Student Performance Prediction Based on a Framework of Teacher's Features

Fernando Ribeiro Trindade and Deller James Ferreira
Instituto de Informática – Universidade Federal de Goiás
CEP 74690-900 – Alameda Palmeiras, Quadra D, Câmpus Samambaia – Goiânia – GO – Brazil
frtrindade@tjgo.tjgo.jus.br, deller@ufg.br

Abstract

Teachers teaching skills are essential to motivate students' engagement in online educational environments, where students and teachers interact with each other, generating a large amount of educational data. However, to the best of our knowledge, there is no previous study that takes advantage of the huge quantity of teachers' behavioral data to predict students' performance. To fill this research gap, we elaborated a theoretically based framework of teacher's characteristics, that guided an automatic data collection of teachers' behaviors to predict students' performance. The implementation of a computational prediction system applied the Random Forest classifying algorithm, which achieved better performance, according to AUC metric, when compared to other algorithms. Two exploratory case studies were conducted to investigate the efficiency and efficacy of the framework of teacher's features in Goiás Judicial School EJUG teachers in Brazil. The results from the case studies shown that the framework is effective to predict students' performance. This work contributes to distant education, enabling monitoring teachers' actions aiming students' academic best achievements.

Keywords: Teaching skills; students' performance; prediction system;

1. Introduction

Nowadays, distance education emerges as a tool for the democratization of educational opportunities and enables the emancipation of the individual in the social context. The flexibility of space and time are characteristics of great social relevance in the field of distance education. However, online teaching modality requires changes in habits of both teachers and students. There are several reasons that can hinder or decrease the learning rate on distance learning platforms, amongst them the following stand out: student evasion, teachers without adequate training, inadequate time management and lack of interaction between teacher and students (EAD, 2019).

Maximizing student performance and teaching quality is a challenge in distant education. Several attempts at systematic associations between the attitudes of educational policy makers and student results have been made, however, few positive results have been found (Kukla-Acevedo, 2009). Thus, the researchers' attention shifted to in-class context, looking for correlations between teachers' actions and the academic achievements of their students.

The teacher assumes a crucial role throughout the learning process, since without the proper pedagogical accompaniment, the education process is not complete (Kyriakides & Christoforou, 2013). The teacher must organize the flow of knowledge in order to allow independent study, as well as observe the individual behavior of students. The teacher of online courses should be a mediator in the learning process, as their attitudes can directly influence the students' school performance.

The growing offer of online courses has raised some questions about the quality of teaching in distance education courses. To improve students' results, in online courses, teachers must get used to the distance learning environment. (Canales & Maldonado, 2018) found that the teachers 'professional experience had a strong influence on students' grades. The mastery of technological tools can be seen as a challenge for some teachers of distance education courses, therefore, teachers must be trained to develop their activities in virtual learning environments (VLE) (Comi & Argentin, 2017). The teacher's teaching style in online teaching environments is also seen as an obstacle, (Naimie & Siraj 2012) identified that modern and innovative assessments had a positive impact on students' grades. It is essential that the teacher offers means for students receive feedbacks (Ngang & Yie 2015).

From a technological point of view, educational platforms are required pedagogical tools in distance learning. From the data stored in educational databases and with the aid of appropriate technological resources, it is possible to reveal valuable information about the teaching environment under analysis. Educational Data Mining, EDM, is a technological resource that assists in converting raw data, collected from educational systems, into useful information that can be used to improve the quality of distance education.

Given the above-mentioned, in this research, we theoretically developed a set of teachers features and their corresponding behaviors, based on features encountered on the literature and Andragogy principles, that can influence the performance of their students. Based on this theoretical framework, a student performance prediction system, applying EDM techniques, was implemented, allowing the teacher's behavior to be monitored and regulated if necessary, depending on the student's performance prediction.

2. Related Works

The development of frameworks approaching teaching features has been the subject of some previous research. (Powell et al. 2014) members of iNACOL and The Learning Accelerator (TLA) motivated by an interest in understanding the roles of teachers in semi-face-to-face courses, brought together a committee of managers and specialists in mixed courses to answer the following question: "What are the main characteristics of teachers in successful mixed learning environments?" The product of this committee's work was a framework of competencies recommended for teachers of semi-presential courses at iNACOL. The framework was designed to be dynamic, as new information on teaching practices is incorporated into the framework. The framework is structured in four general categories of teaching characteristics, the following categories: Mentalities, Qualities, Adaptive Skills and Technical Skills. The teachers' mentality is linked to their motivation, belief, behavior and actions regarding their educational missions. The category of qualities relates personal characteristics and patterns of behavior that are linked to the adaptation of the teacher to new forms of teaching. Adaptive skills list teachers' characteristics in solving problems,

proposing solutions and adapting to new teaching methodologies. Technical skills list characteristics related to the experience of teachers in carrying out their duties.

Adeosun et al. (2013) developed a framework of cognitive, affective and professional characteristics that are desirable in a good teacher. The set of attributes was selected based on questionnaires applied to students, trainees, teachers and teacher trainers in Nigeria's education system. The framework brings together cognitive, affective and professional characteristics of effective teachers in Nigeria. In the context of the re- search, effective teachers were those with a high capacity to inspire and influence student learning. From the questionnaires applied to students and teachers, 27 attributes were identified related to the professional qualities of teachers, such as: Organization, punctuality, experience, motivation. 25 cognitive skills were listed, for example: potential for problem solving, resilience, self-reflection and verbal communication. Among the affective characteristics, 24 were listed, namely: cooperation with colleagues, emotional control, responsibility for their actions, impartiality, among others. However, the authors were unable to conclude whether these characteristics are capable of directly influencing the quality of teaching.

For fifteen years, Walker (2018) collected information from university students on teachers' attitudes and behaviors that they considered to be most efficient and that contributed effectively to their professional careers. From the information collected, Walker (2018) formulated a framework with twelve characteristics of the teachers that positively affected the students' school performance. The results found by the authors suggest that the most effective teachers have the following characteristics: optimism, technical training, positive expectations for their students, creativity, they perform fair assessments, are accessible, convey security to their students, are compassionate with their students, have good sense of humor, respect students, have the ability to forgive and admit their mistakes.

The investigation of teachers 'behavior in relation to students' performance was the subject of academic research. However, no previous work has correlated the characteristics of teachers with the guidelines of Andragogy, therefore, this is the theoretical contribution of this work for the advancement of behavioral studies considering teachers. The technological contribution of this work is enlightened as follows.

The main educational tools found in the market were developed to help teachers to monitor performance and predict results for students only. (Chiang & Brinton, 2020) developed the *Zoomi* tool that uses artificial intelligence techniques to increase course completion rates, improve course effectiveness and increase student participation. Zoomi is an educational management tool that aims to understand the individual needs of students to meliorate their fulfillments, and, consequently, to improve the achievements of the educational institution. The Blackboard Predict tool developed by (Chasen & Pittinsky, 2020) aims to provide educational institutions with a means of identifying students at risk, adapting resources to student's needs. *X-Ray Learning Analytics* is an open source tool created in 2005 by (Miller et al., 2020) to support education centers and companies to understand and diagnose students and teacher's needs. The tool also provides the prediction of students drop out and the generation of detailed reports on student behavior.

All the tools found in the literature and available on the market focus on students and provide services to support teachers and educational managers on monitoring students for decision making. The technical contribution of this work concerns the advancement of the state of the art, by the creation of an educational prediction tool under a perspective of monitoring teacher characteristics for educational interventions.

3. Methodology

The data selected for a case study was collected from the Goiás Judicial School (EJUG), which is a judiciary educational department linked to the Goiás Court of Justice (TJGO). EJUG maintains an active Moodle implementation to provide professional training for TJGO (EJUG, 2017) magistrates, lawyers and other employees. Each record in the analyzed data set represents a student and each record attribute stores information about the student's behavioral actions in a given course. The behavioral actions of students involve participation and student contributions in the course. The analyzed data were collected from 2015 to 2019. The total of records from the EJUG data set is 2752.

According to Fayyad (1996), the classification method is one of the main data mining techniques used in the "real world", having been applied to problems of: fraud detection, investment market, marketing actions and record categorization. In the context of this work, the classification method will also be used to categorize students at risk according to the behavior of teachers, regarding the good teaching practices present in the framework.

To choose the best classifier algorithm for the selected data set, a performance analysis of the main classifiers was conducted with the help of the WEKA Experimenter tool (Weka, 2020). The performance of the main classification algorithms was assessed by WEKA data analysis tool. The performance of the algorithms of the following classification strategies was evaluated: decision trees, decision rules, neural networks, linear regression and Bayesian networks. The classification strategies should seek the largest number of correct classifications possible, this metric is called accuracy, however, this metric will only reveal the real efficiency of the classification model if the data used for training is balanced. In the context of this research, no data balancing technique was applied, however, the area under the curve (AUC) performance metric was used. This is one of the alternative metrics that can be used in unbalanced data sets, as this metric reveals the proportion of wrong classifications.

Table 1. Parameters of Classifying Algorithms in WEKA.

(1) trees.J48 '-C 0.25 -M 2' -217733168393644444
(2) trees.RandomForest '-P 100 -I 100 -num-slots 1 -K 0 -M 1.0 -V 0.001 -S 1' 1116839470751428698
(3) trees.RandomTree '-K 0 -M 1.0 -V 0.001 -S 1' -9051119597407396024
(4) rules.JRip '-F 3 -N 2.0 -O 2 -S 1' -6589312996832147161
(5) rules.PART '-M 2 -C 0.25 -Q 1' 8121455039782598361
(6) rules.DecisionTable '-X 1 -S \"BestFirst -D 1 -N 5\"' 2888557078165701326
(7) rules.OneR '-B 6' -3459427003147861443
(8) functions.MultilayerPerceptron '-L 0.3 -M 0.2 -N 500 -V 0 -S 0 -E 20 -H a' -5990607817048210779
(9) functions.SimpleLogistic '-I 0 -M 500 -H 50 -W 0.0' 7397710626304705059
(10) bayes.NaiveBayes " 5995231201785697655
(11) bayes.BayesNet '-D -Q bayes.net.search.local.K2 – -P 1 -S BAYES -E bayes.net.estimate.SimpleEstimator – -A 0.5' 746037443258775954

Source: Elaborated by the authors.

Table 2. Classifiers AUC value, with unbalanced data.

Dataset	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
COURSES-5-WEEKS	0.69	0.73◦	0.70	0.52•	0.71	0.53•	0.52•	0.69.	0.69	0.66	0.67
COURSES-6-WEEKS	0.90	0.94◦	0.87	0.90	0.90	0.91	0.80•	0.92	0.93◦	0.85•	0.90
COURSES-7-WEEKS	0.70	0.90◦	0.81◦	0.50•	0.78	0.77	0.53•	0.88◦	0.58	0.86◦	0.85◦

◦, • statistically significant improvement or degradation. Source: Elaborated by the authors.

The table 1 shows the parameters used in the algorithms executed in the WEKA *Experimenter* tool. As presented in the table 2 the combinatorial algorithm (ensemble) *Random Forest* reached the largest area under the curve for all subsets of data under analysis. For the data subset of the 6-week courses, the AUC value was 0.96, which is very close to the AUC value for the ideal model, which is 1.

Table 3. Student Attributes.

Module Moodle	Attributes Description
Forums	Total of participation on forums Number of posts Number of updates to publications Number of publications read Number of discussions that participated Number of responses sent Number of responses received Number of typed characters Total of published words Number of sent phrases.
Questionnaires	Total of questionnaires that participated Number of submissions Total of questions answered Total of wrong questions Time spent on questionnaires
Chats	Total chats participated Total of messages sent Number of words typed Number of typed characters
Tasks	Number of tasks performed Number of submissions Total of tasks sent late Total of saved drafts
Logs	Total of interactions Logged time

Source: Elaborated by the authors.

From the performance analysis, the RandomForests (RF) classifier was selected to generate the best classification model for classifying students. The behavior of each student, within Moodle, is described by the set of 40 attributes listed in the table 3. Each attribute was extracted or derived from one or more Moodle tables. In order to achieve the objective of predicting students' academic performance from the behavioral actions of students and teachers, a teacher class attribute was added to the set of student attributes, which will indicate whether the teacher's actions were consistent with the characteristics of framework. The teacher class attribute, indicator of the teacher's actions, is valued with the result of the teacher classification algorithm.

The data of the students, who had already completed the courses, were used to train the RF. However, due to the fact that the behavioral data of the teachers does not have a label, which allows them to be classified as practitioners or not of the good teaching practices, necessary for training the classifier, a classifier named algorithm of means was developed to perform the classification of teachers.

The *averagingAlgorithm* classifies a teacher based on the average value of the teaching attributes present in the framework, so a teacher has a certain attribute if it has a value greater than or equal to the average global, calculated based on the value of the respective attribute for all teachers. And finally, a teacher is classified as andragogic, or not, if he has at least half of the teaching attributes present in the framework. The output of the averaging algorithm is used to allow monitoring of teachers' actions within the course and to value the teacher's class attribute used in predicting student performance.

Algorithm 1. averagingAlgorithm(R)
Data: Record R(X1, ..., X31) Result:"Andragogic" or "Non Andragogic"
1 X1, ..., X31 // andragogical attributes
2 M1, ..., M31 // global average of each attribute
3 C1, C2, C3, C4 // Total of attributes by classes
4 T //total of andragogic classes
5 for I ← 1 to 14 do
6 if (Xi>=Mi) then
7 C1 = C1+ 1
8 end
9 end
10 for i ← 15 to 18 do
11 if (Xi>=Mi) then
12 C2 = C2+ 1
13 end
14 end
15 for I ← 19 to 24 do
16 if (Xi>=Mi) then
17 C3 = C3+ 1
18 end
19 end
20 for I ← 25 to 31 do

```
21. if (Xi>=Mi) then
22        C4 = C4+ 1
23     end
24 end
25 if (C1>= 7 ) then
26     T←T+ 1
27 end
28 if (C2>= 2) then
29     T←T+ 1
30 end
31 if (C3>= 3) then
32     T←T+ 1
33 end
34 if (C4>= 3) then
35     T←T+ 1
36 end
37 if (T >= 3) then
38     return ”Andragogic”
39 else
40     return ”NonAndragogic”
41 end
```

The prediction functionality implementation, in this work, was performed as an extension of the software Moodle Predicta (MP) developed by (Felix 2017). Originally the MP was developed with the objective of collecting data from students in Moodle and from these data make the prediction of students failure or success. Therefore, in order to expand the functions offered by the MP, traceable data from the teachers' actions were included along with the students' behavioral data to improve the students' performance prediction.

4. The teacher Characteristics Framework

The framework of teachers' attributes that impact on students' performance was built from the characteristics observed in works of academic literature and subsequently correlated and based on the characteristics required by Andragogy, which focuses on teaching environments aimed at adults such as distance learning.

The main characteristics of teachers identified in academic works are listed in the table 4. Each row in the table 4 lists a characteristic, the articles that evaluated that attribute, and what impact the teacher's characteristic had on students. The type of impact, in the context of this research, is considered: positive when students had better school performance, negative when the observed characteristics influenced the worsening of school performance, and neutral when the studies did not identify any interference of the evaluated characteristic in the academic performance of students.

To build the framework of teachers' attributes, a subset of the characteristics present was selected in the table 4, because to achieve the objective of predicting student performance from data extracted from

Moodle, it is necessary that the characteristics of the teachers are traceable within the database. The table 5 presents the set of characteristics of the teachers who were selected to compose the framework, based on previous academic studies.

Andragogy focuses on teaching adult students. Andragogy guidelines were included in the framework based on the following propositions: distant education courses focus on young and adult students he precepts of Andragogy are present in decree Number 2.494/MEC, that institutes distance education in Brazil and analyzed data were collected from courses offered to adult students.

According to (Knowles, 1980) the four attributes desired by modern andragogy are: self-direction, previous experience of the learner, applicability of activities and motivation. In short, teachers must guarantee self-direction to their students, the courses taught must address the students' previous experiences, activities must contextualize with the students' professional activities and the teacher's motivation must reflect on the students' motivation.

Table 4. Characteristics of teachers and Impact on Students.

Feature	Positive Impact	Negative Impact	No Impact
Experience	(Canales & Maldonado, 2018) (Clotfelter & Ladd, 2010) (Sant´ın & Sicilia, 2018) (Çakır & Bichelmeyer, 2016)		(Shukla et al., 2018) (Stes & Maeyer, 2012) (Azigwe & Kyriakides, 2016)
Formation	(Shukla et al., 2018)		(Çakır &Bichelmeyer, 2016) (Chu & Loyalka, 2015) (Canales & Maldonado, 2018) (Sant´ın & Sicilia, 2018) (Clotfelter & Ladd, 2010)
Motivation	(You & Dang, 2016) (Lee & Longhurst, 2017)		(Çakır &Bichelmeyer, 2016)
Communication	(Ngang & Yie, 2015)	(Zakharov & Carnoy, 2014)	
Leadership	(Ngang & Yie, 2015) (Passini & Molinari, 2015) (Sant´ın & Sicilia, 2018)		(Naimie & Siraj, 2012)
Teaching Style	(Ngang &Yie, 2015) (Cordero &Gil-Izquierdo, 2018) (Naimie &Siraj, 2012) (Choi & Yang, 2011)	(Cordero & Gil-Izquierdo, 2018) (Comi & Argentin, 2017)	

	(Kyriakides & Christoforou, 2013)		
Time Management	(Azigwe & Kyriakides, 2016) (Kyriakides &Christoforou, 2013)		
Assessments	(Naimie & Siraj, 2012) (Zakharov & Carnoy, 2014)		
Skills in IT	(Comi & Argentin, 2017)		(Lee & Longhurst, 2017)
Training	(Golob, 2012)		(Akiba & Liang, 2016) (Zhang & Lai, 2013) (Stes & Maeyer, 2012)
Self-efficacy	(Mojavezi &Tamiz, 2012) (Friedrich & Flunger, 2015)		
Nonverbal Behavior	(Passini &Molinari, 2015) (Chaudhry &Arif, 2012) (Abdellah, 2015) (Kyriakides &Christoforou, 2013)		

Source: Elaborated by the authors.

Table 5. Teaching Attributes: Academic Literature.

Feature	Description
Assessments	Represents the assessment model applied by teachers.
Training	It concerns professional development.
Communication	Represents the level of interaction between student and teacher.
Teaching Style	Refers to the applied teaching methodology.
Experience	Translates teaching experience.
Formation	Reveals academic background: Undergraduate and Postgraduate
Time Management	It concerns the time dedicated to students.
Leadership	Ability to guide students.
Motivation	Teacher's ability to stimulate students.

Source: Elaborated by the authors.

Table 6 correlates the characteristics of teachers according to Andragogy with the attributes of the 5 table and represents the framework of teaching characteristics, which impact on student performance, which is used in the context of this research.

Table 6. Teacher Characteristics Framework.

Andragogic Characteristics	Characteristics from the Literature in Distant Education
Assessments	Assessments Teaching style Experience Communication
Self-directivity	Time Management Assessments Motivation
Previous Experience	Evaluations Teaching style Communication Experience
Motivation	Motivation Communication Teaching style Leadership

Source: Elaborated by the authors.

Table 7. Correlation of the attributes of the Framework with the data extracted from Moodle.

Andragogical Characteristics	Characteristics of Correlated Literature	Extracted Attributes
Self-directivity	Time Management	Average time of available tasks Average quiz time available Average survey time available Average feedback time available
	Assessments	Number created tasks Number of created quizzes
	Motivation	Number books created Number of wikis created Number of scorms created Number of images used Number of videos used Number of audios used Number of pdf's used Number of office documents used
Assessments	Teaching Style	Total of submissions made in quizzes Total of submissions made on tasks Total of submissions made in feedbacks

	Assessments	Average quiz score Average grade of tasks
	Experience	Average grade for the question: what is the importance of the course for professional life?
Previous Experience	Assessments	Average grade for the question: does the course interest me?
	Communication	Number of chats created Number of forums created
	Teaching Style	Number of workshops created
Motivation	Motivation	Total of hours logged
	Communication	Number posts on forums Number tasks corrected
	Teaching Style	Number feedbacks created Number surveys created
	Leadership	Average grade for the question: does the teacher encourage my participation?

Source: Elaborated by the authors.

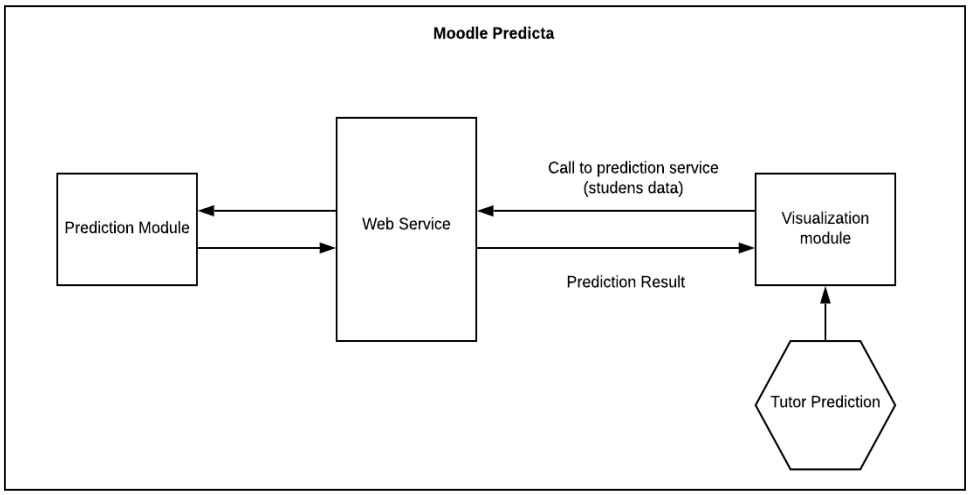
The table 7 shows the correlation between the characteristics of the framework and the data extracted from Moodle. Each andragogical attribute is associated with a set of teaching characteristics and each teaching attribute has been correlated with one or more data extracted from the Moodle database used in EJUG.

5. Moodle Predicta Extension

The Moodle Predicta extension was developed in a modularized way, with the visualization module designed to present the results in a user-friendly way and the prediction module responsible for all tasks involved in the classification process of students and teachers.

The complete operation of the MP extension is shown in the figure 1. The visualization and prediction modules communicate through the services interface provided by Web Service. The client, in a web browser, accesses the visualization module and makes prediction requests. Each prediction request is accompanied by a set of data, from the student to be classified, which are passed on to the prediction service that performs the classification and sends the result to the visualization module, again. With the prediction result in hand, the data is formatted and presented to the user, using friendly results presentation resources available in the data visualization.

Figure 1. Internal view of MP Extension



Source: Elaborated by the authors.

5.1 The Visualization Module

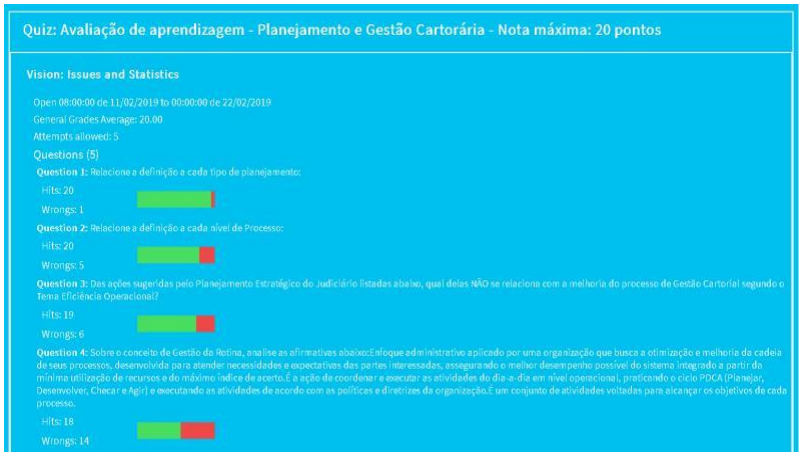
The visualization module is responsible for presenting statistical and graphical reports, which allow course administrators to monitor the progress of students and teachers, starting from the extension of the MP. The tool can produce reports for each of the main Moodle modules, which are: forums, questionnaires, tasks, chats, logs and time.

Figure 2. Forum activity reports

Source: Elaborated by the authors.

The Forum activity report (figure 2) displays all discussion topics created by the teacher, as well as the number of posts, readings, proportion of students who accessed the topic, number of words typed by the teacher, among other information. The teacher' participation in forums is related to the attributes: teaching style, communication and feedback. According to Table 4, such attributes can impact students' performance, which justifies the importance of behavioral analysis of teachers in social interaction environments, such as forums.

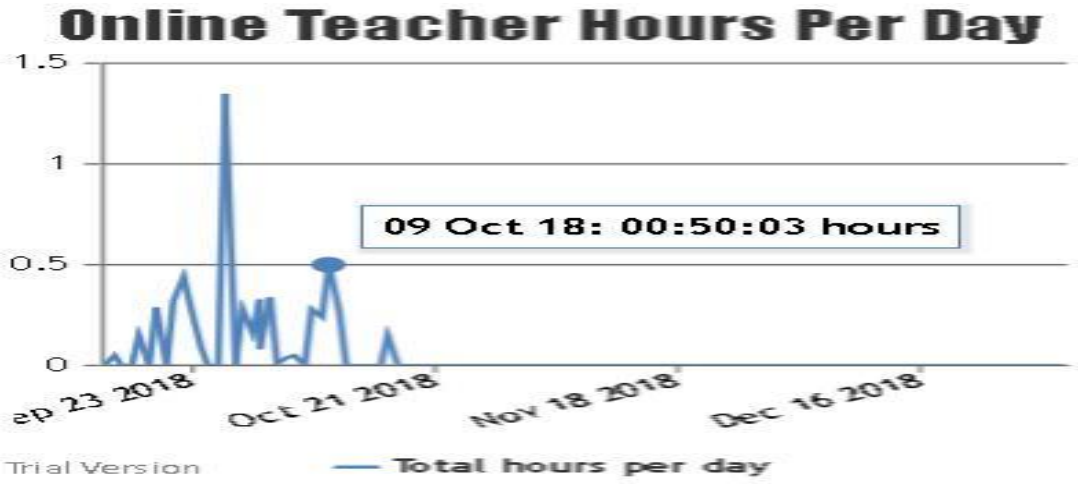
Figure 3. Quiz Reports.



Source: Elaborated by the authors.

Questionnaires, quizzes, and tasks are common assessment modalities in distance education courses. These activities are important tools for verifying students' learning and, also, for feedback to the teacher, as the students' grade reveals whether the teaching process is taking place satisfactorily. Another important function of evaluations is to check the possibility of the student dropping out. The tasks are closely linked to the characteristics: assessments and teaching style. Figure 3 shows how supervision of quizzes created by EJUG educators is done. For each question, the number of hits and errors is calculated, the results are displayed graphically.

Figure 4. Teacher Time Dedicated to the Course.

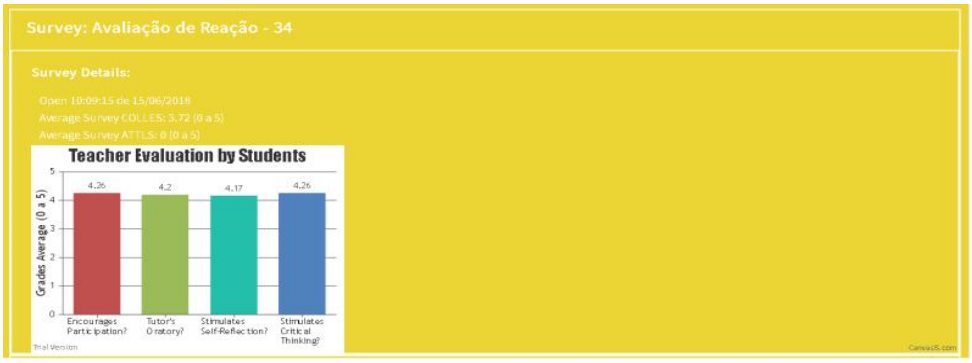


Source: Elaborated by the authors.

The logs feature presents, in detail, each teacher action within the course. All students' steps are recorded by Moodle, and this makes it possible to monitor, in a chrono-logical way, the actions of teachers in the system. From the data of logs the Time Management report was created, which is clearly linked to the time management characteristic of the framework of teaching attributes. The figure 4 shows the total time that the teacher remained active in Moodle and graphically shows the time spent for the course, daily.

In order to check the teachers' alignment regarding the andragogical assumptions, the Surveys and Feedbacks submodules were created, which are responsible for presenting the teacher and course evaluation, carried out by the students. The Surveys are questionnaires, predefined by Moodle, which asks students a series of questions about the teacher's behavior in the course under evaluation. Feedback questionnaires are created by teachers, and generally address topics about the quality of courses and teaching. The figure 5 shows the general average of the evaluations that students made regarding the teacher and the way the course is conducted by the teacher.

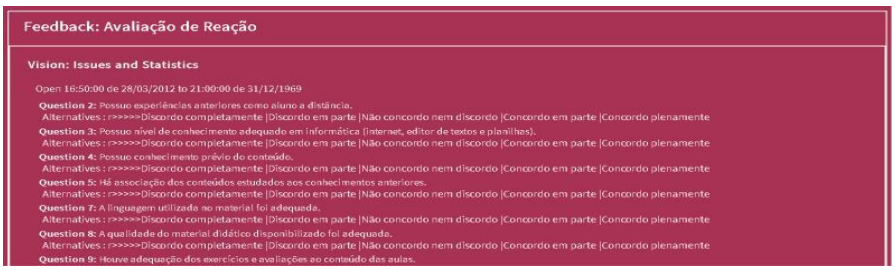
Figure 5. Survey: Teacher Evaluation



Source: Elaborated by the authors.

The average grades presented in Figure 5 allow to evaluate the andragogical at-tributes self-direction, experience, motivation and applicability, desirable in adult education. Self-directivity can be assessed by teacher's stimulus to participation, self-reflection and critical thinking. In order to assess the value of the students 'previous knowledge, the average of the students' grades was calculated: The course content interests me? Motivation was measured from the following question: Does the teacher encourage my participation? The contents of the activities and evaluations, as provided by Andragogia, should privilege issues that reflect on the students' professional activities. To assess this criterion we use the notes for the question: Is what I am learning important for my professional activities?

Figure 6. Feedback Questionnaire.



Source: Elaborated by the authors.

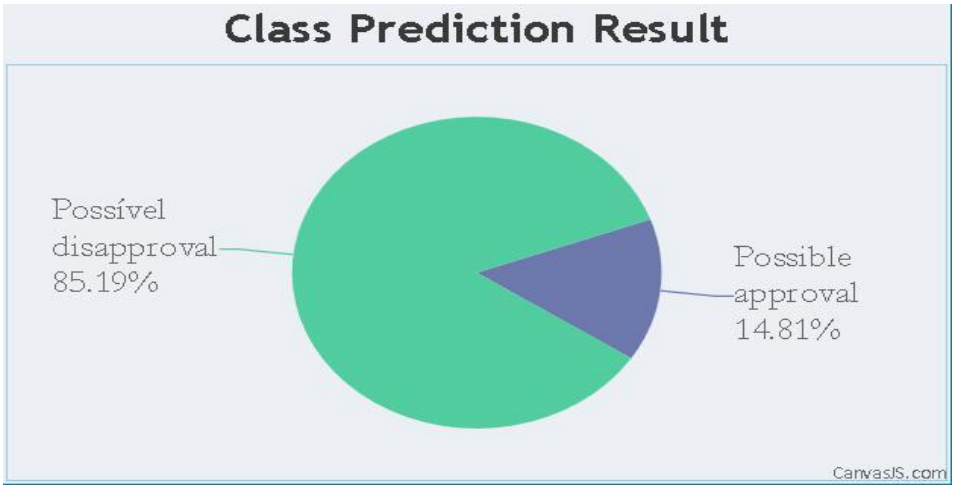
The figure 6 shows an excerpt from a feedback questionnaire created by the teacher, in order to obtain information that can improve the quality of the course, in general. The independent character of these

questionnaires makes generalized analyzes difficult, how-ever, it shows the teacher's complicity with the quality of the course and with the exchange of experience and expectations between students and teacher.

5.2. The Prediction Module

The MP extension is a web tool developed based on the client-server architecture. The figure 1 shows the architecture and communication flow of the MP extension. To use the WEKA algorithm library, the prediction module was developed as a desktop tool. To allow communication, between the visualization and prediction modules, a web service was developed to provide the prediction service.

Figure 7. Prediction Visualization in the Course Context.

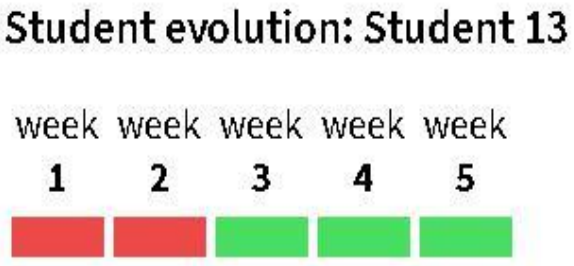


Source: Elaborated by the authors.

5.2.1 Students Prediction

The prediction of success or failure of students can be viewed from two perspectives: the course and the students. In the context of the course the prediction is computed from the percentage, total, of students classified as pass and fail, the proportions of each class of students are displayed on a sector chart. Each sector represents the percentage of each class and the union of the sectors represents the total number of students in the class. The figure 7 shows how the results of the students' performance prediction are presented to users.

Figure 8. Visualization of Prediction in the Student Context.



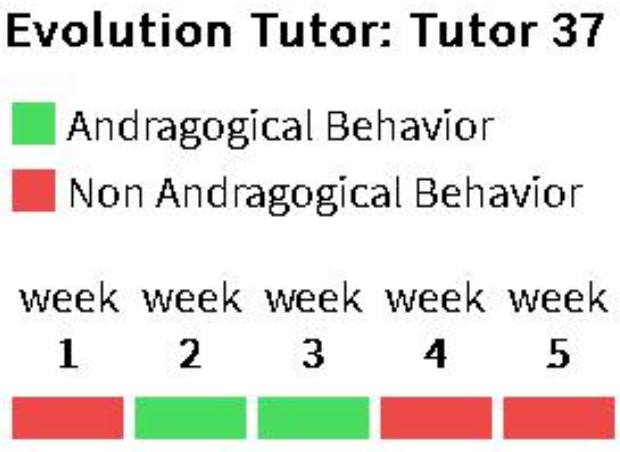
Source: Elaborated by the authors.

From the students' point of view the prediction is presented in the form of the student's evolution during the weeks of the course. The figure 8 shows the student's behavioral trajectory over the course of 5 weeks. The red rectangles signal the weeks when the student's performance compares to the performance of previous students who failed. The green colored rectangles synthesize the information that in the respective weeks the students had satisfactory school performance and consistent with the behavior of students who passed the courses.

5.2.2 Teachers' Prediction

The behavioral prediction of the teachers was performed with the implementation of the averaging algorithm, the data of the teachers are then sent as an input parameter to the algorithm, after execution, the algorithm returns the teacher's classification as: "Andragogical" or "Non Andragogical".

Figure 9. Visualization of Teacher Classification.



Source: Elaborated by the authors.

The visualization of the evolution of the teacher's behavior, in relation to the good teaching practices of the framework, during the course is presented graphically according to the teacher's classification obtained in the execution of the averaging algorithm. The figure 9 shows how the teacher's behavioral actions are represented in the MP extension. In the figure 9 it is noted that in three weeks the behavior of the teacher was not consistent with the characteristics present in the framework, and that only for two weeks the teacher demonstrated the desired characteristics for teaching adult students.

Therefore, based on the classification and visualization of data offered by this tool, managers of educational institutions can easily observe the behavior of teachers and propose different approaches to maximize the quality of teaching.

6. Conclusion

The popularization of distance education has stimulated studies on the behavior of students and teachers, with the objective of maximizing students' school performance. Teachers 'skills are fundamental in the

teaching process and consequently in the students' academic achievements. Therefore, in order to guarantee the quality of teaching, distant education managers and teachers must be aligned with the best teaching practices and used to virtual learning environments.

To assist educational managers and teachers to maximize students' school performance, in this research we developed a system for predicting student performance from a framework of characteristics of good teaching practices. To perform the prediction of students' performance, behavioral data from students and teachers were used, stored by Moodle Platform. The data collected by the Moodle educational database were analyzed using EDM techniques. The prediction of approval, or disapproval, of the students and the classification of the teachers, regarding the good teaching practices, were carried out with the application of the main techniques and methods of classification available in the mining of educational data.

The teachers 'characteristics framework was built in this research from the correlation between the main teaching attributes related to the students' good performance and the desired teaching characteristics in youth/adult education. The teaching attributes were listed through a systematic review of the literature about teaching characteristics that can impact students' school performance. The desired teaching characteristics in the teaching of adult students were extracted from the definitions of Andragogy.

To conduct this research, the Moodle database used by EJUG was used. Through a classifier performance analysis, the best classifier for the EJUG data set was selected. The performance metric used to compare the classifiers was the size of the area under the curve (AUC). According to this metric, the best classifier model was generated by the RandomForest algorithm.

In the development of the MP extension, carried out in this work, information on the didactic actions of the teachers in the prediction of the students' performance was included, in addition to implementing the classification of the teachers according to the good teaching practices present in the framework. The teacher's classification was performed by submitting the behavioral data, extracted according to the characteristics present in the framework of teaching attributes, to the averaging algorithm. The prediction of the students 'performance was implemented based on the students' behavioral data together with the data that synthesize the didactic actions of the teachers.

Assisting educational managers and teachers to improve the quality of online teaching was the main objective of this work, based on the assumption that the teachers' behaviors affects students' behaviors, and, consequently, their performance, helping to reduce failure and dropout rates. We provided a teachers' behavioral classification and prediction, according to good teaching practices, adding to the improvement of distance education, especially with regard to the student-teacher relationships and course management. Based on the results of our research, it is possible to make evidence-based academic, managerial and administrative decisions in distant education. For this reason, the present work contributes to the development and improvement of tools and techniques for distance courses management.

7. References

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