessary to evaluate its level of organizational competence, through three indicators: (I) the client's perception of its product or service; (II) the differentiation and difficulty of being imitated by competitors; and (iii) the capacity of expansion in the long term.

For Porter (1991), the competitive advantage concerns the benefit acquired by the company over its competitors, and this benefit is decisive for the company itself to survive and thrive in the market.

Porter and Kramer (2006) say that the social responsibility has a strategic value to the company and the society. Social responsibility can be source of competitive advantage, implicating in the company's perpetuation and its recognition by the market.

Sustainability, consecutively, refers to innovations that lead to decreased demand for inputs, reducing costs and also enabling the development of products that can be transformed into new business, ultimately resulting in increased revenues (NIDDUMOLU, PRAHALAD, RANGASWAMI, 2009).

According to Brunk (2010), the way companies engage with social responsibility may influence people's perception of their business ethical.

Carroll and Shabana (2010) emphasize that social responsibility is related to business strategy. Faria and Sauerbronn (2008), as well as Barnett (2007), state that responsible practices can not only result in competitive advantages, but also contribute to the company's perpetuity, improvement of its image and promote sustainability values.

In this way, it is known that high levels of attachment to a particular brand make consumers more sensitive and less critical to their activities, including the social responsibility ones (PARK; MACINNIS; PRIESTER; EISINGERICH; IACOBUCCI, 2010) and brands can achieve better and faster results by targeting their CSR (Corporate Social Responsibility) sponsorship efforts to consumer segments that are attached to it, and at the same time have a preference for the topics covered in the campaigns (KAMIYA; HERNANDEZ; XAVIER; RAMOS, 2018).

As for corporate reputation, transparency (reliable, understandable and punctual) in socially responsible actions emerges as an important tool to soften the path of good relationships between a company and its stakeholders (BARAIBAR-DIEZ; SOTORRIO, 2018).

Relations between companies and their employees are also impacted by the socially responsible practices. Azim (2016, p. 57) argues that “employees are not only concern about their payment but also seeking for a meaning for their jobs”. From this perspective, it concludes that engaging in socially responsible activities promoted by the organization provides such a bond for employees, as there is a positive relationship between perceived relative CSR and employee organizational commitment and dedication, and organizational citizenship behavior related to organization (AZIM, 2016).

Consequently, social responsibility and strategy are sides of the same coin; such practices enhance the company's reputation and improve its competitiveness. Social responsibility is part of the company's competitive strategy and, according to Harjoto (2017), fraud is less likely to occur in companies that have high ethical values reflected in social responsibility actions.

All productive sectors are affected by society's growing demand for companies' greater commitment to social responsibility. However, the responsible actions demanded by society often vary, and depend on the economic and social impacts of companies on everyone.

1.3. Social responsibility and strategy in the food and beverage industry

Regarding the food and beverage industry, Hartmann (2011) states that there are three challenges facing the issue of social responsibility: (I) dependence on natural, physical and human resources; (II) great concern and demand from people regarding the production process, as well as the production of raw materials (if organic food is used, if there is guarantee of animal welfare, if the company makes use of sustainable energies, and if waste is disposed of properly. Because people care about healthier, better quality, and sustainably manufactured food); (III) conflicts within the sector, because their structure is complex, with companies of different sizes, which differ in their approach to corporate social responsibility.

According to Maloni and Bronwn (2006), food and beverage industry has suffered significant risks in receiving public criticism related to corporate social responsibility issues. Such criticisms concern the deficiency of social responsibility actions, which may compromise the profitability and long-term survival of the company.

An example of this, in Brazil, involved the companies JBS and BRF that, due to suspected payment of bribes for the release of products that were not properly supervised and, also, adulteration of meat destined for the domestic and foreign markets, had their reputation and image seriously compromised.

Another example related to the intern public of companies, involves Nestlé and Coca Cola. Hartmann (2011) explains that these companies have already operated under inadequate working

conditions and have not had environmentally responsible conduct in their subsidiaries located in developing countries, resulting in significant reputational losses. In addition, the poor quality of products sold in these countries has led activists to boycott products produced by these companies.

As public criticism is not limited solely to the company's internal conduct, but to the entire industry's supply chain, organizations increasingly use codes aimed at promoting social and environmental initiatives. In the face of increasing public perception of corporate social practices, the food and beverage industry is actively involved in social responsibility initiatives.

Aspects of social responsibility that can be seen as strategic for food and beverage companies involve: the link between social responsibility and the mission and values; the development and execution of projects and programs aimed to raise the well-being of external and/or internal publics; the establishment of behavioral standards through the code of ethics or conduct; the disclosure of sustainability reports, aiming to inform about the efforts made to improve the lives of citizens, employees and the environment, as well as the results achieved with social initiatives; and support for institutes or partnerships with entities committed to sustainable development; the concern with the customers' health, among others.

These social attributes need to be planned, executed, verified and communicated throughout the food and beverage chain so that all information is trustworthy to consumers and other stakeholders. Besides, social actions help the company to confront times of difficulty that could cause potential negative impacts on its corporate reputation.

Addressing social responsibility actions in the food and beverage sector, Kong (2012, p. 323) states that "corporate social responsibility in the food sector is particularly important because of the wide range of potential benefits". One of the reasons given by the author for the increased concern about social responsibility in the food sector refers to the growing importance attached to the safety in food production and supervision, highly valued by consumers, in contrast to the harm potential, such as diseases and even death.

From this perspective, Maloni and Brown (2006) deepen the debate about the relevance of social responsibility actions and practices in this sector, highlighting the vulnerability of companies to protests and indignation of the population, due to the high degree of recognition that brands have in relation to other areas of the economy, due to the proximity between the final product and the consumer, and all the social and environmental impacts attributed to these organizations.

In addition to their commitment to public health, companies in this sector have much to gain by incorporating social responsibility into their strategic actions. In this sense, the Akatu Institute - Ethos Institute (2010) points out that: 70% of consumers are willing to overpay for products from sustainable companies, 55% are more likely to buy products that have greater social benefit, and 75% of Brazilian customers say that it is important to examine corporate social responsibility strategies.

1.4. Research Problem

The activities in the food and beverage industry have an impact on society. From this point, the relevance of social responsibility projects and programs arises from the need to minimize the negative impacts of the sector, as well as to promote sustainable development. However, there are only few studies that associate social responsibility and strategy.

Thus, the research questions are: how do food and beverage companies communicate social responsibility actions? How does this sector articulate social responsibility and strategy?

2. Objectives

2.1. General Objective

To study the social responsibility communication of the food and beverage industry in Brazil, as well as to characterize the articulation of social responsibility actions with business strategy, in order to establish an overview of the situation in the referred industry and promote management tactics capable of increasing the return to society, towards sustainable development.

2.2. Specific objectives

- To know the social responsibility actions of companies from the food and beverage industry operating in Brazil;
- To compare the social responsibility actions of foreign companies and those with capital origin in Brazil; and
- To verify the articulation of social responsibility projects and programs with business strategy.

3. Methodology

3.1. Research characteristics

This research is qualitative, once it seeks for an explanation of facts in the social context that, possibly, are relate to many variables. With the purpose to have a more detailed overview about the theme, Knechtel (2014) links this analysis to subjectivity, and the criteria that he considers important to study are: beliefs, values, motivations, social relations, attitudes, strategies, and management models.

Regarding its delimitation, it characterizes as descriptive and explanatory. According to Severino (2007, p. 123) descriptive research is the one that beyond “recording and analyzing the phenomena studied, seeks to identify their causes”. In this sense, it was intended to characterize communication and understand the motivators for social responsibility actions from food and beverage companies. The research is also explanatory, once it was intended to evidence the link between social responsibility and competitive strategy. For Gil (2008, p. 28), this type of research “has the main concern to identify the factors that define or contribute to the occurrence of the phenomena”.

It is also characterized as bibliographic and documentary, because the data collection was performed from public information that is available on the websites of the largest food and beverage companies operating in Brazil.

For the construction of the work and a better understanding on the subject, it was studied the food and beverage companies from Brazil that carry out social responsibility projects and programs. The selection criteria for these companies was the position in the ranking of net revenue of the food and beverage sector in 2017, published in the Valor (2018) ranking. As a result, all the food and beverage companies ranked among the 100 largest Brazilian companies in net revenue were studied: JBS; Ambev;

Bunge Alimentos; Cargill; BRF; Marfrig; Louis Dreyfus; Amaggi; Nestlé; Minerva Foods; Coca-Cola Femsa; and Aurora Alimentos.

The largest companies in the sector were privileged in the analysis, because as proposed by Enderle (2004), research related to corporate social responsibility focuses mainly on large multinational companies, as they are the main agents of economic globalization, being responsible for their influence and impact on society and nature. In addition, the companies' conduct exclusively for capital accumulation have come to be questioned from major world conferences on environmental and social issues, so the business sector, represented by some companies, is at the forefront of sustainability (ELKINGTON, 2012).

3.2. Data collection and analysis

The internet is one of the corporates' ways to present their information regarding the engagement with social responsibility. In general terms, companies keep their key information available on their websites, seeking to give stakeholders a good image. When they disclose their principles and code of conduct, as well as their involvement with responsible practices, companies aim to attract investors, increase sales, gain greater profitability and stand out from other companies in the market.

Based on the ranking of the 100 largest Brazilian companies in net revenue, it was identified the largest in the food and beverage sector and, with this information, it was possible to verify on their websites their respective social responsibility engagements. There was a total of 12 companies analyzed, which are listed in Table 1.

TABLE 1. Food & Beverage Industry Ranking, Brazil, 2017.

Company	Sector	Origin	Net Revenue R\$ millions
JBS	Food and beverage	Brazil	163.170,0
Ambev	Food and beverage	Brazil	47.899,3
Bunge Alimentos	Food and beverage	Netherlands	38.308,2
Cargill	Food and beverage	United States	34.238,2
BRF	Food and beverage	Brazil	33.469,4
Marfrig	Food and beverage	Brazil	18.577,9
Louis Dreyfus	Food and beverage	France	17.254,5
Amaggi	Food and beverage	Brazil	14.144,9
Nestlé	Food and beverage	Switzerland	14.007,0
Minerva Foods	Food and beverage	Brazil	12.103,8
Coca-Cola Femsa	Food and beverage	Mexico	9.899,2
Aurora Alimentos	Food and beverage	Brazil	8.049,9

Source: Valor. Ranking Valor 1000. N° 18, Year 18, August 2018, p. 88-91.

Data were collected from the websites of the 12 companies on the list of the 100 largest companies in Brazil, with net revenues in millions of reais (R \$), between March and April 2019. With the numbers in hand, a section dedicated to the publication of social responsibility information was searched. The aspects analyzed on corporate websites were based on a set of indicators proposed by Branco, Delgado, Sá and

Sousa (2014), involving the following items: ethics or conduct code; link to the corporate social responsibility section; detailing of the corporate social responsibility projects; results of corporate social responsibility projects; press clips and articles related to corporate social responsibility; link to the sustainability report and/or Global Reporting Initiative (GRI); awards and presence in rankings focused in corporate social responsibility; and attendance in institutions and associations dedicated to corporate social responsibility.

3.3. Hypothesis Test

In order to verify the influence of the origin of the company's capital on social responsibility actions, the chi-squared test was performed. This test is nonparametric and its purpose is to verify if two variables are associated. When the differences between observed and expected frequencies are very small, close to zero, there is no association between the variables. The following hypotheses were tested:

Null hypothesis (H0). The social responsibility actions of Brazilian and foreign companies are similar. In this case, the observed frequencies are no different from the expected frequencies.

Alternative hypothesis (H1). The actions of social responsibility of Brazilian and foreign companies are different. In this case, the observed frequencies are different from the expected frequencies and the deviations are significant.

To perform the test, all 12 companies in the food and beverage sector listed among the 100 largest companies in Brazil in the Valor ranking (2018) were surveyed. There were 120 observations, concerning ten different categories. For the purpose of comparing companies with capital origin in Brazil and abroad, the data were grouped into ten categories, in a total of 20 observations.

4. Results Analysis and Discussion

4.1. Social Responsibility communication

The results show, as can be seen in Chart 1, that the largest food and beverage companies ranked according to their net revenue have a variety of information on their engagement with social responsibility.

The six largest companies in the industry, in terms of net revenue, meet all the requirements analyzed. Coca-Cola Femsa also meets all requirements. In other words, a total of seven companies, among the 12 surveyed: have links on their website that refer to pages addressing the theme of social responsibility; have an ethics or conduct code; detail community social responsibility projects and programs and philanthropy actions, as well as responsible business practices; publish annual sustainability reports, suggesting that they monitor and evaluate the results of social responsibility projects; have a press page where they publish news related to social responsibility; have won awards or been rated in rankings that reward initiatives in the field of social responsibility; participate in institutions or associations dedicated to supporting social responsibility projects.

It is also highlighted in Chart 1 that all the companies studied mention social responsibility on their homepage or in other section that addresses this theme on their website. However, from all the twelve companies, five of them did not make available at least one of the aspects studied.

CHART 1. Social Responsibility (SR) in companies of food and beverage. Brazil, 2019.

Companie	Ethics/ conduct code	Link SR	SR project detailing		SR project results		Press clips	GRI* Link	Awards / rankings SR	Participation Institutions / Associations SR
			Communit y engage ment / philanthro py	Responsibl e Practices	Communit y engage ment / philanthro py	Responsi ble Practice s				
JBS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ambev	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Bunge Alimentos	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
BRF	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Cargill	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Marfrig	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Louis Dreyfus		✓	✓	✓	✓	✓	✓	X*		
Nestlé		✓	✓	✓	✓	✓	✓	X*	✓	✓
Amaggi	✓	✓		✓	✓	✓	✓	✓	✓	✓
Minerva Foods		✓		✓		✓		✓		✓
Coca-Cola Femsa	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Aurora alimentos	✓	✓	✓		✓		✓	✓	✓	✓

Source: Elaborated by the authors, based on research data.

(*) GRI= Global Reporting Initiative

The company with the lowest score was Minerva Foods, as only half of the questions raised and analyzed were reported on its corporate website. This result raises attention, due to the fact that this company occupies the tenth place among the food and beverage companies in the Valor (2018) ranking. According to Wanderley, Lucian, Farache and Sousa Filho (2008), the largest companies tend to disclosure more information about their projects and programs of social responsibility than the smaller ones. This is explained, according to Andrikopoulos and Kriklani (2013), because society expects more from large companies, for its greater impact on the population and the environment.

A company that adopts ethical standards that value its relationship with the environment in which it operates has a better image to stakeholders, because it considers its impact on the environment, the stakeholders and customers. Communication is fundamental to build company's reputation, that's why so many companies invest in transparent disclosure that is adapted to the expectations of each of their public, showing commitment in finding solutions to problems that affect their environment.

As for social responsibility programs, only Maggi and Minerva Foods have no details on their website about community engagement and philanthropy. Examining the pages of social responsibility of other companies, it was found that there is an emphasis on education projects (especially for children and youth), artistic and musical development, and environment.

All of the companies analyzed make available on their website projects and programs that benefit their employees, ranging from encouraging them to volunteer, to providing financial support for training and learning. An example of that is Cargill, that has in its website details about its enrolment with the project called "*Semeando Futuro*", in which its employees work, in order to promote the transformation of communities, aiming to make people aware of the importance of healthy, safe and sustainable eating. In this case, volunteering can be exercised during office hours, thus strengthening the company's support for this initiative and the cause of safe eating.

In addition, ten companies use the corporate website to inform policies related to their employees, which aim fair treatment without race and gender discrimination.

Regarding the ethics or conduct code, only three companies does not have a section or a PDF file about it. Among the companies that have a code of ethics or conduct, seven of them mention their code on the homepage of their website.

The selected companies, with the exception of Aurora Alimentos, communicate their responsible practices with suppliers, and inform that the main condition to maintain a partnership is the adoption of a conduct code for suppliers, aiming animal welfare, environmental preservation, and the fight against slavery and child exploitation.

Chart 1 also reveals that all companies present annual sustainability reports. This way, it is possible to affirm that there is an effort to communicate the social responsibility activities, besides monitoring the results obtained through such activities.

Furthermore, it was observed that most of the companies make their reports available in Portuguese. Louis Dreyfus and Nestlé publish their reports only in English, while JBS and Amaggi make it available in both languages, Portuguese and English.

One hypothesis to be considered, as proposed by Silva Filho, Benedicto, Sugahara and Georges (2019), is that companies with websites in Portuguese, but with reports only in English or Spanish suppose that Brazilian customers are not interested in being informed about those companies' social responsibilities practices.

Finally, the results show that the selected food and beverage companies have many ways of informing their social responsibility practices on their corporate website. Nevertheless, the communication could be improved through more detailing of the responsible practices and the results of the developed projects. Thereby, the companies would respond more effectively the stakeholder demands and strengthen their reputation and increase sales and profits in the long term.

However, there are possibilities for improvement. For example, companies would increase the effectiveness of their communication by informing in a more detailed way the period in which the program was executed, which institutions were involved, the number of volunteers, the financial resources involved, the number of benefited people, the generated income, places preserved or restored, the improvements in the manufacturing process that resulted in waste and pollutants reduction, among others.

4.2. Comparing social responsibility actions

The analysis was performed from the corporate website information of food and beverage companies. Each analyzed data received one (01) point. The score achieved by the companies in each rated item, given the highest score possible, was transformed into a percentage. In Table 2, it is highlighted the percentage of companies that communicate, on corporate website, the evaluated item.

TABLE 2. Social Responsibility (SR) food and beverage companies in Brazil, for each evaluated item (in %)

Item	Brazil	Abroad
Ethics or conduct code	86	80
SR Link	100	100
Community engagement and philanthropy detailing	86	100
Responsible Practices Detailing	86	100
Community engagement and philanthropy results	86	100
Responsible practices results	86	100
Press clips	86	100
GRI Link	100	100
SR Awards or Rankings	100	100
Participation institutions or associations SR	100	100

Source: Elaborated by the authors, based on research data.

The χ^2 statistic is 0.949805, and the χ^2 statistic, tabulated with a significance level of 0.05 (or 5%) and nine degrees of freedom, is 3.325, indicating that the hypothesis of independence (H_0) cannot be rejected. Therefore, it is accepted that companies with their capital origin in Brazil and those with capital origin from abroad give similar treatment to the social responsibility theme.

Similar result can be observed in the literature. Silva Filho, Benedicto, Sugahara and Georges (2019), Branco, Delgado, Sá and Souza (2014), and Tang Li (2009) comparing the communication of social responsibility between companies of different nationalities, found that the differences are small, without any statistical significance.

It is important to highlight that, in the case of the studied food and beverage companies, that foreign companies operating in Brazil offer a greater variety of information.

Cormier and Magnan (2003), addressing the proximity of administrative practices to the communication of social responsibility, understand that globalized stock markets induce similar behavior among companies, regardless of stakeholders and the capital origin.

4.3. Social responsibility and strategy

The social responsibility is linked to the competitive strategy of companies, as suggested by the studies of Faria and Sauerbronn (2008) and Barnett (2007), among others. This occurs because social responsibility makes it possible to strengthen the company's image, resulting in a better relationship with customers and other stakeholders, contributing to the company's survival and long-term profit growth.

All researched companies show commitment with social responsibility, detailing their projects and the results of their social action, although the magnitude varies from company to company

In addition, among the surveyed companies, those with the highest net revenue meet all the investigated items. As demonstrated by Branco, Delgado, Sá and Sousa (2014), large companies invest in social responsibility projects and programs, among other things, the purpose of minimizing the impacts resulting from their activities on the population and the environment, building a more positive image with

society.

The companies with the largest net revenue are the ones more likely to communicate their actions of social responsibility. It shows that investments in social responsibility result in competitive advantage in the long term.

All analyzed companies provided sustainability reports, which should be understood as the means to articulate strategy with social responsibility actions and impacts on stakeholders. Through sustainability reports, companies also communicate the foundation to the social, environmental and economic sustainability, from their point of view.

The availability of sustainability reports is essential as they inform stakeholders about the company's actions in a pragmatic manner, highlighting their investment efforts with the purpose of providing a better life for society and protecting the environment. Therefore, the observed results indicate that Brazil's largest food and beverage companies articulate social responsibility with their competitive strategy.

Although developing countries are not at the forefront when it comes to social responsibility concerns, the results show that the Brazilian food and beverage sector has a strong commitment to social responsibility actions, however the level of involvement is different from company to company.

Social responsibility actions contribute to greater market share and, in return, require greater investments in social actions. This is interesting for the country as it contributes to social and environmental progress towards sustainable development, and it encourages other companies to follow the leader ones so that they remain competitive in a scenario of profound and irreversible transformations.

5. Final considerations

The results indicate that food and beverage companies communicate actively their responsible actions. Among the analyzed items, only the code of ethics or conduct were more publicized by companies with capital origin in Brazil than companies with origin of capital abroad. The items: detailing of corporate social responsibility projects; results of corporate social responsibility projects; press clips; and articles related to the social responsibility theme, are more published by companies with capital origin abroad.

These companies also reveal a more complex range of information and offer more space for social responsibility on their corporate websites, when compared to the ones from Brazil. Perhaps because of a cultural issue, the companies with capital origin in Brazil understand that the involvement with social responsibility should be conducted in a more discrete way, against a more commercial attitude of companies from other parts of the world. Evidently, other analysis are necessary to verify if this affirmation is correct. There are many possibilities for future research in this field.

Nevertheless, statistically no significant differences were found between companies with capital origin in Brazil and companies with origin of capital abroad regarding to the involvement with responsible actions.

Thus, no evidence was found that the capital origin and therefore of stakeholders, results in differences in the communication of social responsibility. This points to the convergence of corporate practices that respond to the demands of globalized stock markets.

It was also found that companies with higher net revenues are more likely to engage in social responsibility communications. This suggests that investments in social responsibility result in long-term competitive advantage. Certainly, further analysis is needed to verify whether such statement is correct.

There are possibilities to make the communication of responsible actions more effective. To do so, it is necessary to detail the responsible business practices and the results of developed projects. This enables companies to respond more effectively to stakeholder' demands, overcoming the idea of social responsibility as a marketing or public relations tool.

Regarding the article limitations, first of all, the analysis was restricted to a relatively small sample. Second of all, it is composed only by big companies. However, given the intention to identify the perception and apprehension of the concept of responsibility and its articulation with business strategy, sample size and company size can be an advantage as they minimize the risk of a sample containing companies with very different characteristics, which can alter the results.

The third limitation concerns about the communication channel, as only the information available on websites of food and beverage companies was studied. By all means, there are other possibilities for communicating responsible actions and these were not addressed. However, the communication of social responsibility through the corporate website is a rich source of data and should be studied.

Another obstacle is the mechanism of data capture due to its subjectivity. To minimize the possibility of this limitation interfering in the results, the sample of the companies surveyed was relatively restricted, with only large companies being investigated, and with close attention to the characteristics of the reality studied.

Further researches must be conducted seeking to overcome these barriers. The expansion of the number of companies and also the investigation of other means used for the communication of social responsibility actions needs to be carried out, as well as the analysis of the content of the published information.

Lastly, the results achieved make it possible to demonstrate the importance attributed by food and beverage companies to social responsibility actions, as well as to evidence that social responsibility is becoming an important tool in the competitive strategy of companies in this sector.

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Relationship among quality management practices, innovation and competitive advantage in manufacturing companies certified with ISO 9001 in Brazil

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Abstract

The objective of this study was to investigate the relationship among quality management practices, product and process innovation and competitive advantage in manufacturing companies certified with ISO 9001 in Brazil, using the model proposed by Kafetzopoulos, Gotzamani, and Gkana (2015). The study can be classified as descriptive, with data collection carried out by survey and quantitative approach with structural equation modelling. The results showed the model adopted has quality to measure the proposed relations, in addition to support the hypothesis previously defined. The conclusion of the study indicates the results contribution to the studies on the theme, the quality management practices have a positive and significant relationship with both types of innovation investigated, and the respective constructs of innovation have positive and significant relationships with competitive advantage.

Keywords: Competitiveness; Total quality management; ISO 9001; Process Innovation; Product Innovation; TQM.

1. Introduction

One of the main objectives of companies is the excellence in performing their activities. It is an important element for the success of them in order to obtain competitive advantage compared to their competitors. There are several aspects related to organizational performance, an extensive area of interest to managers and researchers to detect, explain and develop ways to achieve such requirements. Quality and innovation are among the several aspects.

The two areas of research are in a wide range of interpretations and perceptions in conceptual and practical terms. This fact makes them theme of the most varied studies and discussions, which advance the knowledge extent and depth of analysis. Several studies about the two themes contributed to a great accumulation of academic papers investigating the relations in terms of organizational performance, as well as the influences both can have between themselves, as the works of Flynn (1994), Prajogo and Sohal (2003), Martínez-Costa and Martínez-Lorente (2008), Kafetzopoulos, Gotzamani, and Gkana (2015), and others.

The literature shows there is not consensus on the existence of relations between the practices attributed

to quality management related to innovation. There are different results from studies with this objective, also the criticism regarding the methodological elements adopted and the real possibility of inferences provided by the results of studies. This reflects the lack of studies available and can negatively affect or become opportunities for future research (Segarra-Ciprés, Escrig-Tena, & García-Juan, 2017).

For a long time, quality had an important role in the search for competitive advantage. One of the ways to achieve competitive advantage through quality involved the creation of a culture of quality management, based on principles for all the organization, as total quality management (TQM). To formalize the pursuit for quality development in organizations, certifications, as ISO 9001, has emerged. They can be seen as a way to create an organizational culture to pursue quality (Mangiorotti & Riilo, 2014).

However, a better performance in quality became increasingly common among organizations, they begin to give more attention to innovation as a driving force toward achieving competitive advantage (Flynn, 1994). The study of Kafetzopoulos, Gotzamani, and Gkana (2015) tried to identify the relationship among five quality management practices associated with TQM (leadership and support from senior management, training and involvement of employees, information and learning, management of processes, and focus on the client), product innovation, process innovation and competitive advantage. The study has been tested and validated in Greece, proving all the assumptions established previously.

The main justifications for this study are the few studies investigating relationships between quality management practices and innovation in Brazil, lack of studies on this theme also investigating the relationship between innovation and competitive advantage, and low replicability of existing models in literature in different contexts. Thus, the objective of this study was to investigate the relationship between quality management practices, innovation and competitive advantage in manufacturing companies certified with ISO 9001 in Brazil, using the model proposed by Kafetzopoulos, Gotzamani, and Gkana (2015).

2. Literature Review

Historically, the management of quality have developed through several practical policies, tools and methodologies. This shows the effort to pursue quality in an objective and organized way. Other names as principles, elements, constructs and techniques also compose this long list of classifications names related to quality management. They may even be considered synonymous in many cases.

The so-called quality tools are already well known and disseminated, one of the leading names of their popularization is Kaoru Ishikawa. This famous specialist in quality area, proposed seven tools closely related to the statistical control of quality and resolution of problems. They are check sheet, chart for trend analysis, histogram, Pareto chart, cause-and-effect diagram, scatter diagram, and control chart (Neyestani, 2017).

Other designations of quality tools are also present in the literature as affinity diagram, diagram of arrow, array of data analysis, relationship diagram, brainstorming, sampling, and others. The techniques of quality management, for example, are benchmarking, analysis of departmental purpose, design of experiments, Failure Mode and Effects Analysis (FMEA), fault tree analysis, poka yoke, troubleshooting methodology, quality cost, Quality Function Deployment (QFD), times of improvement of quality, Statistical Process Control (SPC), and others (Singh, Khan, & Grover, 2012).

Kafetzopoulos, Gotzamani, and Gkana (2015) present as quality management practices the leadership and support from senior management, training and involvement of employees, information and learning, processes management and customer focus, which are commonly associated with TQM. The leadership and support from senior management go beyond the simple authority to take decisions in organizations. It is a practice associated with managers ability to guide and help to create an environment capable of motivating people to reach goals (Flynn, 1994; Kafetzopoulos, Gotzamani, & Gkana, 2015).

Training is associated with development of employees capacity in organizations, enabling them to acquire the knowledge and skills to better execute its functions (Kim, Kumar, & Kumar, 2012; Saraph et al., 1989). For a better development of quality culture within organizations, employees should be trained in the use of quality tools, as principles of TQM and processes. It is also necessary to involve them in decisions and strategies of the organization, in order to best use their creativity and maintain an environment in which they are motivated (Bon & Mustafa, 2014).

The effective use of information and learning are elements associated with organizations ability to acquire, develop and better use the information to achieve their goals, which can be shared both internally and externally (Calantone, Cavusgil, & Zhao, 2002; Kafetzopoulos, Gotzamani, & Gkana, 2015).

The management of processes involves orientation and direction of efforts in a coordinated way within the framework of the processes. This implies a greater integration between tasks and activities of the most varied functions of organizations (Kafetzopoulos, Gotzamani, & Gkana, 2015; Psomas, Fotopoulos, & Kafetzopoulos, 2011). The management of processes is related to the management of the routine activities of the organization, and those that generate the products and services offered (Gutierrez Gutierrez, Tamayo Towers, & Garcia Morales, 2010).

The focus on the customer is the core of the total quality management, a perspective that tries to first identify the needs of customers to serve them (Carvalho, 2012; Kafetzopoulos, Gotzamani, & Gkana, 2015). An organization following the principles of TQM has the customer in the centre of its decisions (Ross, 1999).

Innovation can be understood as the creation of something new or with significant improvements (OECD, 2004). This and other definitions are associated with different classifications. Some classifications can be grouped by type (product innovations, process, organizational or marketing), degree of novelty (new innovations for the company, the market or the world), and impact (radical or disruptive). Other classifications of innovation are incremental innovation (Tether, 2003; Constant, 1987), open innovation (Barczak, 2012; West et al., 2014), and social innovation (Barczak, 2012).

Kafetzopoulos, Gotzamani, and Gkana (2015) present a model to product and process innovations. The product innovation can be understood as an entirely new product or service, or a product or service with significant improvements in functional aspects (OECD, 2004). Tether (2003) and Saviotti, and Metcalfe (1984) say a product involves the output of a process, subsequently delivered to a particular customer, specified in relation to what it is (technical characteristics) and what it does (service features). The authors complement affirming the characteristics of service are the most perceived by customers, and the changes or recombination of technical features and services determine the emergence of a new product.

The process innovation can be understood as a new or significantly improved way to produce or deliver products and services, new or not. Innovation in processes involves technological aspects (process

technology) and non-technological aspects (methods and techniques of production and distribution) (OECD, 2004). A process can be specified by what it does (product) and how it does (steps of manufacturing). Different from what happens with a product, the identification of a process innovation is not clear, because it usually involves small changes to its improvement over time, the "continuous improvement". However, if the change is on a large scale and involve substitutions or significative improvements in technologies and techniques used, then the innovation process becomes more evident (Tether, 2003).

The concept of the competitive advantage is intimately connected to the value an organization creates and delivers to its customers, value not generated by another competitor (Porter, 1985; Barney, 1991). Another aspect raised by Porter (1985) and Barney (1991) involves more than obtain a competitive advantage: its sustainability. Gain a competitive advantage is not a great benefit for an organization if it cannot continue for a specified period of time (Porter, 1985). It should also involve something difficult to replicate (Barney, 1991).

Prajog and Sohal (2003) emphasize the quality would no longer be a criterion for winning order, because strategies would be widely adopted in organizations, making the performance in quality only for qualifying order. Innovation would be assuming this role to represent a criterion for winning order for organizations, replacing quality, which would make innovation a more effective aspect to pursue competitive advantage.

Martínez-Costa and Martínez-Lorente (2008) emphasize innovation is a critical success factor for organizations, an important strategic component allowing them to react better to quick environmental changes by the exploration of new markets launching new products. In this way, innovation is becoming not only a competitive advantage for organizations, but also a necessity in times of great competition, rapid technological change and shortage of resources.

Trivellas and Santouridis (2009) argue the total quality is still an important strategic factor for organizations, the effective application of TQM principles impacts directly the organizational performance in such a way they are still able to increase competitiveness. However, organizations rely increasingly on knowledge management, and innovation will be the main point for achieving sustainable competitive advantage.

Kafetzopoulos, Gotzamani, and Gkana (2015) argue innovation is a competitive advantage, it is not enough to an organization create something new, it has to penetrates in its culture, such a concept. The internal and external pressures of an organization force it to pursue creative solutions, and it can configure a fertile environment to test the capacity of an organization in terms of innovations generation.

3. Development of Hypotheses

An organization experienced at the use of quality management practices has a solid basis for innovation (Flynn, 1994). Considering change a basic element for innovation (Tether, 2003), this can happen due to the adoption of quality management practices reflecting a desire and a need for change in organizations, as the case of companies pursuing certification ISO 9001 (Segarra-Ciprés, Escrig-Tena, & García-Juan, 2017).

In addition, Perdomo-Ortiz, González-Benito, and Galende (2006) argue the adoption of quality

management practices can also contribute to accumulation and better use of knowledge, important elements for decision-making concerning changes in organizations, which is important for the development of innovation. Many empirical studies found positive and significant relationships between quality management practices and innovation, and a few empirical studies found negative relationships. Researches about the product and process innovations are more common (Segarra-Ciprés, Escrig-Tena, & García-Juan, 2017).

The quality management practices adopted in the model of Kafetzopoulos, Gotzamani, and Gkana (2015) are found in other works on the same theme, most often associated with TQM (Bourke & Roper, 2017; Kim, Kumar, & Kumar, 2012). The authors designated them leadership and support from senior management, training and involvement of employees, information and learning, processes management, and customer focus. In terms of innovation, the roles of leadership can be assist in building a culture of innovation (Ooi et al., 2012), align the innovation strategies with the overall strategy of the organization (Dervitsiotis, 2010), making decisions about the design of products and processes (Flynn, 1994), and others.

The development of new knowledge and skills provided by training is more than the mere performance of basic tasks. It also qualifies the employees to develop new ideas, operate new systems more easily, as well as to accept and better promote changes in organizations (Martínez Lorente, Dewhurst, & Mitchell, 1999). Combined to training, the involvement of employees in the decisions and in providing innovative ideas allows companies to leverage their innovative capabilities, this would not exist without employees participation (Kafetzopoulos, Gotzamani, & Gkana, 2015; Perdomo-Ortiz, González-Benito, & Galende, 2006).

The intelligent and effective use of information gives employees of an organization more understanding of its processes and products, assisting the identification of elements that add value or not, and reduce the time necessary for the introduction of new products on the market, and the improvement of processes (Kim, Kumar, & Kumar, 2012).

Manage processes can reduce the response time of the organization by increasing efficiency, which also helps to reduce the time to launch new products (Honarpour, Jusoh, & Md Nor, 2017). In addition, continuous improvement is a critical element for the innovation process (Tether, 2003), and it is also provided by the effective management of processes (Kafetzopoulos, Gotzamani, & Gkana, 2015; Honarpour, Jusoh, & Md Nor, 2017).

The focus on the customer, as a pursue to identificate the needs of customers, allows organizations to obtain important information about desirable requirements for new products to be developed (Kim, Kumar, & Kumar, 2012), improvements in existing products (Honarpour, Jusoh, & Md Nor, 2017) and also the production processes and delivery of these products (Kafetzopoulos, Gotzamani, & Gkana, 2015). Based on these arguments, and following the work of Kafetzopoulos, Gotzamani, and Gkana (2015), the following assumptions are made:

H1 – Quality management practices have a positive and significant relationship with product innovation.

H2 – Quality management practices have a positive and significant relationship with process innovation.

In terms of innovation, Flynn (1994) says aspects as fast deliveries and high quality were becoming increasingly common among organizations, which would no longer be ensuring competitive advantage for them. Instead, a source of competitive advantage would be the differentiation provided by launching new products on the market. In addition, some elements to be observed in the external diagnosis of competitive forces, such as markets stagnation, non-explored emerging markets, lower transaction costs, and reduction of trade barriers, are important drivers of innovation in organizations, in terms of products and processes, to obtain sustainable competitive advantages (Volberda et al., 2013; Kafetzopoulos, Gotzamani, & Gkana, 2015). Based on this, and following the work of Kafetzopoulos, Gotzamani, and Gkana (2015), the following hypotheses are presented:

H3 – Product innovation has a positive and significant relationship with competitive advantage.

H4 – Process innovation has a positive and significant relationship with competitive advantage.

With the proposition of hypotheses, the theoretical model used in this study can be presented. It has been extracted and adapted from the article of Kafetzopoulos, Gotzamani, and Gkana (2015), and is illustrated in figure 1. The model establishes the relationship between quality management practices as a single construct, to investigate the relationships between them and the innovations in product and process, as well as the relations between the two types of innovation and competitive advantage.

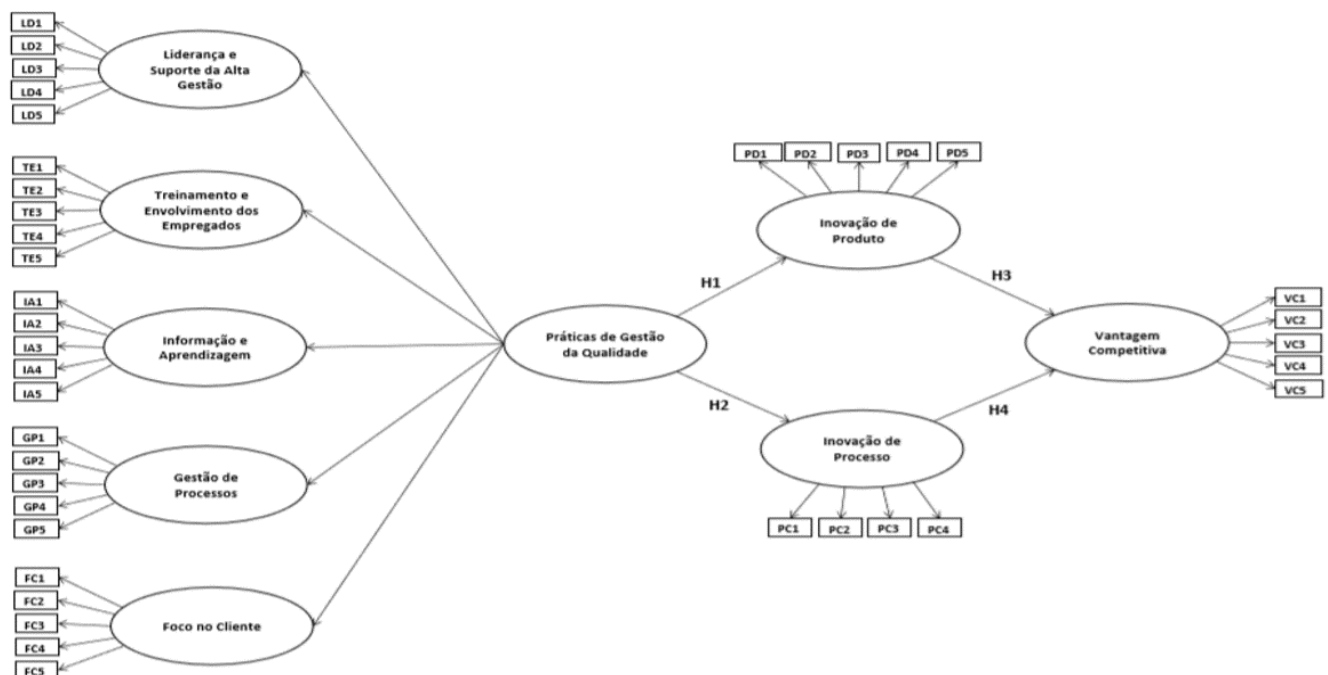


Figure 1. Theoretical Model of research.

Adapted from Kafetzopoulos, Gotzamani, and Gkana (2015).

4. Method

This research can be characterized as descriptive, because it aims to describe the relationships between quality management practices, product and process innovation, and competitive advantage in manufacturing companies certified with ISO 9001 in Brazil. Furthermore, it is also a quantitative research,

because it uses numerical data obtained from responses to a closed questionnaire submitted to statistical tests, both from the point of view of descriptive and inferential statistics. The softwares used for the analysis of the data were: Microsoft Excel® 16.0, IBM SPSS® 25, G*Power 3.1, and SmartPLS© 2.0.

The instrument for data collection adopted in this study was a questionnaire extracted and adapted from Kafetzopoulos, Gotzamani, and Gkana (2015) translated by the researcher. The original questionnaire has 39 questions, they have been translated, some of them were adapted by the researcher. In addition, other 4 questions relating to general information of the company and of the respondents were added.

The 39 questions of the original instrument are related to constructs of quality management practices, product and process innovation, and competitive advantage. Each construct comprises 5 questions, except the construct of process innovation, with 4 questions. The Likert scale of seven points was adopted, ranging from 1 (very low) to 7 (very high). The 4 questions about general information of companies and of the respondents were open and had the following themes: branch of the company, company size, state in which the company is located, and sector in which the respondent work in the company. The questionnaires were addressed to employees of different areas and hierarchical levels of companies.

A list with 7670 manufacturing companies, certified with ISO 9001 in Brazil, was obtained from the site Certifq, of the Instituto Nacional de Metrologia, Qualidade e Tecnologia (National Institute of Metrology, Quality and Technology - Inmetro, 2018). After eliminate double records (722), companies the researcher could not contact or could not find the site (1263), companies not identified as industries (113), organizations not identified as companies (5), and companies identified but not contacted in time (106), the questionnaire were sent by email to que remaining 5461 companies.

131 questionnaires were answered. This number, for the purposes of multivariate analysis with the techniques of structural equation modelling by partial least squares (SEM - PLS), can be considered sufficient, since it is an approach that can produce consistent results with small samples (Ringle, Silva, & Bido, 2014).

To identify a minimum sample of reference a priori and an estimate of the post hoc statistical power, based on statistical criteria, software G*Power (Ringle, Silva, & Bido, 2014) were used. The results revealed a value of 68 respondents as minimum sample, fixing a median effect size ($f^2 = 0.15$), a power of 0.80 and a maximum number of two predictors pointing to a latent variable (construct "competitive advantage").

To calculate the power of post hoc test, it was used as input the size of the sample obtained in the present study, number of two predictors and median effect size ($f^2 = 0.15$). The results showed that, for a sample of 131 respondents, the power of the test is 0.98, in other words, there is 98% chance of correctly rejecting a null hypothesis when it is false (Hair Jr et al., 2009).

The analysis of the sample found, with respect to the branch of activity, that most of the companies of the sample act in metallurgy (14 companies - 10.69%). About the size of the company, the majority consists in midsize businesses (68 companies - 51.91%). In regard to localization, most companies are in the state of São Paulo (53 companies - 40.46%). With respect to the sectors in which the respondents work in their respective companies, most of them are in the sector of Quality (75 respondents - 57.25%).

This research used the multivariate statistics, more specifically the structural equations modelling by partial least squares (PLS - SEM). The steps followed for data analysis consisted in the preparation of data

(analysis of lost data, atypical observations and test of normality), quality evaluation of measurement model adjustment, quality evaluation of structural model adjustment, and testing of hypotheses.

The analysis of atypical observations was performed by boxplot graphs and normality was assessed using the Shapiro-Wilk and Kolmogorov-Smirnov tests. They test the hypothesis of normality for each variable observed, considering not normal data presenting value of less than 5% significance (Hair Jr et al., 2009).

The quality evaluation of measurement model adjustment considered the validity (convergent and discriminant) and the reliability of latent variables. To analyse the convergent validity, the average variance extracted (AVE) of each latent construct were observed. In the case of the discriminant validity, two criteria were adopted: the criterion of Chin and the criterion of Fornell and Larker. About reliability, Cronbach's alpha (CA) and composite reliability (CR) (Ringle, Silva, & Bido, 2014) were analysed.

The quality evaluation of model structural adjustment involved the observation of the Pearson coefficient of determination (R^2), t-Student test (t), predictive validity or indicator of Stone Geisser (Q^2), the size of the effect or Cohen indicator (f^2), and path coefficients (Γ). Table 1 presents a summary of the indices used to evaluate the quality of adjustment of measurement and structural models. For this study, the index of adequacy of the model (Goodness of Fit - GoF) was not used, because its power to distinguish valid and not valid models is controversial (Ringle, Silva, & Bido, 2014).

Table 1. Indices of adjustment of measurement and structural models.

INDEX / PROCEDURE	PURPOSE	REFERENCE VALUES / CRITERIA
Average Variance Extracted (AVE)	Convergent validity	AVE > 0.50
Cross-loads	Discriminant validity	Values of loads in the originals VLs higher than in others
Criterion of Fornell and Larker	Discriminant validity	The square roots of AVE values of each construct are compared to correlations (Pearson) between the constructs (or latent variables). The square roots of AVEs must be larger than the correlations of the constructs
Cronbach's alpha and composite reliability	Reliability of the model	CA > 0.70 CR > 0.70
T-Student Test	Evaluation of the significances of the correlations and regression	$t \geq 1.96$
Evaluation of Pearson coefficients of determination (R^2)	Evaluates the portion of the variance of the endogenous variables, which is explained by structural model.	For social and behavioural sciences, $R^2 = 2\%$ is small effect, $R^2 = 13\%$ is average effect and $R^2 = 26\%$ is large effect.
Size of the effect (f^2) or indicator of Cohen	Evaluates whether each construct is "useful" for the adjustment of the model	Values of 0.02, 0.15 and 0.35 are considered small, medium and large.
Valid Predictive (Q^2) or indicator of Stone-Geisser	Evaluates the accuracy of the adjusted model	$Q^2 > 0$

Index of adequacy of the model (GoF)	It is a score of the overall quality of the adjusted model	GoF > 0.36
Coefficient of path (γ)	Evaluation of the causal relations	Interpretation of the values based on the theory.

Source: Adapted by the authors from Ringle, Silva, and Bido (2014).

The test of hypotheses was performed through the analysis of statistical significance, strength, and signal of causal relations established in the structural model. The statistical significance was analysed based on the values of t-Student test, values above 1.96 were considered significant. The strength and the signal of relations are associated with the path coefficients (Γ), which indicate relationships stronger or weaker depending on how far the values are from 0, as well as if they are positive or negative based on signal (Ringle, Silva, & Bido, 2014).

5. Results

This section presents the results of the research, demonstrating the preparation of the data, performing the quality analysis of measurement model adjustment, the quality analysis of structural model adjustment and test of hypotheses.

5.1 Preparation of data

With respect to lost data, there were no omissions of response of participants to the 39 questions about the performance of companies in the implementation of quality management, innovation and competitive advantage practices. Even so, as regards the answers to the descriptive questions (branch of activity, company size, location and working sector of the respondent), it was impossible to identify some of the replies, the only cases of omission of data in the present study.

Analysing the atypical data, by a box-plot graphs it was identified that 17 variables presented outliers. According Hair Jr et al. (2009), occurrences like this are common, there is no need expressed for the disposal or processing the data when the researcher feels it is important to keep them. Thus, the choice was to maintain the variables without changing the original data set, because the original configuration is important to elucidate the reality.

To analyse whether or not the variables have a normal distribution, the tests Shapiro-Wilk and Kolmogorov-Smirnov were performed. They test the hypothesis of normality in the data through the observation of the values of significance for each variable observed. Very low values of significance reject the null hypothesis, in other words, they show the data do not have a normal distribution (Hair Jr et al., 2009). The results of the tests of normality showed significance levels below 1% for all variables, which rejects the hypothesis of normality in all of them.

With this, it is possible to say the variables does not meet the assumption of normality, and it is not advised to follow with structural equation modelling based on covariance (CB - SEM). In cases in which it does not have a set of data meeting the assumption of normality, it is possible to use the approach known as structural equations modelling by partial least squares (SEM - PLS) (Ringle, Silva, & Bido, 2014).

5.2 Quality analysis of measurement model adjustment

In the case of the quality analysis of the measurement model adjustment, the first index to be analysed was AVE to certify how the observed variables converge to their respective latent variables, in other words, the convergent validity. AVE values higher than 0.5 indicate a satisfactory level of convergent validity (Ringle, Silva, & Bido, 2014). Analysing the AVE results of each latent variable, all the constructs are higher than 0.5, and the second-order construct "quality management practices" presents the lowest value (a little more than 0.5). Table 2 shows the initial values of AVE for each latent variable model of measurement.

Table 2. Indicators of initial measurement model adjustment

LATENT VARIABLES	AVE	CR	CA
Focus on Customer	0.781288	0.946882	0.929506
Processes Management	0.557981	0.861806	0.798331
Information and Learning	0.76806	0.942993	0.92424
Process Innovation	0.88392	0.968195	0.956025
Product Innovation	0.777767	0.945893	0.928321
Leadership and Support from Senior Management	0.670588	0.910079	0.875238
Quality Management Practices	0.500131	0.960818	0.956822
Training and Involvement of Employees	0.601102	0.882584	0.833412
Competitive Advantage	0.558573	0.862856	0.814645

Source: Prepared by the authors (2019).

The second step consists on evaluate the discriminant validity, and can be done by the observation of cross loadings of observed variables (OV) (criterion of Chin) (Ringle, Silva, & Bido, 2014), and the comparison of the square roots of AVEs with Pearson correlations between the latent variables of the first order (criterion of Fornell and Larcker) (Wetzels, Odekerken-Schröder, & Oppen, 2009; Oliveira et al., 2016). The analysis of cross-loads table shows the results conform the criterion of Chin, because the factorial load of each item are higher in its respective constructs than in others, as can be seen in bold in Table 3.

Table 3. Cross-loads of observed variables

OV	Focus on the Customer	Processes Management	Inform and Learning	Process Innovation	Product Innovation	Leader. and sup. of Senior Management	Train. and Invol. of Employees	Competitive Advantage
FC1	0.83246	0.508657	0.675277	0.398804	0.428496	0.626523	0.550805	0.648295
FC2	0.92915	0.474076	0.695004	0.389591	0.373498	0.687312	0.608612	0.689497
FC3	0.89317	0.362972	0.578835	0.375768	0.290292	0.597871	0.568625	0.652632
FC4	0.91801	0.465442	0.677185	0.437308	0.434248	0.648298	0.619029	0.714941
FC5	0.84241	0.400856	0.535806	0.3333	0.329612	0.555515	0.457033	0.642894
GP1	0.242869	0.70925	0.40958	0.448071	0.435745	0.439495	0.400346	0.435685
GP2	0.202785	0.7496	0.390488	0.440665	0.365944	0.433437	0.394178	0.395217
GP3	0.496034	0.84243	0.579841	0.420648	0.328938	0.575453	0.576541	0.524147
GP4	0.424364	0.6068	0.474098	0.330224	0.321409	0.392474	0.481271	0.382234

GP5	0.447267	0.80441	0.433224	0.280376	0.258607	0.462713	0.506572	0.450812
IA1	0.544983	0.524417	0.84502	0.440593	0.507382	0.664241	0.593258	0.476009
IA2	0.610662	0.53628	0.89094	0.559334	0.599702	0.662838	0.560539	0.572742
IA3	0.667563	0.538124	0.90906	0.538493	0.578212	0.752963	0.618974	0.588373
IA4	0.645651	0.559248	0.89206	0.564869	0.594109	0.749643	0.676441	0.630634
IA5	0.676596	0.564589	0.8428	0.392801	0.43748	0.732441	0.590921	0.577691
PC1	0.403071	0.458705	0.546215	0.91541	0.66741	0.500292	0.407584	0.605429
PC2	0.416523	0.501694	0.517604	0.96024	0.674115	0.5386	0.470045	0.666892
PC3	0.391284	0.528518	0.528568	0.96453	0.686043	0.555665	0.511378	0.63482
PC4	0.441342	0.426113	0.554921	0.91941	0.674216	0.507605	0.430906	0.665816
PD1	0.414824	0.389133	0.560019	0.651298	0.91567	0.556296	0.476146	0.614937
PD2	0.38097	0.409585	0.587676	0.738552	0.88469	0.549899	0.440783	0.576925
PD3	0.399661	0.419278	0.533059	0.626187	0.85187	0.429821	0.450978	0.633798
PD4	0.379951	0.370004	0.576054	0.570864	0.90658	0.549359	0.41256	0.587238
PD5	0.27593	0.400199	0.473472	0.575829	0.84861	0.399253	0.380805	0.566122
LD1	0.532123	0.448049	0.666821	0.476594	0.451697	0.83699	0.517277	0.603037
LD2	0.565206	0.479891	0.751142	0.471549	0.499644	0.88161	0.566876	0.542292
LD3	0.526781	0.539456	0.609065	0.493153	0.45313	0.79426	0.605475	0.522417
LD4	0.664547	0.554799	0.737119	0.472157	0.49787	0.86206	0.62849	0.606583
LD5	0.600094	0.532105	0.553323	0.372415	0.405597	0.70792	0.604546	0.566291
Nt1	0.474276	0.5576	0.520614	0.331646	0.317158	0.5015	0.70058	0.367148
Nt2	0.591946	0.55982	0.517643	0.424153	0.416007	0.617481	0.80614	0.560891
Nt3	0.359632	0.478799	0.450972	0.404057	0.455813	0.522191	0.78328	0.498852
Nt4	0.426446	0.453307	0.565212	0.36897	0.360128	0.539448	0.79108	0.480184
Nt5	0.590514	0.437575	0.626477	0.349062	0.360179	0.577542	0.79087	0.495982
VC1	0.603383	0.50423	0.549078	0.44566	0.535864	0.487759	0.485993	0.72116
VC2	0.507761	0.576407	0.49149	0.433896	0.313805	0.590244	0.468073	0.70209
VC3	0.675901	0.409868	0.354908	0.290524	0.181948	0.446189	0.443294	0.67989
VC4	0.786413	0.460889	0.572107	0.465116	0.41616	0.639117	0.590233	0.81667
VC5	0.436472	0.355596	0.459891	0.720141	0.765812	0.481554	0.406679	0.80664

Source: Prepared by the authors (2019).

As regards the criterion of Fornell and Larcker, the value of the square root of AVE of "competitive advantage" (0.747377) is a little smaller than its correlation with "Customer Focus" (0.758512), demonstrating "competitive advantage" does not meet the criterion established for the discriminant validity. Table 4 presents the correlation matrix of the latent variables with their respective values of square roots of AVEs in the main diagonal cells (in yellow), with red highlights for "competitive advantage" and "focus on the customer".

Table 4. Pearson Correlation Matrix

Latent variables	Focus on the Customer	Processes Management	Inform. and learning	Process Innovation	Product Innovation	Lead. and sup. of Senior Management	Train. and Invol. of Employees	Competitive Advantage
Focus on the Customer	0.883905							
Processes Management	0.502852	0.74698						

Information and Learning	0.7195	0.62164	0.87639					
Process Innovation	0.439503	0.509461	0.570719	0.94017				
Product Innovation	0.422401	0.450698	0.620621	0.718445	0.88191			
Leader. and sup. of Senior Management	0.707622	0.62437	0.814456	0.559314	0.56563	0.81889		
Train. and Involv. of Employees	0.637918	0.641738	0.694885	0.484599	0.491638	0.71455	0.77531	
Competitive Advantage	0.758512	0.591755	0.651252	0.684801	0.676372	0.694159	0.622435	0.747377

Source: Prepared by the authors (2019).

To comply with the criterion of Fornell and Larker, it was observed in table 3, the differences between the cross-loads of items related to the variables "Customer Focus" and "Competitive Advantage" in the table of cross-loads (Ringle, Silva, & Bido, 2014). The smallest difference found was for the item VC3 ($0.675901 - 0.679891 = 0.00399$). The removal of this item contributed to increase the value of the square root of AVE on the construct "Competitive Advantage" (0.763053), above the new value of correlation with "Customer Focus" (0.729475).

Table 5 shows the new values in the matrix of correlations, illustrating the compliance with the criterion of Fornell and Larker for the assessment of discriminant validity. As the withdrawal of VC3 also influenced the indices of convergent validity and reliability of the measurement model, these indices were updated in Table 6.

Table 5. New matrix of correlations after the withdrawal of VC3

Latent variables	Focus on the Customer	Processes Management	Inform. and learning	Process Innovation	Product Innovation	Lead. and sup. of Senior Management	Train. and Invol. of Employees	Competitive Advantage
Focus on the Customer	0.8839							
Processes Management	0.502852	0.74698						
Information and Learning	0.7195	0.62164	0.87639					
Process Innovation	0.439516	0.509426	0.570802	0.94017				
Production Innovation	0.421971	0.450718	0.620429	0.71839	0.88193			
Leader. and sup. of Senior Management	0.707622	0.62437	0.814456	0.559292	0.565419	0.81889		
Train. and Involv. of Employees	0.637918	0.641738	0.694885	0.484533	0.491408	0.714549	0.77531	
Competitive Advantage	0.729475	0.586553	0.660349	0.707161	0.7148	0.693226	0.615315	0.763053

Source: Prepared by the authors (2019).

The third step involves the indexes of reliability and internal consistency: CA and CR. These two

indices assess whether the variables, on the whole, are reliable to measure the proposition. Values higher than 0.7, both CA and CR, indicate good reliability and internal consistency of the latent variables (Ringle, Silva, & Bido, 2014). According to the results, all the latent variables showed values higher than 0.7 for both CA and CR, indicating the measurement model is reliable. The values of CA and CR can be seen in Table 6.

Table 6. Indicators of measurement model adjustment after VC3 removal

LATENT VARIABLES	AVE	CR	CA
Focus on the Customer	0.781288	0.946882	0.929506
Processes Management	0.557981	0.861806	0.798331
Information and Learning	0.76806	0.942993	0.92424
Process Innovation	0.883923	0.968196	0.956025
Product Innovation	0.777808	0.945906	0.928321
Leadership and Support from Senior Management	0.670588	0.910079	0.875238
Quality Management Practices	0.500131	0.960818	0.956822
Training and Involvement of Employees	0.601102	0.882584	0.833412
Competitive Advantage	0.58225	0.847265	0.768667

Source: Prepared by the authors (2019).

5.3 Quality analysis of structural model adjustment

Regarding the quality analysis of structural model adjustment, the results of coefficient R^2 showed values higher than 26%, which indicates large effects (R^2 of the construct "quality management practices", apparently is not only predictor, there is no arrow pointing it in the structural model). In the case of the indicator Q^2 , it is possible to see all variables presented values higher than zero, which indicates the predictive validity of the structural model. The evaluation of the values f^2 confirms almost all constructs have large size effects (above 0.35), with a construct (competitive advantage) with effect between medium and large. Table 7 shows the values R^2 , Q^2 and f^2 for the structural model.

Table 7. Indicators of structural model adjustment

LATENT VARIABLES	Q^2	F^2	R^2
Focus on the Customer	0.53235	0.649407	0.716446
Processes Management	0.315795	0.363839	0.578568
Information and Learning	0.637216	0.642627	0.834999
Process Innovation	0.311838	0.780322	0.358035
Product Innovation	0.269972	0.65774	0.360874
Leadership and Support from Senior Management	0.549361	0.502092	0.825255
Quality Management Practices	0.45254	0.45254	-
Training and involvement of employees	0.421113	0.396322	0.719766
Competitive Advantage	0.296583	0.31166	0.588437

Source: Prepared by the authors (2019).

The *t*-Student test aims to evaluate the significance of relations in the structural model, considering significant relations in which *t*-values are larger than 1.96 (*p*-value ≤ 0.05) (Ringle, Silva, & Bido, 2014).

Thus, the relations present in the structural model analysed can be considered significant, since they all have t-values greater than 1.96. Figure 2 presents the values of *t*-Student test.

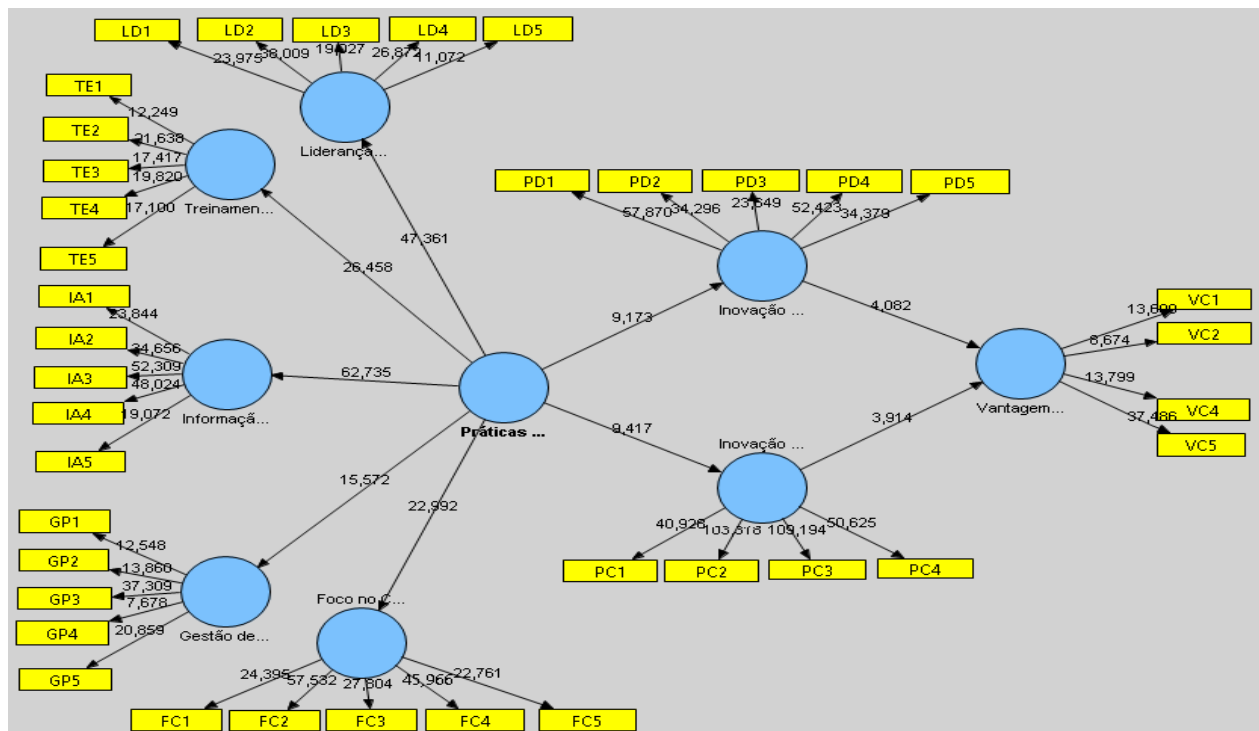
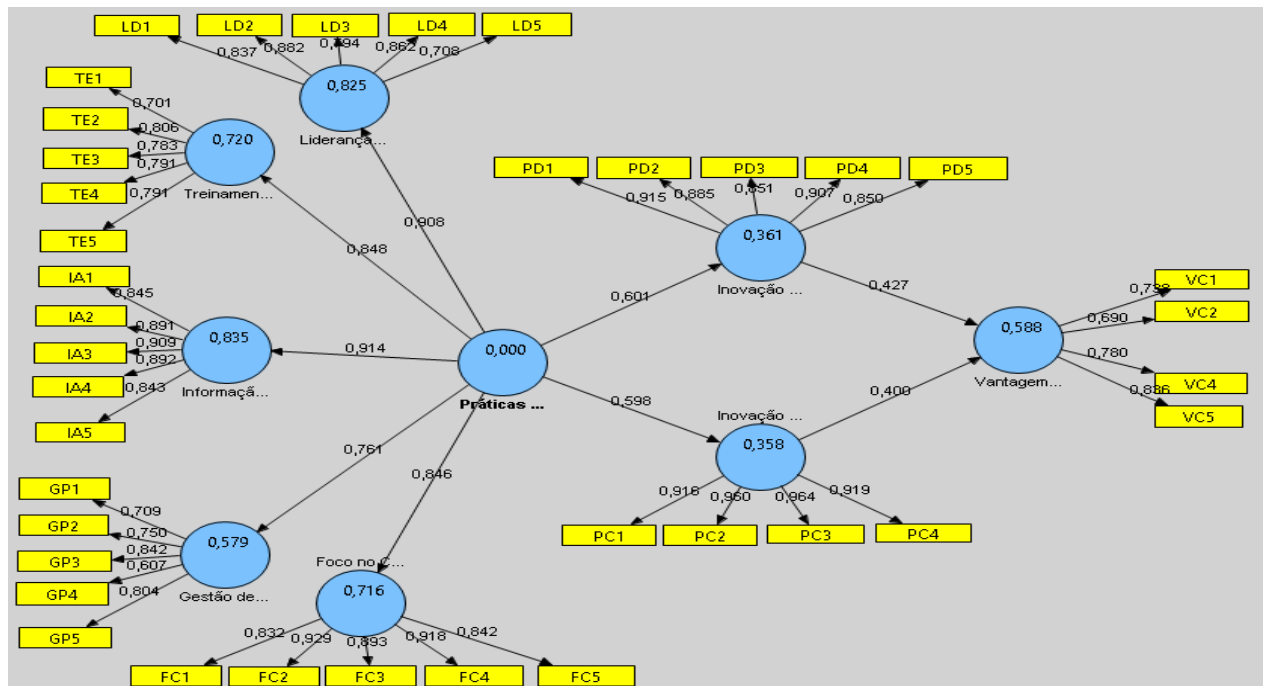


Figure 2. Values of *t*-Student test.

The path coefficients (Γ) values are similar to the values β in regression equations, ranging from -1 to +1. The more distant from 0 is the value, stronger is the relationship between two variables (Ringle, Silva, & Bido, 2014). The results of Γ coefficients for the structural model of this study were all positives and distant to 0, indicating a positive and strong relationship. Figure 3 illustrates the coefficients Γ (the values are represented by the arrows in the paths diagram).

Figure 3. Values of Γ coefficients

5.4 Quality analysis of structural model adjustment

To find out if the assumptions presented in this study are real, the values of path coefficients (Γ) and Student's t -test were analysed for the relations established between the exogenous latent variable "quality management practices" with the endogenous variables "product innovation" and "process innovation" (H1 and H2), and between the endogenous variables "product innovation" and "process innovation" with other endogenous variable "competitive advantage" (H3 and H4).

Observing the values of the coefficients Γ in the paths diagram, it is possible to see they are all positive, and distant from zero, also indicating strong relations. Analysing the paths diagram with t -values for each causal relation established by the hypotheses of the study, it is possible to see all of them have t -values greater than 1.96, indicating significant relations. Thus, the null hypothesis is rejected for the four alternative hypotheses of this research. Table 8 presents a summary of t -values and Γ coefficients, demonstrating the confirmation of alternative hypotheses based on the results achieved.

Table 8. Summary of the testing of hypotheses

CAUSAL RELATIONS	Γ coefficients	T-values	Hypotheses	Result
Quality Management Practices → Product Innovation	0.601	9.173	H1	Confirmed
Quality Management Practices → Process Innovation	0.598	9.417	H2	Confirmed
Product Innovation → Competitive Advantage	0.427	4.082	H3	Confirmed
Process Innovation → Competitive Advantage	0.400	3.914	H4	Confirmed

Source: Prepared by the authors (2019).

6. Discussion

This chapter discusses the results of the present study in order to better reflect about them, comparing them with results of other studies on the same topic. Also infer about the possible impacts quality management practices can have on innovation performance in manufacturing companies certified with ISO 9001, as well as the possible effects of innovation on competitive advantage.

To Prajogo and Sohal (2003), the result found by them indicates a positive relationship between quality management practices and product innovation can be an indirect result of the adoption of the practices of TQM, since the aim, in essence, is the improvement of quality in organizations. Furthermore, the authors believe the contribution of TQM for product innovation tends to be more incremental than radical, which may be related to the philosophy of continuous improvement (change) from TQM.

Prajogo and Sohal (2003) and Dedy et al. (2016) offer to discussion of the results obtained in their research, the argument of positive and significant relationship between the practices of TQM and process innovation is more consistent, understanding the focus on continuous improvement promoted by TQM adds a series of incremental innovations of process, aiming to improve the performance of production and the quality of products.

Advancing, Prajogo, and Sohal (2003) also argue a large and continuous number of incremental innovations in a process can generate radical innovations, depending on the degree of overall change in the process. Furthermore, the authors also suggest that the pursue for quality, understood as an important criterion for the achievement of organizational goals, can contribute to facilitate the adoption of process innovation with this purpose, as the introduction of new technologies, for example.

According to the analysis of the results of the study of Kafetzopoulos, Gotzamani, and Gkana (2015), the authors affirm quality management and innovation are important strategic components for improving the competitive performance of organizations. Furthermore, according to the authors, the quality management practices influence directly on the innovative performance of organizations, and innovative organizations tend to gain greater competitive advantage than non-innovative companies.

To Kafetzopoulos, Gotzamani, and Gkana (2015), the innovation process is usually introduced in an organization, precisely in order to improve its overall performance, because it promotes more profitable ways to produce with fewer losses and delivers quality products to customers. This highlights the strategic character of the innovation process, because it allows organizations to be more competitive both in cost and in quality.

Comparing the results of the study of Kafetzopoulos, Gotzamani, and Gkana (2015) with the present study, it is possible to see a greater effect of quality management practices in innovation performance of enterprises. This can be associated with a greater internalization of quality management in Greek companies compared to the Brazilian, and can make the desire and the acceptance of change at the companies analysed easier. Additionally, the managers of quality, having greater knowledge about the quality management in companies, may observe a greater correspondence between the quality management practices and innovation than employees in lower hierarchical levels.

Another detail this comparison can highlight is the lowest strength of relationship between the innovation process and the competitive advantage in the results of Kafetzopoulos, Gotzamani, and Gkana

(2015), in relation to the one obtained in this study. Considering the innovation process as an aspect of performance closely associated with the improvement of companies quality of the products (Prajogo & Sohal, 2003; Dedy et al., 2016), the results may point to a perception that quality is a criterion qualifier in Greek companies, while in Brazil could be still seen as a criterion to win orders.

7. Conclusion

The objective of this study was to investigate the relationship between quality management practices, innovation and competitive advantage in manufacturing companies certified with ISO 9001 in Brazil, using the model proposed by Kafetzopoulos, Gotzamani, and Gkana (2015). For this reason, a survey was carried out by closed questionnaires sent by e-mail, addressed to companies classified as processing industry (manufacturing), certified with ISO 9001, which are in the database of the site Certifq of Inmetro.

According to the results, the theoretical model of Kafetzopoulos, Gotzamani, and Gkana (2015), when replicated in the context of companies certified with ISO 9001 in Brazil, presented good adjustment quality of measurement and structural models. However, it was necessary the exclusion of the item VC3, the latent variable "competitive advantage", to meet the criteria of discriminant validity. By statistical evidence, a change in quality management practices causes a similar amendment in both product innovation and process innovation, as well as the product innovation contribute a little more to competitive advantage of the innovation process.

This research contributes to the theory revealing the existence of a positive and significant relationship between quality management practices and innovation in organizations, specifically the product and process innovations. This corroborates the results of most of the jobs about the theme. It also contributes to the production of knowledge specific to Brazil, in addition to be a way to disclose even more this topic of research, aiming to attract more Brazilian researchers to do similar studies. Furthermore, the replication of models contributes to the achievement of broader research as meta-analysis, using the results of empirical studies as its input data to analyse the consistency of results of research or even testing the same hypotheses (Card, 2012).

When a large number of studies presents results in one direction regarding the investigation of causal relations, it is possible to say the evidence of the existence of this type of relationship becomes stronger. In this way, taking as a premise, for example, the quality management practices influence positively on the innovative performance of organizations, as well as assuming that a company more innovative has competitive advantage face its competitors, the greater the number of results pointing in these directions, the larger will be the possibilities of practical implications.

This study was characterized as quantitative, which usually assumes the analysis of a greater volume of data, pursuing results in greater amplitude, as a way to describe or explain what is being investigated. Even so, this type of research has the limitation of not pay attention to specific details about each component of a sample, for example, leaving out important details that can differentiate each element. In this way, to capture these particular characteristics, it is possible to perform qualitative research to assess, with more details, cases of companies adopting quality management practices and how they can influence on innovation and competitive advantage.

The arguments used in this study tried to confirm certain types of quality management practices, together, can influence both types of innovation (product and process), and process may influence the competitive advantage. Even so, it is known that other aspects can affect innovation and competitive advantage that can be inserted in the theoretical model as latent constructs, as the performance in quality of products, aspects of the development process of innovation, other types of innovation, organizational culture, and others.

About the theoretical model used, different arrangements can be carried out based on several arguments found in literature. Among them, the quality management practices would be better represented by more than one dimension, as the closest practices to the prescriptive management tools used by the organizations (hard quality management) and those more associated with human and social factors (soft quality management) (Zeng, Anh Phan, & Matsui, 2015; Zeng et al., 2017). With this, future research could pursue a new configuration for the model, dividing the practice in hard and soft dimensions of quality management, instead of a single construct.

As the context and the composition of the sample to perform the study can influence its results, it is also suggested to perform local studies instead of national studies. In this way, it is possible to find different results to the relations established in the model, also allowing a comparison between regions. About the composition of the sample, future research could explore specific industry sectors (such as only the metallurgical industry or information technology, for example), highlighting their differences to other sectors.

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A New Framework to Explore the International Vision of College Teacher

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Abstract

Aiming to address the methodology to explore and broaden college teachers' international vision and horizon for engineering education of college students or engineers, this paper proposed an exploration framework based on Johari Window model. The framework of international vision exploration for teachers includes four zones: open/active vision, called Zone A; hidden/sleeping vision, called Zone B; blind/potential vision, called Zone C; and unknown/darkness vision, called Zone D. The four zones' characteristics and formation mechanisms were generally analyzed, the corresponding driving forces were then identified in order to help transform teacher international vision within Zone B, Zone C and Zone D into Zone A. To provide the effective and feasible approach, several significant factors including culture tension, original vision conflict and pure curiosity for unknown were then determined in exploring and improving teacher's international vision in terms of curiosity, inner creativity, potential vision, career development, and worldwide adaptability on engineering education evolution.

Keywords: college teacher international vision; exploration framework; engineering education; Johari Window model

1. Background Introduction

Internationalization and globalization in engineering education have become stimulating trends during recent decades in response to the rapid development in international industries, internet communication, artificial/intelligent computer, and promptly convenient transportation [1]. More and more engineering college students or engineers have been required to work outside their own countries and open to completely different environments associated with various cultures and unpredictably potential conflicts. University/college teachers face the upstream of engineering education, thus it is urgent and does make significant to explore teachers' international vision for engineering education to benefit students (potential future engineers) at the first beginning in terms of their international awareness, openness, adaptability, flexibility and career development

Johari window model is a psychologically effective tool firstly presented by Joseph Luft and Harry Ingham in 1955 [2] as a communication model that can be used to improve understanding and self-understanding between individuals within a team, a group, a community, or potential cooperative research or projects.

Based on the fundamental mechanisms of disclosure, self-disclosure, and feedback, the Johari Window can also be employed to improve a group's relationship with other groups. This research aims to develop an improved framework in helping college/university teachers explore and enlighten their international visions on engineering education in an effective and systematic way based on Johari Window model.

2. International Vision Exploration Framework in Engineering Education

An improved framework was proposed to explore the international vision of college teachers on engineering education, as shown in Fig.1, which is based on the original Johari Window model. The framework includes four vision levels/areas: *Zone A*) Active vision is an open area to student/engineer and teacher. *Zone B*) Sleeping vision is a hidden or invisible to student/engineer, and it is also a passive vision for teacher. *Zone C*) Potential vision is a probably clear and visible to student/engineer. However, this area keeps blind to teacher himself/herself. *Zone D*) Darkness vision is a completely invisible or unknown both to teacher and student/engineer concerning engineering education's future development and potential evolution procedure. Based on the framework, this research focuses on addressing the possible methodology and effective approaches to broaden and improve the international visions of college teachers to achieve a successful engineering education, as indicated by the "Red dotted lines" in Fig 1 to expand the territory of thought of college teacher in his or her professional engineering education.

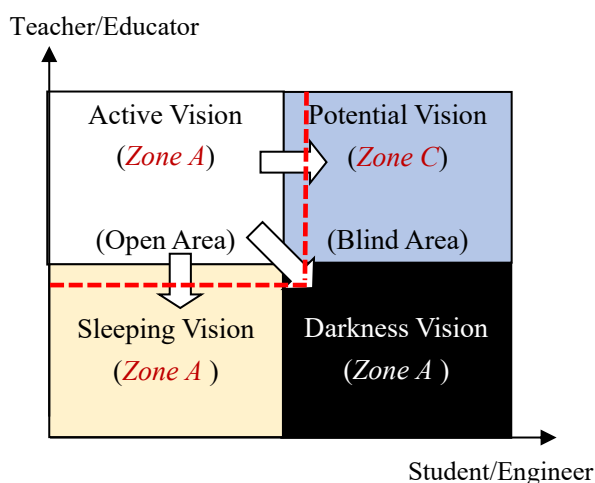


Fig.1. International vision exploration framework for teachers aiming at engineering education.

2.1 Active Vision in Engineering Education

College teacher, who is assumed to be active in engineering education, usually involves class teaching, textbook reading, writing, editing, researching, and communicating with college students and engineers through industry projects' cooperation. Therefore, teacher can effectively share his knowledge, experience, research, and understanding in engineering education with college students and engineers. This analysis means that *Zone A* is a clear and active vision in helping college teacher implement and educate engineering students, and students and engineers can also effectively benefit from the active vision and thorough understanding of college teacher.

2.2 Sleeping Vision in Engineering Education

College teacher has a sleeping vision/horizon including interdisciplinary knowledge, fabulous fundamental research experience, creativity in industry problem solving, *Zone B*, which are hidden or invisible to student/engineer. Due to the restriction of discipline requirement, university regulation, time schedule and activities in class teaching, it is regret that these rich resources are also a passive vision for teacher himself/herself as if he has never owed such existing teaching practice and organization. Therefore, students and engineers cannot benefit from teachers' hidden capacity until it is intentionally explored by college teacher.

2.3 Potential Vision in Engineering Education

College teacher possesses a potential vision, which is probably clear and visible especially to international students/engineers, however, this area is blind to teacher himself/herself. The potential vision includes teacher's culture prejudice or narrowness, localized professional training, shaped personality associated with cultures and traditions, closed preference, and limited experiences compared with those of the international students and engineers. Thus, *Zone C* is particularly important to arouse the awareness of teacher to enlighten his/her international vision in engineer education.

2.4 Darkness Vision in Engineering Education

Both for teacher and students/engineers around the world, darkness vision is inevitably and completely invisible or unknown concerning the future development and potential evolution of engineering education since tremendous factors are undetermined, changing and developing all the time in different places worldwide, indicated in *Zone D*. These aspects include political and religion's fusion, collision, and conflicts, the rapid development of science and technology. It is related with new materials invention, space exploration, and Artificial Intelligent (AI) robots, and more and more closely international exchanges of students, scientist, engineers, and ordinary persons by means of international cooperation, exchanged students program, conference, dynamic alliance of projects, lab visiting, industry fair, and even personal traveling. The truth poses an imminently great challenge for teachers, students and potential engineers in developing a matched vision for a potentially successful engineering education

3. Driving forces to active sleeping vision

To activate the sleeping vision (*Zone B*) of college teacher, it is crucial to discover the driving forces to stimulate and draw teacher's attention to the sleeping knowledge, experience and understanding hidden to students. Three active approaches were proposed to sharpen teachers' awareness and waken their sleeping vision, and eventually help them achieve the transformation from passive vision to active vision.

3.1 Try A Variety of Flexible Teaching Methods

Classroom teaching is a traditional approach in delivering the fundamentals, principle, processes, and knowledge framework of analysis, synthesis, application and optimization in engineering education for students and engineers. However, a variety novel and creative teaching methods are needed to stimulate students' interests, curiosity, and particularly help discovery teacher's potentially sleeping vision that has

already been incubated during long-term teaching and research experience. For example, I usually select topics proposed by engineers in manufacturing industry, my research projects cooperated with companies, and hot research topics in manufacturing front as course projects. I have found it is helpful to relate my teaching to industrial popular topics, interests, teams, and cooperated companies and factories to get my students fully guided in manufacturing discipline. Students have applied invention patent through completing their course projects. I clearly realized how it is stimulating for students to taste the pleasure of achievement incorporated with my course. By means of this approach, I realize that such teaching activity can also greatly benefit me by exploring and manifesting my hidden professional training and experience which I have obtained from my cooperative experience with other professors, engineers, experts, and even my graduate students.

3.2 Combination of Teaching and Scientific Research

Generally, teachers in engineering education possess abundant experiences due to their deeply involvement in industry practice concerning engineering problem solving and scientific, fundamental, hot topics in academic circle [3]. Thus, it is a potential approach to merge the research experience into teaching process in engineering education. This helps stimulate the interest of students and remind teachers of their wonderful hidden capacity and vision developed in research experience. This is a powerful activity in mutually benefiting students and teachers in terms of professional development, aspiration enlightenment, problem solving capacity improvement, and international visions exploration.

3.3 Intentionally Break through Discipline Boundaries

Another important approach is intentionally managing to break the boundaries of disciplines, especially the rigid boundaries of engineering, science, general education, philosophy and culture, which unconsciously shaped teachers' thinking pattern and boundary. To realize the truth, it is an intentional activity to breakthrough teachers' possible rigid thinking especially after decades in engineering education, since the knowledge framework, design steps, material selection, and optimization procedures have been standardized, modularized and serialized in engineering education. The logically defined framework is helpful in shaping the thinking of students and teachers themselves. However, it is unfavorable in developing critical thinking and creativity for the future product, market, competitiveness associated with international visions [4].

Several potential approaches are presented here to illustrate such type of efforts: 1) Surpass discipline boundary by paying attention to natural things including the biological world in terms of function, structure, material, mechanism, energy, resources, transition, and efficiency. 3D printing, as a popular manufacturing technology, is a good example that human being learned from natural process, which is an opposite manufacturing mode compared with the subtractive processing such as machining, grinding and honing. 2) Aesthetic design in mechanical product usually requires a good sense of Art and Literature, human sensitivity, intuitive power, which blur the boundaries of rational and sensible, static and dynamic, rigid and flexible thinking [5]. 3) Survival and sustainable products possess a long-term life with the communication not only engineering function and scientific foundation, but also philosophical consideration and cultural respect. Those aspects provide an international vision without any constriction

from discipline boundaries.

3.4 Challenge and Refresh Teaching Pedagogy by Interacting with Peers

To share teaching experience with peer is an excellent approach to mutually explore teaching capacity and international vision. I do benefit from sharing with senior professor, young professor, and colleagues during my teaching process. For example, when the “Digital Manufacturing Superior Course Prize” was proposed, five professors participated the cooperative teaching activity, honestly shared, and intimately worked with each other during the application procedure. It made me surprised that my hidden creativity in teaching has been stimulated through the cooperative teaching activities. Based on the intuitive knowledge, I realize that challenging and refreshing teaching pedagogy is an effective approach to explore international vision, which could be incorporated with active interaction with peers. To deepen the cognition, I initially applied and took part in the construction of General Education with my colleagues at Shanghai Jiao Tong University. As a teaching assistant, I participated the Summer Course of IE470 delivered by a professor of Purdue University. I helped design and participated the Summer Course of Critical Thinking and Creativity presented by a professor from IAESTE (The International Association for the Exchange of Students for Technical Experience). Those experiences strengthen the effectiveness of the proposed method in exploring international vision hidden in my inner understanding

In addition to the methods mentioned above, it is particularly important to conduct self-reflection the familiar teaching methods and intentionally cooperative teaching activities interaction with international peers as promoted by several international organization such as U21 (Global Teaching and Learning of 21 Universities) and The Higher Education Academy in Australia.

4. Tension Conflict to Explore the Potential Visions

It is quite difficult to explore the potential vision, *Zone C*, blind area of teachers although it is clear and easy for students and engineers to realize. What is the true situation for the teacher to ignore the blind spot? Why is it possible for a teacher to blind to this cognition? What is key to overcome the blind spot? Based on my understanding, the most important point is firstly sensitive to the tension conflicts among teacher, students, and engineers, and then manage to reflect from fresh angles in terms of different cultures, religious beliefs, nationalities, ages, experiences, personal preferences, and personalities during tension conflicts [6]. The attempt will help college teacher broaden their horizons and improve their international vision, which will help college teacher overcome their originally narrow visions, a great meaning process for teacher professional development.

4.1 Culture Tension Conflict

The primary concern in international vision for engineering education is to identify and solve the potential tension conflict from different cultures [7]. Therefore, it is a crucial consideration for teacher to actively learn, contact, touch, understand, and communicate with other cultures to expand their narrowness of traditionally local visions. College teachers can strengthen their international vision by actively opening to international students, professors, experts, conference, exhibitions.

4.2 Religious Tension Conflict

Religion tension conflict is an extremely important factor for college teachers worldwide, although this issue was ignored in engineering education [8]. Thus, college teachers should not be blind to it anymore since religion conflict is the root reason for culture tension. An effective method is to actively learn, tolerate and closely pay attention to the feedbacks of students with different backgrounds associated with religious regulations, distinct prohibitions such as typical shapes, colors, materials, customs, and preferences. It is a cumulative and interesting exploration process for college teachers to share and understand different religions and their conflicts and give reasonable consideration in engineering education. Therefore, this effort can gradually explore teachers' international vision in engineering education.

4.3 Nationality Tension Conflict

Nationality is a critical problem to call college teachers' attention in engineering education worldwide, especially when teachers give lectures or presentations to undergraduate students, graduate students or trainees with different nationalities, since some topics are sensitive, aggressive, misunderstanding, or irritating related to nationality. When college teachers face international students, it is a basic quality to be sensitive to the feedback from students due to a fact that patriotic education is still very popular at present. It is a good way to make students' nationalities known at first class and honestly share their preference [9]. I truly benefit this method and develop necessary awareness during my teaching experience.

4.4 Experience Tension Conflict

In most cases, college teachers possess rich and colorful experience in design, implementation, optimization, practice, teaching, research, communication, presentation concerning engineering education. However, students usually lack such experiences. This situation can arouse tension conflicts in understanding some concepts, principles, mechanisms, processes, etc. concerning engineering education. For example, an undergraduate student cannot design a successful casting gating system due to their lack of industry practice and experience. College teachers should not feel angry or enraged by students' performance [10]. The design task explores the vision of college teachers to realize the reality and learn to share with students' their practical experience.

4.5 Original Vision Tension Conflict

This section is particularly adaptive for graduate students or engineers since their backgrounds and experiences vary greatly [11]. The original visions can result in tension conflicts among teachers and students during teaching process, task assignment, and project practice. For example, one student designed a very complex product given function requirements, and the other student design a simple product to meet the same function requirements. The first student got low grade and the second student got high grade. The first student talked to me that the grade is unfair since he spent more time and resource on the design, but the other student's design is too simple to cost more time and energy. I made great efforts to convince him that it is misunderstanding to spend more time, energy, resources, processes, costs to produce a very complex product if there is a much simpler substitute.

4.6 Expectation Tension Conflict

The expectation of students usually cannot be fulfilled by college teachers in engineering education. However, this phenomenon provides a fabulous method to explore college teachers' international vision by identifying the critical points blocked by the students' expectation for college teacher [12]. For example, Student 1 expects that teacher give more details and explanations on the lecture. Student 2 hope teacher combine class content with practical application and project practice. Student 3 are eagerly to visit Factory, Lab, Industry site, Exhibition for engineering education. As shown in Fig. 2

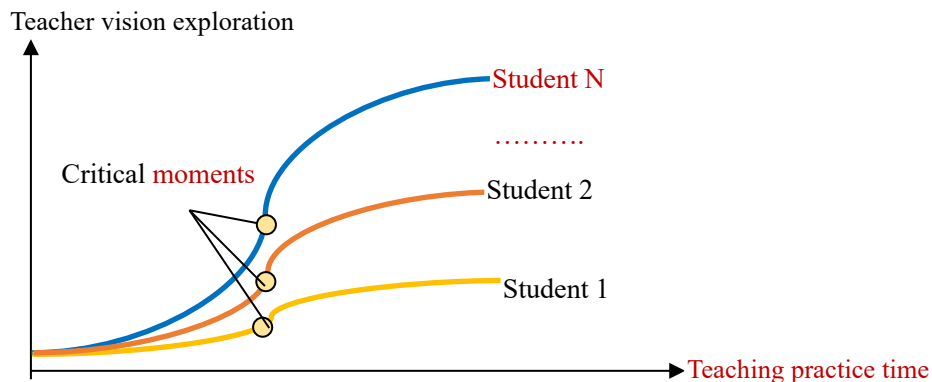


Fig.2. Expectation tension conflicts between college teachers and students on engineering education.

However, there exists the critical point for each student expectation, which can be transferred as time allocation of lecture content organization. Therefore, full understanding international students' expectation and identifying their corresponding critical points are the fundamental capacity for college teachers. The capacity development is an effective process in exploring college teachers' international vision.

5. Curiosity to Enlightening Darkness Vision

Although future trend in engineering education is completely unknown to teacher and students/engineers, it still makes significant to predict, prepare and actively discovery an effective and efficient orientation to improve, explore, and broaden international vision of college teachers. Based on logical and critical thinking and understanding, curiosity has been the everlasting driving forces in human understanding improvement and international vision promotion in science, art, architecture, machine, various products and technology evolution [13]. Thus, born curiosity should be the greatest driving forces to enlighten the darkness vision, *Zone D*, of college teachers and students. Several aspects related with curiosity will be discussed to particularly explore the darkness vision of college teachers for engineering education.

5.1 Curiosity for Solving Existing Difficult Problems

In engineering education, the most excited capacity for college teachers is to stimulate student's curiosity to resolve various practical problems, especially difficult problems or puzzles concerning the existing products or future developed application. By means of proposing and incorporating difficult problems in industry application into lecture content, college teachers can effectively stimulate students' passion and desire to solve practical puzzles encountered in engineering practice.

Assumed college teachers can well guide and manage students' passion for problem solving, college teachers can explore their vision for future and enlighten their present darkness vision. For example, to resolve automobile weight reduction, an existing issue, college teachers, students, and engineers have developed tremendous new materials, mechanisms, processes, and technologies to improve automobile performance. This effort explores college teachers' vision, especially international vision for engineering education.

5.2 Curiosity for Challenging Existing Engineering Product, Production Concept and System.

Curiosity will never be satisfied with existing and the known things including product, service, production, system, etc. As college teachers in the for engineering education, curiosity for unknown area is to challenge existing engineering product and production in terms of materials, structures, quality, efficiency, effectiveness, cost and psychological satisfaction. For example, group technology, lean production, TRIZ (Theory of Inventive Problem Solving) [14], agile manufacturing, smart manufacturing, and intelligent production, etc. which have been developed in challenging existing products and production system, provide novel, creative or newly opened visions for college teachers on engineering education.

5.3 Curiosity for Breaking Thinking Boundaries

College teachers should keep the curiosity for breaking their own thinking boundaries and further students' thinking dimensions. In addition to rigid discipline boundaries, there are many invisible thinking boundaries formed and shaped by culture, experience, community, practice, personality, etc. Thus, identification and awareness of thinking boundaries are necessary to drive the curiosity for breaking those thinking boundaries. Curiosity provides an everlasting driving force to explore college teachers on engineering education. As indicated by Yue [15], teacher professional development is not an only one step but a continual and sustainable process by exploring and keeping awareness of what is actively happening around the world.

5.4 Curiosity for Improving Self-Understanding

Compare with K-12 schooling, higher education teachers demand more precise, comprehensive, enlightening knowledge and skills [15]. The development of human mind and understanding capacity is always an attractive topic for college teachers, students, and engineers. Curiosity for developing human mind and understanding constitutes a dynamic and positive driving force to explore college teachers' creativity with international vision in engineering education. The professional quality of college teacher will help students develop adaptability for future engineering development around the worldwide. To achieve the curiosity for improving human mind and understanding, it is especially helpful to attend international conference, organize lab visiting, enrich factory experience, propose project solution, multi-read textbook, videos in Youtube, Google, Wiki, Baidu, handbooks, reports, keep open mind to online Journal, electrical books, and exhibition. Especially it is necessary capability of college teacher to keep sensitivity and awareness of new theories, potential thinking, and newly developed technologies associated with new software and platform in industry [16].

6. Summary and Conclusion

Based on Johari window model, this paper presented a methodology framework to explore college teachers' international vision in stimulating students' and engineers' curiosity for engineering education. Four typical zones of college teacher vision/thinking were firstly analysed and the according approaches were proposed to explore college teacher international vision for engineering education step by step. Those methods were summarized in Table 1.

Table 1: Approach to explore the international vision of college teacher in engineering education

Method No.	Be transferred into Active Vision (Open Area, <i>Zone A</i>) from		
	Hidden Vision Sleeping Area: <i>Zone B</i>	Blind Vision Potential Vision: <i>Zone C</i>	Darkness Vision Unknown Future: <i>Zone D</i>
1	Try a variety of flexible teaching methods	Identify culture tension conflict	Curiosity for solving existing difficult problems
2.	Combination of teaching & scientific research	Sensitive to religious tension conflict	Curiosity for challenging existing product, service or production system
3.	Intentionally break through discipline boundaries	Actively aware of nationality tension conflict	Curiosity for breaking thinking boundaries
4.	Challenge and refresh teaching pedagogy by interacting with peers	Actively reflect on experience tension conflict	Curiosity for improving human mind and self-understanding
5.	Self-reflection familiar teaching methods	Original vision tension conflict awareness	Curiosity for newly developed technologies
6	Cooperative teaching activities interaction with international peers	Expectation tension conflict awareness	Curiosity for new theories and potential thinkings

In order to explore the hidden vision, *Zone B*, intentionally active practices are necessarily required for college teacher to awaken and actively reflect their rich and colourful experiences, knowledge, capacities accumulated during teaching and research processes.

In order to open blind vision of college teacher, it is crucial to identify the driving forces including various tension conflicts such as culture, religious beliefs, intuitive feelings, experience, reasoning habit, language, etc. to discovery the potential areas.

In order to enlighten the darkness vision *Zone D* of college teacher in engineering education for unknown or unclear future development, curiosity is determined as the most significant cutting edges. It provides an effective approach by solving existing difficult problems, challenging existing product, service, industry practice, production system, breaking human thinking boundaries, and improving human mind, understanding and self-understanding toward unknown, unclear or dark areas for human being.

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Research Topics on Educational Data Mining in MOOCS

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Abstract

Educational Data Mining Techniques have been widely used in MOOC environments to conduct different educational analyzes. In this context, a systematic mapping was conducted in five databases in order to verify which aspects of studies are inherent to the use of Educational Data Mining in MOOCs. The search comprised the period from 2015 to 2019, and 253 searches were found, out of this total, 133 studies were selected. The results revealed that studies on performance analysis, behavior analysis, forum analysis and implementation of recommendation systems are the most frequent themes.

Keywords: MOOCs, Educational Data Mining, Systematic Mapping;

1. Introduction

Massive open courses on open lines (MOOCs) drew the attention of education scholars as a new possibility of access to learning. The proposal, in general, is to serve as a knowledge platform for anyone, anytime, anywhere, making it an emerging and powerful learning strategy, with repercussions in the technological and educational areas (Zheng et al. 2016). Zheng et al. (2016) also state that MOOCs originated with the aim of promoting educational innovation through pedagogical approaches that expand learning possibilities, in order to reach a large number of students.

For Mackness et al. (2010), MOOCs are modern means of teaching and supporting learning, with high potential, for the exponential dissemination of knowledge. They are based on connectivist theory, enabling the creation and generation of knowledge through the interaction between participants, encouraging them to use digital technologies, social networks, among others, with a focus on collaborative learning. For Comier (2010), MOOCs are a combination of actions that start in connection, go through collaboration until reaching involvement in the learning process, in which a large group of people, concerned with a certain topic, get together to discuss it in a structured way.

MOOCs can be seen as an evolution of existing online courses, offering an opportunity to rethink new open educational models. For Butcher (2014), compared to traditional online courses, MOOCs have two main characteristics that distinguish them, namely: 1) Open access: courses must be open and free,

allowing anyone to participate in the course; and 2) Scalability: they must support a large volume of participants.

In this sense, through the variety of learning resources and due to the high number of subscribers that MOOCs reach, different types of data can be generated, as the platforms record information about the interactions of students through log files, which leads to new possibilities of understanding learning from a quantitative perspective (Lee, 2018). It is concluded, therefore, that a differential of the MOOC courses is the large amount of data generated by the interactions in the Virtual Learning Environment (VLE). In this context, the analysis of students' actions is an important activity to detect barriers to learning, especially in MOOCs that live with low completion rates, and dropout is quite frequent (He et al., 2015).

In this way, the potential for new studies was visualized and some areas of research have emerged in recent years to assist in issues such as these. For example, Educational Data Mining (EDM), which is an area of interdisciplinary research that deals with the development of methods to explore data originating in the educational context (Romero and Ventura, 2016). EDM techniques allow the extraction of valuable information from the data and learning interactions stored during the performance of a MOOC, which leads to the identification of behavioral characteristics and indicators related to learning (Lu et al., 2017).

Thus, considering that the MDE techniques work in the context of analysis of learning data obtained from online interaction records, this research aimed to carry out a systematic mapping of the literature, in order to survey studies focusing on the application of EDM in MOOCs, and to identify the thematic aspects and the general purposes of its use in courses of this nature.

2. Educational Data Mining Applied to MOOCs

MOOCs generate a large amount of data, and the analysis of large volumes of data without the aid of computational resources is impractical, as knowledge is often hidden in these bases. Therefore, it is essential to provide tools that assist people in the task of verifying, interpreting and relating this data, in order to generate useful and relevant knowledge (Goldschmidt and Bezerra, 2015). In this perspective, the MDE techniques emerged to contribute to the extraction of relevant information from the large mass of data generated in current educational contexts, such as MOOCs.

The MDE is defined as the research area whose main focus is the development of methods to explore data sets collected in educational environments (Baker, Isotani and Carvalho, 2011). For Romero and Ventura (2013), the MDE area can be defined as the application of data mining techniques for a specific type of data set coming from educational environments, to answer important questions in this area.

Through MOE MDE, it is possible to understand students more clearly and adequately during the learning process, in addition to other factors that influence learning. For example, it is possible to identify in which situation a type of instructional approach (e.g. individual or collaborative learning) provides better educational benefits to the student.

It is also possible to check if the student is learning or confused, identify levels of motivation, involvement in online activities, discover elements or behavioral indicators of completion and success in a course, identify patterns of interaction, discover strategies that contribute to permanence of students (Pursel et al., 2016), elements that can help to personalize the teaching environment and methods to offer better

learning conditions (Baker, Isotani and Carvalho, 2011).

In short, the MDE is concerned with the development, research and computerized application of methods to detect patterns in large sets of educational data, which would otherwise be difficult or impossible to analyze due to its enormous volume (Romero and Ventura, 2010). The techniques most used by the MDE are those of classification (decision tree) and grouping, in addition to the discovery of associations (Romero and Ventura, 2010). In MOOCS, for example, classification techniques can be used to predict students' performance and / or to detect student behavior. The grouping technique can be used to group students based on their learning and behavior patterns (Romero and Ventura, 2013).

The various possibilities of using the techniques of DEM in MOOCs environments motivated the accomplishment of this research in order to find out which are the strands of studies related to this theme.

3. Methodology

In this research, a systematic mapping of the literature was carried out, with the objective of selecting publications that apply EDM in MOOCs. Mapping sought to find out what the main themes exist when it comes to this premise, permeating what are the main objectives of EDM applied to MOOCS. In this sense, this article was inspired by the work developed by Souza, Wives and Perry (2019) who carried out the same mapping, but with a focus on Learning Analysis in MOOCs, it should be noted that the contribution of this research was relevant to the development of this manuscript.

A mapping, as its name implies, does not seek to evaluate how the set of literature answers certain research questions, but to make an overview of a given area, presenting a panorama that allows the identification of research opportunities. As in a systematic review, moreover, one must use well-defined procedures to find, evaluate and synthesize the results of relevant research in the area under study - but it does so with more scope.

The Kitchenham and Charters (2007) guidelines were used to carry out the Mapping, which present a protocol - based on other protocols widely used in medical research based on evidence - which is the most used both in the area of computing, in general, and in work systematic survey of literature in the field of Informatics in Education. The RSL process, as presented in these guidelines, includes several activities (Figure 1), which can be grouped into three main phases: planning, conducting and reporting.

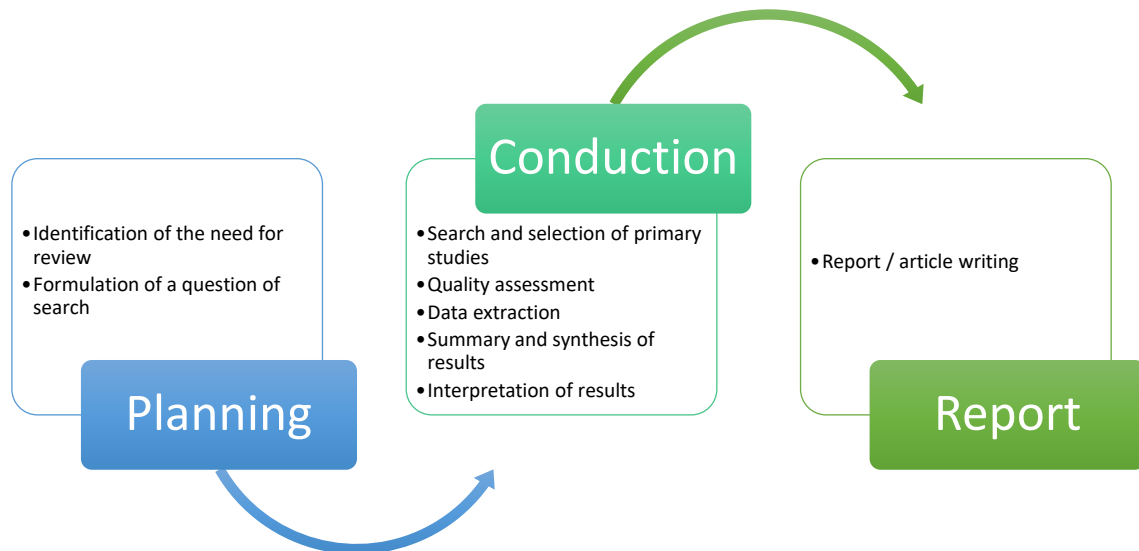


Figure 1. Phases and activities of the systematic literature review and mapping process.

Source: Based on Kitchenham and Charters (2007).

The Mapping then started planning by asking 4 research questions:

- 1) Which databases have the most publications in the Area?
- 2) Which years have there been more publications?
- 3) What topics are most addressed when it comes to EDM in MOOCs?

The conduct of this mapping was formed by the stages of formatting the search string, definition of the databases, establishment of the inclusion and exclusion criteria.

Then the Search String was defined and formulated as follows: ((“educational data mining” OR “EDM”) AND (“massive open online courses” OR “MOOCs”)).

Next, the search databases were defined, which were: (1) IEEEExplore Digital Library; (2) ACM Digital Library; (3) ERIC - Education Resources Information Center; (4) Science @ Direct and (5) SciElo.

The inclusion and exclusion criteria were as follows: Inclusion: 1) Full or summary articles, 2) Articles published between 2015 and 2019, 3) Articles written in English, and 4) Articles that describe the application of EDM in MOOCs. Exclusion: 1) Duplicate articles, 2) Use of EDM in contexts other than MOOCs, 3) Application of different techniques than EDM on MOOCs, 4) Literature reviews or mappings, and 5) Articles in languages other than English.

After applying the search string on the bases and returning the articles, it was then possible to select those that met the inclusion criteria or exclude those that met the exclusion criteria. For this, at first, only the abstracts of the articles were read, for a first screening, then the articles that were selected were analyzed in more detail.

For the third phase of the mapping, generating the report, Excel was used to extract and analyze the data, corresponding to the last stage of the mapping. The records were formed by 8 attributes¹: title, authors, place of publication, year, thematic / objective summary, criteria (whether the inclusion / exclusion criteria

¹ The articles returned in the survey are available at this link: <https://drive.google.com/file/d/1I2v83vJI4HXUvX2FW-gZQ2hlwml1dWwC/view?ths=true>

were met or not) and situation (included or excluded). The results were analyzed taking into account the number of publications per year, place of publication and the research topic. These items are described in section 4 that presents the results.

4. Results

The organization of this section was inspired by the work of Souza, Wives and Perry (2019), in this way the systematic mapping selected articles from 2015 to 2018, from the cited databases, it is noteworthy that articles that did not use EDM in MOOCs were not selected, nor were articles that were literature reviews or mappings. Table 1 lists the number of articles returned from each database.

Table 1. Totals of papers found and selected

DATA BASE	RETURNED ITEMS	SELECTED
IEEE	98	67
ACM	22	11
ERIC	47	43
SCIENCE@DIRECT	64	12
SCIELO	22	0
TOTALS	253	133

As shown in Table 1, of the total of 253 studies found, 133 studies met the inclusion criteria. As can be seen in the SciElo database, no article was selected, since all those dealing with the EAW in the context of MOOCs were texts in Spanish, therefore, by the exclusion criterion, none can be selected. Below, each of the research questions listed in section 3 is answered.

4.1 Which databases have the most publications in the Area?

The IEEE database presented the largest number of publications according to the inclusion criteria, with 67 selected searches, followed by ERIC with 43 selected studies. Science @ Direct, despite presenting a significant number of returned works, however, most were not within the scope of this mapping. The 133 works selected and retrieved by the databases come from conferences and journals, published in 71 different locations, 60 of which are conferences and 11 journals. Of this total, those who returned at least 3 publications on the topic were classified, as shown in Table 2. Table 2 shows that the International Conference on Educational Data Mining (EDM) is the event that has the largest number of surveys that report the use of Educational Data Mining in MOOCs.

Table 2. Total papers by publication basis

DATA BASE	# PAPERS
International Conference on Educational Data Mining (EDM)	36
IEEE Access	5
Computers in Human Behavior	4
Computers & Education	4
International Conference on Educational Innovation through Technology (EITT)	3
International Conference on Computer Science and Education (ICCSE)	3
International Conference on Learning Analytics & Knowledge Pages	3
Conference on Learning @ Scale Pages	3

4.2 Which years have there been more publications?

The second question investigated is the identification of the number of publications per year. As the mapping was carried out from the period of publications from 2015 to 2019, the following figures were identified:

- ✓ 2015 - 16 posts
- ✓ 2016 - 36 posts
- ✓ 2017 - 33 posts
- ✓ 2018 - 35 posts
- ✓ 2019 - 13 posts

This figure can be seen in Figure 1.

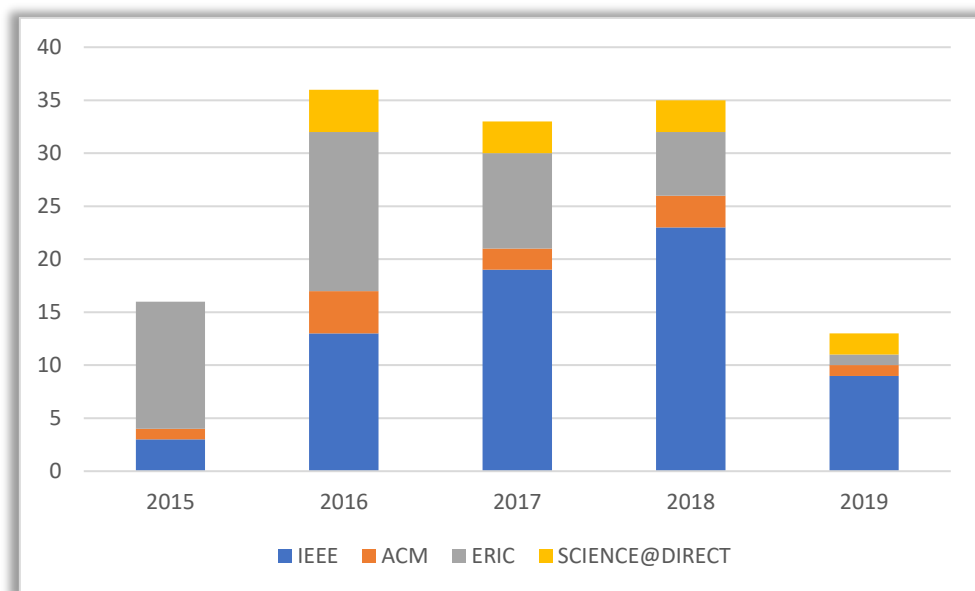


Figure 2. Number of publications per year.

In Figure 2, the number of publications per year in each database can be better viewed. Analyzing by base, it can be seen in Figure 2 that in IEEE Xplore there is an increase in the number of publications in 2018. ACM (with 4 searches), ERIC (15 searches) and Science @ Direct (4 research) presented more publications in 2016. Due to the mapping being carried out until October 2019, it is possible that many studies this year have not yet been published and made available in these databases.

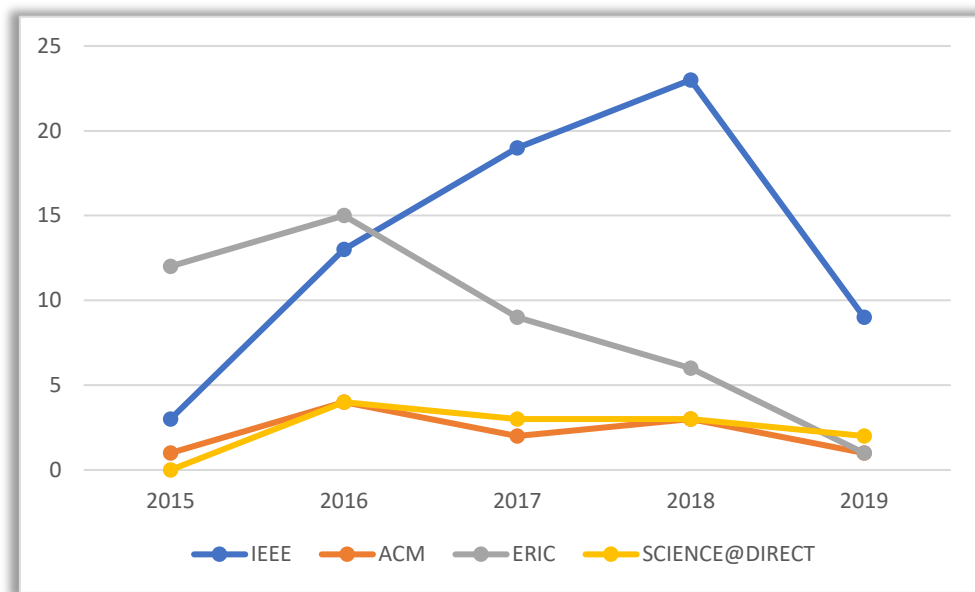


Figure 3. Number of publications per base per year.

4.3 What topics are most addressed when it comes to EDM in MOOCs?

From reading the articles, it was possible to determine the theme the article was about, and then list the main research topics on EDM in MOOCs, these can be listed in 18 main themes: 1) Behavior Analysis, 2) Behavior Analysis in Prediction / Detection of Performance (subcategory), 3) Behavior Analysis in Prediction / Detection of Abandonment (Subcategory), 4) Behavior Analysis in Conclusion of Prediction / Detection (Subcategory), 5) Analysis of Behavior in engagement prediction / detection (subcategory), 6) forum analysis, 7) recommendation systems, 8) MOOC management platforms, 9) text mining, 10) video analysis, 11) cheating identification, 12) analysis of feelings, 13) Analysis of the MOOC curricula, 14) Self-regulated learning, 15) Gamification, 16) Peer review, 17) Effort / capacity model, 18) Simulation of artificial students. The Table 3 shows the themes highlighted in quantities per year of publication.

Table 3. Total papers by publication basis

CATEGORY	Publication Year / # de Papers					TOTAL
	2015	2016	2017	2018	2019	
Performance	1	6	6	6	3	22
Behavior Analysis	2	5	5	7	1	20
Forum Analysis	6	2	2	5	2	17
Recommendation Systems	0	2	8	5	1	16
Abandonment	1	6	1	3	2	13
Conclusion	2	1	0	3	0	6
MOOC Management Platforms	0	1	2	2	1	6
Text Mining	1	2	2	1	0	6
Video Analysis	1	2	1	0	1	5
Cheating Identification	0	2	3	0	0	5
Engagement	1	2	1	0	0	4
Sentiment Analysis	0	3	0	0	0	3
Analysis of MOOC Curricula	1	0	0	1	0	2
Self-Regulated Learning	0	0	1	0	1	2
Gamification	0	0	1	1	0	2
Peer Review	0	1	0	1	0	2
Effort / Capacity Model	0	0	0	0	1	1
Simulation of Artificial Students	0	1	0	0	0	1

Table 3 shows that the student's performance forecast; investigations with an emphasis on analyzing student behavior in different contexts; analysis of discussion forums; systems of recommendation and analysis of patterns of behavior to predict and / or detect abandonment are the most frequent themes in research using EDM in MOOCs. It is worth mentioning that some thematic categories have many associated themes, for example, behavior analysis with many aspects, such as profile analysis, motivation, engagement, abandonment prediction / detection, conclusion prediction / detection and performance prediction / detection, among others.

In the forum analysis category, the most diverse approaches were observed, such as detecting student errors, thematic relevance, student engagement, posts that need the attention of teachers, among others. Along with this theme, there is the category of text mining in which the most different sources were explored, by email, texts on social networks and interactions between students on the MOOC platform, different categories were considered, because not all analyzes of the forums were by text mining, and this technique was used in different discussion forum scenarios.

Another frequent topic concerns the implementation of recommendation systems for MOOCs, which can be developed in the most diverse contexts, to recommend contacts for the exchange of information, to recommend content and also courses in this format, based on the characteristics extracted from each person. In the scope of management platforms, a survey was identified that exposed new types of AVAS for the purposes of data analysis and mining. The other identified approaches turned to video analysis, sentiment analysis, MOOC curriculum analysis, which seems to be a very promising topic, as well as peer analysis

and effort / capacity model, although with few published studies.

In addition to the most frequent thematic categories mentioned above, there were also some recent trends, such as Cheating Identification, in which students use fake accounts, called Cameo, by the authors, to get the answers in the course and put them in their real accounts. In addition, analysis of self-regulation of learning, application of EDM in MOOCS to improve Gamification, and the most innovative ones identified to perform simulations of artificial students, created through artificial intelligence of artificial students to train MDE algorithms.

4. Conclusion

An important milestone in the evolutionary process of education was the emergence of MOOCs, to meet the demands arising from a new global technological scenario. The emergence of this type of course contributed to strengthen the changes in the existing educational paradigms, in addition to meeting the process of democratization of education and the yearnings for a new student profile in the digital age, increasingly present in educational institutions. These courses are being considered the next step in distance education in the world (Wulf et al., 2014).

MOOCs are one of the greatest examples of changes in the educational standard, constituting a form of distance learning, based on the open and free offer of online courses for a large number of geographically dispersed people (Vázquez et al., 2013). Its philosophy is centered on the democratization of knowledge, making it available to people, regardless of their geographical location or financial conditions (Barak et al., 2016). In addition to all these characteristics, one of the biggest differentials of MOOCs is the amount and diversity of data generated by students on the offer platforms, a fact that made it possible to explore this mass of data, discover new knowledge about how individuals' study, learn, interact .

In this scenario, Educational Data Mining (MDE), an area of interdisciplinary research that deals with the development of methods to explore data originating in the educational field (Romero & Ventura, 2016) has gained prominence. The MDE techniques aim to extract information from the data recorded by the platforms during the course of a MOOC, and which can lead to the identification of behavioral characteristics and indicators related to learning, the main contributions of the MDE can be summarized in: (1) the creation of models to better understand the learning processes; and (2) the development of more effective methods to support learning when the student studies using educational software or Virtual Teaching Learning Environment (VLEs).

Based on these claims, this research carried out a systematic mapping of the literature that aimed to verify which research topics employ Educational Data Mining in MOOCs, EDM is one of the main mechanisms for obtaining new knowledge in large volumes of educational data. The results showed that data from MOOCs can be used in many research topics, and the best way to conduct such research on these data is EDM.

The Mapping carried out pointed out that the performance analysis, behavior analysis, forum analysis and implementation of recommendation and prediction abandonment detection systems are the main lines of research, indicating frequent occurrences in the use of MOOC data for the purpose of identification and predicting events. In fact, very new topics have been identified that have the potential to be extensively

studied, such as cheating analysis, peer review, gamification, effort/capacity model and also data production in artificial students.

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Pedagogical Praxis and Educational Practices in Post-Critical Theory: Rethinking Concepts and Methods

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Abstract

The changes that occur in the educational field are nourished by the rationality of different paradigms, with post-structuralism and post-modern thinking determining in the (re)configuration of educational practices in contemporary times. This article aims to reflect on the contributions of Post-Critical Theory in the formulation, understanding and development of pedagogical *praxis* and educational practice in terms of conceptualization and methodology. The proposal comes from the epistemological, social and educational changes brought about by the reflections of the Post-Critical Theory, instigating us to raise elements to promote a dialogue that can collaborate to meet the theoretical-practical demands brought by the referred scientific approach. The ideas are based both on authors who analyze the concept of *praxis* and educational practices (SOUZA, 2012), as well as on those who validate the influence of the post-structuralist paradigm and post-modern thinking such as Jean-François Lyotard (1984), Gadamer (1997) and Habermas (1987a, 1987b), who approach hermeneutics and dialectics as possibilities of methodological composition for data analysis. And, in this aspect, we anchored, too, with Heidegger (2005a, 2005b) who helps in the intelligibility of the hermeneutic circle. The intention is to promote reflection on the concept of educational practices and their epistemological implications from the perspective of Post-Critical Theory so that it is possible to understand current social phenomena and, thus, strengthen the methodological proposals that are in line with the problems undertaken by this current theoretical. Our considerations, therefore, provide subsidies that broaden the debate about educational *praxis* and pedagogical *praxis* as *sine qua non* categories in the educational field.

Keywords: Educational practices; Post-Critical Theory; Hermeneutic Circle.

1. Introduction

Since the second half of the twentieth century, social theory and postmodern society have characteristics that have been putting into question issues that are influencing educational practices. Although there is no unified postmodern social theory, some aspects permeate the discussions, among which can be mentioned: the rejection of the search for a great synthetic theory; the acceptance of a range of short-range synthetic efforts; the destruction of disciplinary boundaries; the idea that new syntheses can be inspired by ideas from several different disciplines and the demystification of theoretical rhetoric (RITZER, 1993).

Concomitant to the development of postmodern thinking, the post-structuralist paradigm brought contributions to the Post-Critical Theory to gain consistency. In this understanding, there are two aspects that make up this context of formation of Post-Structuralism, they are: the approximation of subjective perspectives and the analyzes of postmodern society. To understand more effectively the influence of Post-Structuralism it is necessary to understand that this paradigmatic school perceives the social world as a text (GIDDENS, 1996; LYOTARD, 1984). This statement leads us to a question: what social meaning permeates the conception of the world as a textual chain?

When analyzing the above question from the perspective of post-structuralist thinking, in an attempt to understand, we highlight four elements that are evident. The first element implies the assertion that the theory conceives a form of discourse that results in texts. The second argues that the empirical scope that investigates the theory, also, is part of the texts produced. The third is the admission that the meaning of empirical texts is subject to interpretations of the positions contained in theoretical texts. The fourth is configured by the recognition that the analysis of empirical texts leads to a deeper understanding of diversified empirical analyzes (LEMERT, 1990).

Other central aspects of analytical concern of post-structuralism and post-modernism are the lack of interest in the idea of social totality and the decentralization of the subject. The first led the post-structuralists to stick to the studies of minority groups and the second enabled the focus of analysis to “leave the subject” for an internal understanding of the meanings of the texts, placing the structure of society as the focus and not the function undertaken by agents in the social composition (GIDDENS, 1996).

It is relevant to highlight here the post-structuralist thinking of Michael Foucault, which brings relevant contributions to the analysis, among which we can mention the study about the fields of knowledge, ideas and modes of discourse about the production of knowledge permeated by power relations, as well as as reflections about the “domestication of bodies” and the institutions of social controls (FOUCAULT, 2008). Among the main influences that composed the ideas of Foucault (1979, 1996, 2008) we can mention: the Marxist ideas, the hermeneutics applied to the understanding of social phenomena, phenomenology, disconnected from the autonomous subject, structuralism without a normative model and the productions Friedrich Nietzsche (1989; 2000; 2002; 2004; 2006; 2008) about power and knowledge.

The constituent elements of the changes in perspectives arising from the post-structuralist paradigm and from postmodern society therefore require new ways of interpreting reality; a rationality that goes beyond monological, subjective, deterministic and simplified reason, inducing us to question how they affect educational practices and what are their implications in modeling and understanding the educational

phenomenon. However, before entering this sphere of analysis, albeit slightly, it is necessary to remember the emergence of science and its progress over the centuries and we do so in the words of Ghedin and Franco (2011, p. 37)

A construção da ciência talvez tenha sido a maior aventura do homem no que diz respeito à sua realidade existencial. O conhecimento científico foi, aos poucos, permitindo-lhe descobrir as estruturas e o funcionamento do universo em suas diferentes manifestações de vida, propiciando enormes progressos nas formas de medir, avaliar e controlar a existência humana. É sabido que a ciência, ao mesmo tempo que proporcionou ao homem esclarecimento, libertação de antigos mitos, alargamento dos saberes e domínio sobre o ambiente, produziu condições de aniquilamento e de opressão da humanidade.

It is based on this understanding that the reflection on the specificities of scientific research in education and its social practices is focused. And in this aspect, according to the authors themselves, when studying the educational phenomenon, science has already found that education consists of a human social practice and being a historical social practice, it is transformed by human action, thus producing changes in those who participate in it. As an object of study, education has the ability to partially change when trying to get to know it, as well as, throughout its understanding, to bring about changes in those who appropriate it. The process of understanding this object, although there is no direct relationship between the observable signifier and the meaning, education is able to foster it, reinforcing its intentional dimension and its axiological and evaluative character (GHEDIN; FRANCO, 2011).

In view of these scientific findings, it is clear that education is an object of study outlined by its dynamism and complexity and, therefore, it cannot suffer reductions or scientific fragmentation so as not to be mischaracterized. This is the reason why criteria adopted by traditional paradigms, such as, for example, conservative paradigms, among which we can mention the Traditional Approach, the Escolanovista Approach and the Technicist Approach (BEHRENS, 2010), fail to meet the demands of complexity of the educational phenomenon. Thus, as advocated by Ghedin and Franco (2011) as it is an object dimensioned by axiology, it requires in the scientific attitude a method capable of entering the sphere of implicit and explicit values, because educational situations are always subject to unforeseen and intentionalities. It therefore requires a multi-referential perspective.

In this respect, to overcome scientific obstacles, the new rationality brought by post-structuralist thinking, according to Ghedin and Franco (2011), must strive to reconstruct and redefine the assumptions that provide the basis for classical science, among which we can mention: overcoming the principle of the exteriority of reality and the incorporation of subjectivity as a constructor of reality; the inclusion of a dialectical complexity of social reality; the recomposition of scientific reason based on the search for causal relations between the facts considering the multi-referentiality of the compositions that systematize the human phenomenon; overcoming scientific neutrality; the incorporation of qualitative aspects in the analysis; the abandonment of the mechanistic view, as well as the search for general laws; the fragmentation and specification of social phenomena for their understanding; the revision of the claim of only two valid forms of knowledge: the empirical and the logical; scientific rigor and understanding of the ideological

dimension of society if it becomes a technique.

This way of seeing the phenomena installs the need to rethink the scientific construction of research in human and social sciences, among them the science of education, with an epistemological apparatus capable of covering most of the complexity, both of the social phenomenon and of the human aspects that permeate education. But, what field of knowledge does education study, if it has as many other fields? Libanêo (2005) answers: it is Pedagogy, being understood as a field of knowledge that assumes the social phenomenon of human formation of the human subject as an object of study. His view focuses on the educational practices carried out within society as basic processes of humanity, loaded with intentionalities. Pedagogy, therefore, studies the pedagogical of educational action with the intention of highlighting socio-political objectives, reverberating and predicting forms of pedagogical intervention for education.

And, in this education it can be understood as a theorization of the socio-educational problems, their limits and possibilities, as well as, of the demands to be faced in the educational practice, or more intrinsically, in the Pedagogical *Praxis* (SOUZA, 2012). However, these two terms, that is, the concept of pedagogical *praxis* and teaching practice over the last decades of the twentieth century, had some conceptual divergences and, in many productions, were treated as being the same object.

The educational practice conceived and intentionally carried out by its subjects, allows us the possibility to conceptualize the pedagogical praxis, in the confluence of the thought of Carr (1999) that defines praxis as a reflective action (practice) that is directed to the realization of an end and the its end is always a morally valuable asset. That is why it is not neutral and, also, it is not material because this 'asset produced' can only materialize through action. Carvalho (2007) adds that praxis is the intention of a practice that is configured by an action permeated by knowledge, values, principles. In the author's perspective, praxis emanates from knowledge, from a way of seeing the world, from beliefs, from a cultural tradition that are shaped by people in a given reality, from a paradigm. Souza (2012) concludes these ideas by conceptualizing educational praxis as an educational process in constant construction, historically situated within a culture, intentionally organized by institutions designated as an end with practical implications for everyone and individually in the construction of the knowledge indispensable to social, technical and technological performance. This concept is ingrained in his thinking and that the scientific investigations of the educational and social phenomenon are thus characterized

[...] por sua provisoriedade, por sua construção e reconstrução permanentes na medida em que seu objeto constitui um desafio pelo caráter de prática social permeada pelas disputas ideológicas, políticas e, portanto, de intencionalidade diversas e divergentes, enfim de valores. Esta, com finalidade e objetivos conflitantes, polêmicos e alvo de disputas no interior de grupos culturais e entre esses grupos culturais numa determinada sociedade. (SOUZA, 2012, p. 27)

When establishing this concept, the pedagogical *praxis* assumes a *tempus* and a *locus* of intentional and elaborated effectuation of education, where, according to Souza (2012) a *locus* of conflicts in which education is carried out collectively, intentionally organized in an explicit way in a school or not and a *tempus* of emotional, efficient and rational maturation in the search for a cultural position and a social status.

For this reason, we understand pedagogical practice as a praxis developed in specialized institutions to

foster education, this concept being linked to transformation. It is, therefore, a specific collective action, inserted in a more extensive social phenomenon, which is education, whose character is systematized, with explicit objectives and purpose, being carried out in partnership with social institutions. Pedagogical praxis, therefore, when expressing a paradigm and assuming a social theory, (re) dynamically constitutes and continues society itself. And, it is with this reasoning that we now analyze educational practices within the scope of post-critical theories.

2. Post-Critical Theory and educational practices: dialogues and possibilities

Based on the characteristics of the post-structuralist paradigm and post-modern society, the constitution of the scientificity of the educational phenomenon and its movement determined by pedagogical praxis, it is possible, at this moment, to analyze the characteristics of the post-critical theory and how these can directly influence the composition of new perspectives for educational practices.

The reformulations brought about by the post-critical theory favored the reduction of obstacles between academic and school knowledge and the knowledge of mass culture (SILVA, 2002), where, according to Corazza (2001), the changes brought by language modify the composition of educational problems, as well as the analyzes that will be undertaken and the consequent resolutions.

In the field of education, post-critical theorists favor the apprehension that in today's society new cultural dispositions are happening at school due to the privilege over people's education, as confirmed by Maknamara and Paraíso (2013, p. 42)

No âmbito das teorizações pós-críticas é ressaltado que muitas das representações disponibilizadas pelos discursos veiculados por diferentes artefatos culturais não apenas chegam às escolas, mas também entram em conflito com o que nelas se ensina. Artefatos como a televisão, o cinema, os jornais, a literatura, o rádio, as revistas, os brinquedos, a música etc., passam a ser vistos, nas palavras de Giroux (2001), como máquinas de ensinar.

In this understanding, the authors' statements allow us to perceive the influence on the ways of thinking and acting that these “machines” have, reaching a direct interference in the school curricula, as well as in the subjects' knowledge, their alterity and existential relationships (MOITA, 2006). For believing in the content and strength of the investments of these teaching machines that post-critical theories in education believe it is legitimate to recognize and investigate the existence and functioning of cultural pedagogies.

According to Costa (2005) the expression “cultural pedagogies” emphasizes that the coordination and regulation of people are not restricted, only, by the speeches that circulate in institutionalized pedagogical spaces. Thus, it is possible to point out in the same way as education, the other cultural dimensions are also pedagogical, they also have something to teach (SILVA, 2002).

These discussions lead us to the openness provided by the combined effects of the various theories that make up post-critical thinking in the Brazilian educational field. However, before entering the methodological instances of post-critical theory, an explanation of the contributions of dialectics and hermeneutics in the structuring of post-critical thinking is necessary.

Dialectical contributions in post-critical thinking are based on the influence suffered by Marxist ideas. In a broader analysis the dialectical approach implies an understanding of social totality, however, such an understanding is criticized by postmodern Marxists. Thus, considering that any partial aspect of social life and no other social phenomenon can be understood in isolation, such phenomena must be considered as participants in history and, consequently, in the social structure conceived as a global entity, thus demanding exclusion from isolated analyzes, specific to social life (RITZER, 1993). The author stresses that in the dialectical approach the relationships between social reality and its cultural and economic dimensions and individual consciousness are extremely intrinsic and, therefore, cannot be studied in isolation.

This means that it is possible to study this reality observing a synchronic and diachronic perspective, where, according to Bauman (1976) the first perspective is based on the interrelation between social phenomena as belonging to a contemporary totality and the diachronic perspective is permeated by the historical propensities of contemporary society, as well as its further development.

Another aspect that makes up the understanding of the influence of dialectics in post-critical theory is the authentication process (BAUMAN, 1976). According to Ritzer (1993), critical theorists focus on the analysis of the cultural superstructure, thus being committed to the analysis of the real world. This implies the assertion that these theorists are not satisfied with laboratory analyzes which are not applicable in practical life.

Therefore, based on the thinking of Ritzer (1993), we can say that critical theorists are concerned with establishing a relationship between theory and practice. However, this seems to be the biggest challenge of critical theory recognized by Ritzer (1993, p. 171)

A pesar de reconocer este objetivo, la mayor parte de la teoría crítica ha fracasado totalmente en su intento de integrar teoría y práctica. De hecho, una de las críticas más famosas que se dirigen a la teoría crítica es que adopta formas de expresión tan complejas que las masas no pueden acceder a ella. Además, comprometida con el estudio de la cultura y la superestructura, aborda una serie de cuestiones sumamente esotéricas y apenas se ocupa de las preocupaciones pragmáticas y cotidianas de la mayoría de las personas.

It is in this understanding that resides the contributions of Jurgen Habermas (1982) on the critical school and that, later, opens space for the emergence of post-critical thinking. This author builds an understanding that knowledge and human interest is an example of the directions of dialectics to establish a relationship between objective and subjective factors. Thus, for Habermas (1982), subjective and objective factors could not be analyzed in isolation, since knowledge systems exist at the objective level, while human interests are constituted as subjective phenomena.

We support on the ideas of Melo (2012) to affirm that the hermeneutic approach gained notoriety with the productions of Friedrich Schleiermacher, where, the author conceived interpretation and understanding as similar acts, which would be consequences of individual and diachronic actions. Also, according to Melo (2012, p. 11), hermeneutics is formed "in the understanding of mental products [...] and finds in Dilthey's work another way for his development of methodological hermeneutics". And, in this respect, the author

continues, the movement of the hermeneutic language is concerned with the understanding of texts through interpretation.

Hans-Georg Gadamer is the author who will give us a basis for understanding the composition of hermeneutical thinking. In his work entitled "Truth and Method: fundamental features for a philosophical hermeneutics" there is a concern with the articulation between tradition and modernity with the notion of horizon. The author understands that "the whole experience implies the horizons of the anterior and the posterior and it merges, in the last analysis, with the *continuum* of the experiences present in the anterior and posterior in the unit of the experiential current". (GADAMER, 1997, p. 372). In this understanding, Gadamer (1997) creates a notion of horizon as a scope of vision that involves everything that is apparent from a given point. In his work, it is necessary to highlight that in the construction of understanding, the experience of historical tradition is relevant, as the discourse needs reflection, considering that the idea of the discourse does not manifest itself immediately, thus demanding an understanding from itself and its context. For this reason, the author urges us to accept the opinion of the other, so that the text presents itself in its otherness and, from that point on, allows the confrontation between the truths of the text and the previous truths of the subject (MELO, 2012).

Rereading the works of Hans George Gadamer, in the mid-1960s Jürgen Habermas appears. The theoretician receives influence from the Critical Theory, however, moving away from the Marxist nucleus for rejecting functionalist reduction and criticizing economicist / mechanistic Marxism. Habermas (1982) is influenced by Max Weber's productions (2004) regarding the rationalization of the modern western world. And, when realizing the limitations in the theorist's productions about rationality tending towards bureaucratization, he adopts rationalization as an argumentative process. These basic elements enable us to understand the dialectic constituted by Habermas to rethink hermeneutics under four basic elements, as reported by Melo (2012, p. 19):

1. A razão humana possui uma força transcendental que se exerce na crítica e consegue ultrapassar preconceitos. A mesma razão que compreende, esclarece e reúne, também contesta e dissocia.
2. A estrutura do "significado" presente na linguagem é apenas um factor na totalidade do mundo real, que para Habermas se compõe de trabalho, linguagem e poder. A linguagem também é vista como meio de dominação e de poder social.
3. Um trabalho crítico busca um método no qual a interpretação seja transformação e vice-versa, o que implica o reconhecimento de um engajamento em todo o processo de compreensão.
4. Ressalta o condicionamento histórico do pensamento, da reflexão e dos determinismos materiais da ideologia.

In the sense of Habermas (1982), hermeneutics has its relevance insofar as it establishes a critical reflection and is capable of understanding linguistically communicable thinking that may not be understood for different reasons. Thus, it is clear that the author does not reject hermeneutics. Paradoxically, it rescues some of its elements by suggesting a junction between hermeneutics and dialectics as a form of reflection that would not be disconnected from social *praxis*. The suggestion of complementarity between hermeneutics and the author's dialectic is due to the mixture between social sciences and philosophy,

seeming to be the most correct point of a methodological balance, especially when the investigative concern is an analysis of social *praxis*.

This means that hermeneutics, in favoring the critical analysis of thought, has the capacity to understand the rationality contained in communications and, in this aspect, it can serve as an input for research in the field of research as we will deal with below.

3. The reflection of hermeneutics as an epistemological paradigm of research

Hermeneutics as the science of interpretation, which focuses on researching the result of the interpretation given by the subjects of an observable and intelligible world through language, can be perceived as human activity, thus becoming a potential means of making this knowable world. The language, according to Gadamer (2002, p. 135), "is not just the fact, but universality of the principle, and that rests on that of Hermeneutics".

Bakhtin (1997, p 280) collaborates by remembering that language is a

“atividade da língua que efetua-se em forma de enunciados (orais e escritos), concretos e únicos [...]. O enunciado reflete as condições específicas e as finalidades de cada uma dessas esferas, não só por seu conteúdo (temático) e por seu estilo verbal [...], mas também, e sobretudo, por sua construção composicional”.

This means that the textual construction and its relationship with the context, represents a way of explaining the world. It is, therefore, a language that intends to interpret and signify things, a fact that is consistent with the whole of the statement, or the world of life, as Habermas (1982) categorized it well. In the sense of Guedin and Franco (2011) the statement, the specific conditions and the purposes constitute a totality that support the creation of the reality of the statement, a composition that makes it possible to translate the interpretation of reality through the text.

Thus, the authors cited above refer us to an understanding of meaning as being composed of a perception of the world, as well as a way of understanding the meanings that are perceived or not in the most differentiated relationships. This condition of meaning leads us to multiple looks from the same object or subject, highlighting the individual manifestations shown in the speech genres, because speech, in this context, reveals how the subject interprets and understands human history (GHEDIN; FRANCO, 2011).

In this understanding, Ghedin and Franco (2011, p. 155) support us to perceive speech discourses, as “primary forms of expression of meaning, because any simultaneous expression of thought and speech rarely allows, at the very moment of action, conducting a reflection on what is being said”. For, these are speeches located at the primary level of meaning of life, thus not requiring more complex elaborations, only the particular meaning of everyday life.

Secondary discourse, on the other hand, requires reflection on speech, a fact that prevents this reflection from being made during speech. Thus, it can be said that this way of making the senses explicit implies a double movement of thought. This situation is valid as a phenomenal reality of the reality of the discourse, because, for a methodological issue, one must have the notion that a simple, primary, elementary, basic discourse is being analyzed (GHEDIN; FRANCO, 2011).

Thus, language and life are intrinsically linked, considering that the first enters the second through the concrete statements that make it effective. Thus, language comes to be seen as the expression of humanity, differentiating us from other animals, because for them there is language, but there is no parlance. However, due to the fact that in everyday relationships the act of meaning coincides with the way of living, it is necessary to go beyond the sphere of explanation for understanding and understanding, it is also necessary to have a second order discourse, because that is where, besides from the sense, meanings and their constructive processes are conceived (GHEDIN; FRANCO, 2011).

With regard to the construction of discourse as a potential for significant meaning for understanding in the investigative process, the development of understanding in differentiated acts translates into affective, real and concrete, where, according to Ghedin and Franco (2011), such acts they merge into a single process, summed up as the psychophysiological perception of the physical sign. This means that every sign leaves a visible way of being, because it is in this dimension that it is perceived and understood. Such recognition and understanding of its meaning is reproduced in the language, because it is in the conjugation of the meaning that the discourse is constructed and thus, it is intended to express and understand the world in its way of being. In addition, the understanding of meaning takes place in context. Therefore, every form of discourse is constituted by a mode of insertion in a given context.

To analyze the meaning of the discourse, hermeneutics appears as the unveiling of the interpretative. However, it is necessary to ask to what extent it is possible, or through what it can be done. Vygotsky (2000) reveals that it is the meaning of words, since word and thought have a close relationship, giving conditions for the human being and acting. Therefore, meaning can be analyzed equally as a phenomenon of language due to its nature and as a phenomenon in the field of thought. This perspective allows us to speak about the meaning of the word, as it carries a meaning permeated with meaning which reflects the subject's unique way of expressing his perception of the world and things and producing culture.

For this reason, the written language is permeated by the speech genres both primary, which are configured by the daily forms of expression of meaning in the act of speech, and secondary ones whose reflection is made after it, being more complex and usually mediated by writing. Although distinctly characterized, the essence of discursive genres is the same (BAKHTIN, 1997). Hence the importance of analyzing the genres in a dialogical way, since the secondary discourse is elaborated based on the primary.

Therefore, understanding hermeneutically presupposes critical reflection that considers what the text manifests, what truth it supposes in a respectful perspective and, simultaneously, dialectically confront them with the world of life, considering their objective, subjective and normative dimensions (Anonymous, 2008).

And it is in this context that the hermeneutic circle presents itself, bringing theoretical and methodological elements that can broaden the understanding of educational practices and their (re) construction in contemporary times.

4. The hermeneutic circle and methodological possibilities: building paths to rethinking

The proposal to look at educational practices as a collective action built socially from the relationships

established within social institutions, implies the adoption of an analytical model that interprets such relationships. With this done, as educational practices are part of social and cultural actions, where the transmission process of these aspects permeates the construction of society and the changes it contains, it encourages us to investigate an interpretation model linked to the consolidation of human and social sciences as a scientific field. In this perspective, according to Mantzavinos (2014), the hermeneutic circle serves as an argument to support the autonomy of the human and social sciences and, in this case, to analyze educational practices.

The notion of hermeneutic circle receives a new approach in the reflections undertaken by Martin Heidegger and Hans George Gadamer, thus adding an existential dimension. In the production entitled *Ser e Tempo*, Heidegger (2009) attributes it an ontological character, emphasizing that every hermeneutic situation presupposes an interpretation based on the subject's previous views. The author's emphasis throws into the hermeneutic circle the constitutive character of existence as a being that exists from the perspective of understanding, of being in the world (*Dasein*). In this sense, Silva (2013, p. 56) states that

Mais precisamente, Heidegger alega que a nossa existência do mundo só é possível a partir do sentido que é projetado a partir da nossa rede de práticas e do nosso contexto histórico, permanecendo inelutavelmente condicionada pelo horizonte do intérprete.

The position of the theoretician mentioned above, according to Silva (2013), leads us to two epistemological situations. The first is associated with an inversion in the traditional relationship between interpretation and understanding, considering this as the culmination of a successful interpretive process. The second, connected with the first situation, refers to Heidegger's opposition to subjectivism and hermeneutic objectivism, since, for Heidegger, interpretation is projective, as it consists in elaborating or exploring possibilities.

In this understanding, Heidegger and Gadamer show similarities in their analysis of the hermeneutic circle. For these theorists there is a recognition that there is no interpretation without presuppositions exempt from the actions of our prejudices, actions that develop, naturally, in a critique of the principles of an objective sense. So much so that “a expressão círculo hermenêutico é utilizada no sentido de que, nossa compreensão da relação todo-parte, singular-plural, uno-múltiplo, sujeito-objeto não se fecha em um círculo vicioso, mas se processo em forma de círculos concêntricos.” (MATINAZZO, 2004 p.36). It is, therefore, a process, according to Nunes (2019, p. 22) “de construção e reconstrução da realidade de forma dialógica através de um vai e vem constante (dialética) entre as interpretações e reinterpretações sucessivas dos indivíduos para estudar e analisar um determinado fato, objeto, tema ou fenômeno da realidade”. Undeniably, the phenomena analyzed under the flashlight of the hermeneutic circle, as constant movement, present a critical-reflexive and dialectical character in the interpretation of the whole part, that is, favoring the understanding of the object of study.

Thus, the hermeneutic circle that can be analyzed under three dimensions: the ontological problem, the logical problem and the empirical problem (MANTZAVINOS, 2014). Considered as an ontological problem, the hermeneutic circle is based on the traditional view that ontology is about what exists and the ontological arguments presented usually defend that the world is bounded by assumptions. Heidegger (2009)

emphasizes that the circle of understanding belongs to the structure of meaning that has as a platform the constitution of the existence of the being itself, that is, in whom in the understanding it interprets.

In this sense in the hermeneutic circle, truth and understanding occur through the unveiling of being. However, there are questions about whether, in fact, it is formulated based on its ontological conception.

As a logical problem, Mantzavinos (2014, p. 58) asks whether “[...] a relação do todo significativo com os seus elementos e vice-versa poderia ser de natureza lógica. [...]”. In this case, two problems can be raised. The first is to perceive the hermeneutic circle as a case of circular argumentation based on deduction, because it appears in the process of proving something that presupposes statements that we should prove. And, the second understand that the hermeneutic circle could be a circular definition, because the concept in which it arises, and which is yet to be defined, has already been used instinctively. In any case, this problem weakens the principles of the human sciences, compromising its scientific character, points out the author.

Bearing in mind that sometimes the hermeneutic circle is problematized as an ontological problem and sometimes as a logical problem is it possible to admit that it is an empirical problem? Yes, says Gadamer (2009) because the exercise of reading and interpretation is directly related to the movement of empiricism, hermeneutics being a practical and also theoretical task that requires knowledge of the text as a whole, of critical reflection on it and of reading the parts and part for all in a circular and dialectical movement. It is, therefore, a mental procedure that can be analyzed with the instruments of empirical science, and, therefore, a *praxis*.

In this perspective, Mantzavinos (2014, p. 59) states that

[...] o círculo da compreensão não teria nenhum vínculo com a ontologia ou com a lógica, mas com a representação do conhecimento na mente do intérprete, apresentando o seguinte tipo de problema empírico: como o sistema cognitivo do intérprete percebe, classifica e compreende os sinais escritos? Essa operação mental está automatizada? Que tipo de mecanismo cognitivo é ativado para que o significado da parte de uma expressão escrita só seja acessível ao intérprete em relação ao todo e vice-versa?

However, the adoption of the problem of the hermeneutic circle as being of an empirical nature does not imply considering hermeneutics as a neutral method, purely instrumental in which the researcher has no relationship. Although it consists of a systematic method of organizing interpretation, as stated by Stein (1988), it is not mechanical because of the peculiar characteristics of text interpretation (linguistic repertoire) as the mental phenomenon that moves towards meaning, dynamically. Therefore, it can be used as a qualitative analysis tool by the human and social sciences.

In fact, Martinazzo (2004), analyzing contemporary Pedagogy under the paradigm of modern subjectivity and the paradigm of communicative action by Jürgen Habermas, proposed a Pedagogy of Subjective Understanding, in the light of philosophical hermeneutics, that is, as a lantern, as content and methodological path. The author understands that Pedagogy

Como teoria da e para a prática pedagógica, que mantem um vínculo orgânico e

dialético com o todo da sociedade, a Pedagogia necessita de uma racionalidade ampla, sem menosprezar ou hipostasiar nenhum de suas tríplices dimensões: a hermenêutica, acrítico-emancipatória e a instrumental, sob s apenas de se tornar redutível e estéril. (p. 27).

It is important to highlight the recent investigation by Nunes (2019) who, using the hermeneutic circle, analyzed the pedagogical practice of teaching reading and writing of the “Se Liga” Program of the Municipal Education Department of the city of Teresina-PI. Interpretations have shown that pedagogical practices in that context, on the one hand, move in overcoming difficulties, social and educational prejudices. On the other hand, they allow the teacher to recognize the importance of the mastery of linguistics in the students' development process, carrying out educational *praxis*.

Therefore, the reflections made about the hermeneutics and empirical perspective evidenced in these studies lead us to understand that Pedagogy, when studying educational practices in general, can use hermeneutics as a guide for understanding the educational phenomenon, relationship with culture and transformations social. And, in a specific way, to understand what their subjects do, how they do it and why they do it, in their eagerness to understand the impact of these practices on the construction of society and how to (re) configure them, having the text as a mediator, since language is its principle.

5. Conclusion

When reflecting on the concepts of education and educational practices, we built the idea that the educational practice is intentionally conceived and executed by its subjects and, in this aspect, the pedagogical praxis can be conceptualized as an educational process in constant construction, situated in a historical context inserted a culture, intentionally organized by designated institutions. This position, combined with the perception of education as an act of transmitting cultural aspects to the subjects, shows us that educational practices are collective actions developed in a social context permeated by power relations.

When carrying out the analyzes on the Post-Critical Theory, we intended to demonstrate how it can bring, in contemporary times, new perspectives to understand the social phenomenon, being the reflection on educational practices that will collaborate in the understanding of the different socio-cultural contexts. Notably, these contributions affect the way of interpreting the social phenomenon considering its context, its subjects, the researcher himself and his existence and awareness. This means that their concepts, previous visions and conceptions, their truths are not abandoned a priori, but are confronted with reality among the truths of the text. In this reasoning, it is the objective and subjective views that allow us to understand, in the most exact possible way, the observed phenomenon. This means that the construction of knowledge rests on the objectivity of the text subjectified by the researcher, that is, on the intersubjectivity.

The discussions brought about by hermeneutics and dialectics allowed us to perceive how they can influence the formulation of analysis methods to understand the social phenomenon and, thus, to conceive educational practices in a way closer to contemporary social reality. In this understanding, the hermeneutic circle was briefly explained in its epistemological and methodological conception, to demonstrate its interpretative potential of social reality and the consequent contribution to the conception of free, authentic,

emancipatory, critical and encouraging educational practices. Therefore, we can conclude by stating that hermeneutics and dialectics as a methodological contribution collaborate in the resignification of the pedagogical dimension of educational practices, because it emphasizes the reasons why it, the practices are determined.

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