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## About the Journal

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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-5, ISSUE-9 of IJIER*** which is scheduled to be published on **30th September 2016.**

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,**

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# Table of content

# Undergraduate performance assessment: Attitudes towards and acceptance of OSCEs among 4th year medical students

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## Abstract

***Introduction:*** *Objective Structured Clinical Examination (OSCE) is considered a useful method of assessing clinical skills besides Multiple Choice Questions (MCQs) and clinical evaluations.*

*Aim: To explore the acceptance of medical students to this assessment tool in medical education and to determine whether the assessment results of MCQs and faculty clinical evaluations agree with the respective OSCE scores of 4th year medical students (Med IV).*

***Methods:*** *performance of a total of 223 Med IV students distributed on academic years 2006-2007, 2007-2008, and 2008-2009 in OSCE, MCQs and faculty evaluations were compared. Out of the total 93 students were asked randomly to fill a questionnaire about their attitudes and acceptance of this tool. The OSCE was conducted every two months for two different groups of medical students who had completed their family medicine rotation, while faculty evaluation based on observation by assessors was submitted on a monthly basis upon the completion of the rotation. The final exam for the family medicine clerkship was performed at the end of the 4thacademic year, and it consisted of MCQs*

***Results:*** *Students highly commended the OSCE as a tool of evaluation by faculty members as it provides a true measure of required clinical skills and communication skills compared to MCQs and faculty evaluation. The study showed a significant positive correlation between the OSCE scores and the clinical evaluation scores while there was no association between the OSCE score and the final exam scores.*

***Conclusion:*** *Student showed high appreciation and acceptance of this type of clinical skills testing. Despite the fact that OSCEs make them more stressed than other modalities of assessment, it remained the preferred one.*

## Introduction

The Objective Structured Clinical Examination (OSCE) is an evaluation tool to assess clinical skills[1]. In a study conducted on medical students, OSCE was not considered an adequate measure of either clinical or technical skills, besides being too “artificial,” and suffers inadequate provision of feedback given with the examination[2,13].

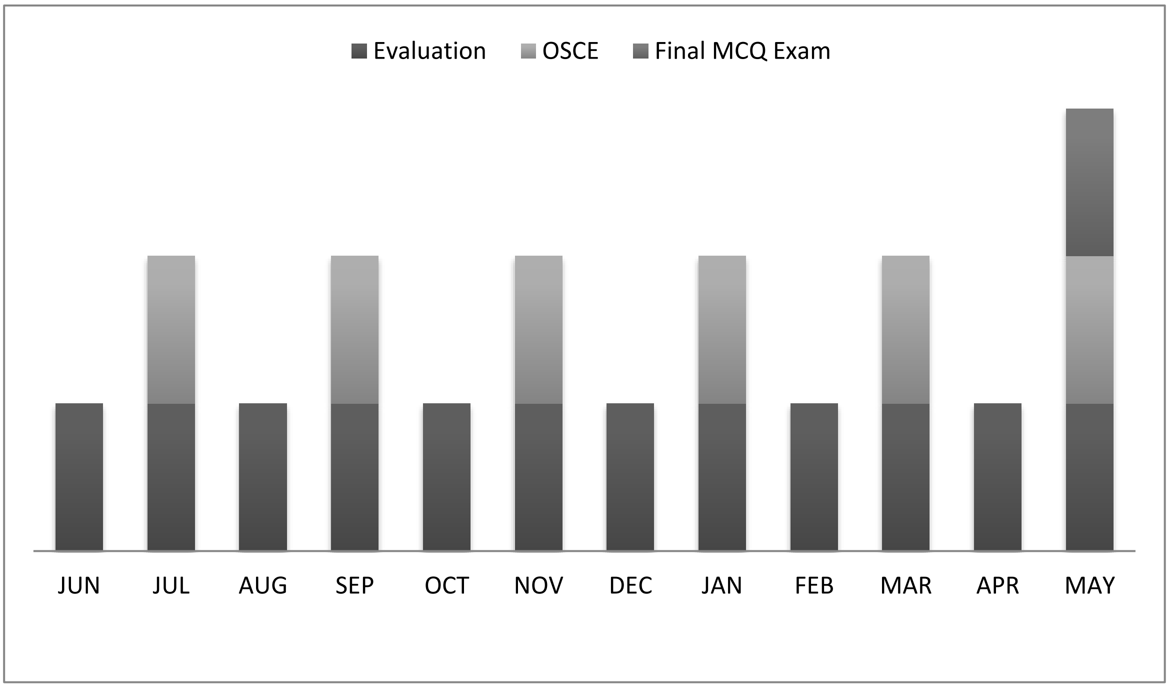
While Multiple Choice Questions (MCQs) focus on the students' knowledge base, they ignore important skills like physical examination skills[3,4,5,6,7]and they do not typically determine clinical behavioral success. On the other hand, faculty evaluations such as directly observed cases, objective structured clinical examinations, and the use of standardized patients are grossly subjective assessment methods that tend to expand student performance and provide inaccurate evaluation of clinical competence including behavioral and cognitive functions[8].

The purpose of this study was to evaluate Med IV students' perception of the OSCE, and determine their acceptance of this tool, by comparing scores of OSCE, MCQs and the faculty clinical evaluation.

## Methods

We retrieved OSCE scores, final exam scores, and faculty clinical evaluations of the MED IV students in the three academic years 2006-2007, 2007-2008, and 2008-2009 in our institution(Figure1). Students rotating in family medicine over a 2- years' period, extending from 2008 to 2009, were asked to fill a questionnaire about their attitudes of this evaluation tool after completing the OSCE.

Figure 1: Distribution of exams and evaluations during one academic year




*The OSCE*

Students completed OSCEs consisting of 9 stations where they perform a practical task related either to history taking or physical examination, in the presence of a different faculty assessors completing a prepared checklist on student's performance. The OSCE was done every 2 months including 2 groups of medical students who have just completed their rotation. Stations included tasks that have been emphasized during the clerkship. OSCE instructions were given by clinical instructor in some stations and by by a videotaped structured clinical exam in others.

*MCQs*

Family Medicine(FM) students had to sit for a final exam at the end of their 4th academic year.

*Faculty assessment*

The students were evaluated during their FM rotation by three teachers(clinicians) on the basis of their presentations and clinical performance including all the questions that the students were expected to tackle in relation to history taking, counseling, physical examination or differential diagnosis. A score of maximum of 5 was awarded on a Likert scale. A mean mark was calculated and multiplied by 20to allow comparison with the data from the OSCE and MCQs.

*Students' attitudes and perception*

Successive groups of students completed a self-administered questionnaire after the OSCE. The questionnaire included 16 items related to acceptance of the test, fairness and usefulness, quality of instructions and organization, quality of performance, scope of evaluation, and level of induced stress compared with other modes of assessment such as MCQs. The Institutional Review Board at the American University of Beirut approved the study.

*Statistical analysis*

We computed descriptive statistics using means and standard deviation as well as range for the three scores. Correlations were assessed between the three scores using Pearson's correlation coefficient. A paired t-test was used to compare mean scores between the three tests, and then stratified the analyses by academic year. Questions about attitudes towards OSCE were summarized using frequency distributions. Results were analyzed using SPSS, considering a p-value of .01 to be significant. This level of significance was chosen to adjust for possible inflation in type one error caused by multiple testing.

## Results

We retrieved data for a total of 223 students distributed on the three consecutive academic years (2006 to 2009). Score were represented in Table1. The mean OSCE score was 66.0±7.1. The mean score for final examination and clinical evaluation were 63.5±7.6 and 77.5±17.1 respectively. The mean OSCE scores was significantly higher ($p < 0.001$) than the mean of the final examination and significantly lower ($p < 0.001$) than that of the clinical evaluation in AY 2007-2008 and 2008-2009. But for AY 2006-2007 there was no significant difference between the means of OSCE and clinical evaluation score. Overall, there was a significant positive correlation ($r=0.21$, $p=0.002$) between the OSCE scores and the clinical evaluation scores but not between the OSCE score and the final exam scores ($r=0.06$, $p=0.372$), and only in AY 2007-2008 OSCE significantly correlated with both clinical evaluation scores and final exam scores.

Table 1: Comparing OSCE, Final Exam and Clinical Evaluation scores

| **Variable** | **AY 2006-2007** | **AY 2007-2008** | **AY 2008-2009** | **All three academic years** |
|---|---|---|---|---|
| | mean (sd) | mean (sd) | mean (sd) | mean (sd) [Range] |
| **OSCE** | 62.9 (7.9)[a] | 67.1 (7.2)[a] | 67.8 (4.9)[a] | 66.0 (7.1)[a] [40-87] |
| **Final Exam** | 67.0 (7.1)[b] | 59.9 (6.9)[b] | 63.9 (7.0)[b] | 63.5 (7.6)[b] [40-84] |
| **Clinical Evaluation** | 67.3 (24.9)[a,b] | 81.6 (7.6)[c] | 82.9 (9.3)[c] | 77.5 (17.1)[c] [30-100] |
| | r (p-value) | r (p-value) | r (p-value) | r (p-value) |
| **Correlation between OSCE and Final Exam scores** | 0.03 (0.814) | 0.37 (0.001)* | 0.10 (0.401) | 0.06 (0.372) |
| **Correlation between OSCE and Clinical Evaluation scores** | 0.07 (0.568) | 0.37 (0.001)* | -0.02 (0.845) | 0.21 (0.002)* |

*significant at the 1% level a,b,c different letters indicate significant differences in the means (within a column)

A total of 93 students randomly picked from the academic years took the attitudes towards OSCE questionnaire. Almost all of the students at least agreed that OSCE tests different skills than formal assessment methods (91.4%). Results showing percentages of agreement or disagreement to each part of the questionnaire are shown in table2.

Table 2: Students Attitudes towards OSCE

| Questions | SD | D | N | A | SA | NA |
|---|---|---|---|---|---|---|
| Tests different skills than formal assessment methods | 0 (0.0%) | 1 (1.1%) | 5 (5.4%) | 47 (50.5%) | 38 (40.9%) | 2 (2.2%) |
| | 1.1% | | 5.4% | 91.1% | | 2.2% |
| Scores provide true measure of essential clinical skills | 0 (0.0%) | 5 (5.4%) | 17 (18.3%) | 49 (52.7%) | 21 (22.6%) | 1 (1.1%) |
| | 5.4% | | 18.3% | 75.3% | | 1.1% |
| Scores provide true measure of communication skills | 0 (0.0%) | 7 (7.5%) | 13 (14.0%) | 49 (52.7%) | 21 (22.6%) | 3 (3.2%) |
| | 7.5% | | 14.0% | 75.3% | | 302% |
| Scores are standardized | 1 (1.1%) | 4 (4.3%) | 18 (19.4%) | 52 (55.9%) | 16 (17.2%) | 2 (2.2%) |
| | 5.4% | | 19.4% | 73.1% | | 2.2% |
| Medical students should continue taking OSCE | 0 (0.0%) | 0 (0.0%) | 3 (3.2%) | 43 (46.2%) | 47 (50.5%) | 0 (0.0%) |
| | 0.0% | | 3.2% | 96.7% | | 0.0% |
| Should be included in other | 0 | 1 | 4 (4.3%) | 39 | 49 | 0 (0.0%) |

| | | | | | | |
|---|---|---|---|---|---|---|
| clerkships | (0.0%) | (1.1%) | | (41.9%) | (52.7%) | |
| | 1.1% | | 4.3% | 94.6% | | 0.0% |
| Received enough information about the exam prior to taking it | 5 (5.4%) | 19 (20.4%) | 14 (15.1%) | 43 (46.2%) | 12 (12.9%) | 0 (0.0%) |
| | 25.8% | | 15.1% | 59.1% | | 0.0% |
| Relevant to the course | 1 (1.1%) | 7 (7.5%) | 12 (12.9%) | 53 (57.0%) | 20 (21.5%) | 0 (0.0%) |
| | 8.6% | | 12.9% | 78.5% | | 0.0% |
| Cases simulate real life scenarios | 0 (0.0%) | 1 (1.1%) | 6 (6.5%) | 54 (58.1%) | 32 (34.4%) | 0 (0.0%) |
| | 1.1% | | 6.5% | 92.5% | | 0.0% |
| Number of stations is suitable | 0 (0.0%) | 3 (3.2%) | 6 (6.5%) | 57 (61.3%) | 27 (29.0%) | 0 (0.0%) |
| | 3.2% | | 6.5% | 90.3% | | 0.0% |
| Time available for each station is enough | 2 (2.2%) | 9 (9.7%) | 16 (17.2%) | 47 (50.5%) | 19 (20.4%) | 0 (0.0%) |
| | 11.9% | | 17.2% | 70.9% | | 0.0% |
| All tasks/questions are clear | 2 (2.2%) | 6 (6.5%) | 18 (19.4%) | 47 (50.5%) | 20 (21.5%) | 0 (0.0%) |
| | 8.7% | | 19.4% | 72% | | 0.0% |
| Interference by staff members during the exam has a negative impact | 12 (12.9%) | 48 (51.6%) | 18 (19.4%) | 13 (14.0%) | 2 (2.2%) | 0 (0.0%) |
| | 64.5% | | 19.4% | 16.2% | | 0.0% |
| Videotaped structured clinical exam would be less stressful than the presence of a faculty member | 7 (7.5%) | 25 (26.9%) | 27(29.0%) | 23 (24.7%) | 11 (11.8%) | 0 (0.0%) |
| | 34.4% | | 29.0% | 36.5% | | 0.0% |
| More stressful than MCQs | 2 (2.2%) | 12 (12.9%) | 17 (18.3%) | 47 (50.5%) | 15 (16.1%) | 0 (0.0%) |
| | 15.1% | | 18.3% | 66.6% | | 0.0% |
| Simulated patients are equally adequate as true patients | 6 (6.5%) | 19 (20.4%) | 25 (26.9%) | 34 (36.6%) | 9 (9.7%) | 0 (0.0%) |
| | 26.9% | | 26.9% | 46.3% | | 0.0% |

SD=Strongly Disagree, D=Disagree, N=Neutral, A=Agree, SA=Strongly Agree, and NA=No Answer

## Discussion

The results revealed no clear association between performance on MCQs examinations and performance on the OSCEs (r=0.06, p=0.372), but an correlation between the scores was present for the faculty evaluation (OSCE and Clinical evaluation r=0.21, p=0.002).

Students displayed a positive attitude towards the OSCE and appreciated this type of clinical appraisal compared to MCQs and clinical Evaluation. This is similar to a German study showing the positive effect of OSCE on the medical and dental students learning behaviour.[2,9]

Our study showed that 66.6% of students found the OSCE to be more stressful than MCQs, while it was 50% in another study.[10]Despite the stressful experience, 75.3% agreed that OSCE provides true measure for essential clinical skills such as performing a practical task including history taking or physical examination from directly observed cases. In the current study 25% of students felt they were not prepared and this may have accounted for the high stress encountered as reported in other studies[11].

Even though students were split about whether videotaped structured clinical exam would be less stressful than the presence of a faculty member, Sturpe et al showed that these observation methods were not interchangeable, and important differences in OSCE pass/fail determinations were found between real-time and video observations depending on the score they get from the completed checklist by the assessor [12].

Students evaluated by faculty had higher averages as compared to their OSCEs. Besides being inherently subjective[13], having 3 faculty assessors for each student would definitely better measure students' performances[14]. Both OSCE and faculty evaluations assess some common dimensions of clinical and social skills and this explains the agreement.

Similar to our study, a study from Saudi Arabia revealed a significant correlation between scores and results in OSCE and in all other forms of psychiatry examinations, except for the MCQ marks.[15]

The positive associations in the Year 2007-2008 may be attributed to differences in the questions administered in the MCQs, calibrations of the evaluators, and the degree where the examination focuses on clinical skills versus critical thinking skills. Further studies are needed to validate this aspect.

The OSCE and final exam were not done at the same time. The effect of this difference might have been diluted by the nature of OSCE which tests cognitive behavioral skills[16], and the fact that students were familiar with this type of assessment. The final exam assessed another dimension in the time framework needed for it.

## Conclusion

The findings highlighted the attitudes of student's towards OSCE that were in favor of this tool. It was perceived to be transparent, authentic and valid. Despite the fact that OSCEs make them more stressed than other modalities of assessment, it remained the preferred one. Traditional medical curricula must be responsive to global paradigm shifts in undergraduate medical education.

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# Engineering Curriculum Design - Understanding motivational variables and their influence on self-directed learners when using 1:1 mobile devices.

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## Abstract

*Engineering curriculum design and delivery within the framework of budget restraints, learning outcome policies and industry standards, is a complex task that understandably universities and the engineering industry invest significant resources. It would be expected that what is actually occurring within the engineering learning space is a reflection of the constraints upon the industry, producing graduates, and products and services that provide a return on investment through intellectual capital. Firstly, the literature review will contextualise and explain the engineering student's motivational variables to actively engage in their learning spaces, and how this may be applied by curriculum designers to improve the quality and delivery of courses. In particular, what are the intrinsic and extrinsic motivational variables and associated values that student's desire during their engineering learning experience. Secondly, the research study will explore how motivational theory can be applied to the stages of 'active learning' when integrating 1:1 mobile devices for engineering learning. 1:1 mobile devices include iPad, mobile phones, Surface Tablets or handheld Wi-Fi or Internet accessible device used for learning purposes. It is not fully understood how to influence 'active learning using existing teaching and learning strategies. How to influence an engineering undergraduate student to prioritise the use of 1:1 mobile devices as a means to source prescribed and unprescribed curriculum resources to improve learning outcomes. Is it unreasonable to expect engineering students to be constrained to the learning resources supplied by the engineering course facilitated, or should engineering students be encouraged to use their own initiative and find their own supporting information?*

**Keywords:** 1:1 mobile device, Engineering education, learners, active learning, self-regulated

## 1.0 Introduction

*'The most important attitude that can be formed is that of desire to go on learning.'*
John Dewey – (Dewey, 1963)

Engineering curriculum design and delivery within the framework of budget restraints, learning outcome policies and industry standards, is a complex task that understandably universities and the engineering industry invest significant resources. It would be expected that what is actually occurring within the engineering learning space is a reflection of the constraints upon the industry, producing graduates, and products and services that provide a return on investment through intellectual capital. Firstly, the literature review will contextualise and explain the engineering student's motivational variables to actively engage in their learning spaces, and how this may be applied by curriculum designers to improve the quality and delivery of courses. In particular, what are the intrinsic and extrinsic motivational variables and associated values that student's desire during their engineering learning experience. Secondly, the research study will explore how historical motivational theory can be applied to understand the stages of 'active learning' when integrating 1:1 mobile devices for engineering learning. 1:1 mobile devices include iPad, mobile phones, Surface Tablets or similar handheld Wi-Fi or Internet accessible device used for learning purposes. It is not fully understood how to influence 'active learning using existing teaching and learning strategies. How to influence an engineering undergraduate student to prioritise the use of 1:1 mobile devices as a means to source prescribed and unprescribed curriculum resources to improve learning outcomes. Is it unreasonable to expect engineering students to be constrained to the learning resources supplied by the engineering course facilitated, or should engineering students be encouraged to use their own initiative and find their own supporting information?

This research study is within the theoretical framework of 'self-regulated learning' and 'Active Learning' principles. In this study, academic views are presented from the literature to contextualise motivational theories during a time when mobile technologies did not exist and contrast these with current developments to highlight learning motivations influencing the use of 1:1 mobile devices.

## 2.0 Methodology

In consultation with the research authors, a library search protocol was developed prior to the literature search commencing. A mixed search strategy via accessing electronic databases and drawing on library held hard copy resources was undertaken between 2016-17. The following electronic resources were accessed in the literature search:

- EBSCO (http://search.ebscohost.com/),
- IEEE Digital Library (http://ieeexplore.ieee.org/), and
- Google Scholar (http://scholar.google.co.uk/).

Keywords were used to facilitated searches: active learning, self-regulated learning, learning motivation, learning theory, mobile technology, tablet, iPad; 1:1 mobile device, instruction, instructional, learning, and engineering learning. Studies were included in the literature review if they were peer reviewed and contributed to explaining the historical development of learning theories to contextualize or explain the emergence and motivation of learners' use of mobile technology (e.g., WiFi accessible mobile devices such as iPhones, iPads and Android mobile devices); and were written in English. Studies were excluded

if they were not reporting on adult learning behaviour, or could not demonstrate empirical evidence.
The guiding questions for the literature review included:

1. How does the learning process use 1:1 mobile devices to support ‘surface and deep’ learning?
2. How can ‘intrinsic and extrinsic’ values be developed in engineering students as thinking while using 1:1 mobile devices for active learning?
3. Can an engineering curriculum design influence the way an engineering course is designed to cater for students who have already adopted the use of 1:1 mobile devices to improve their learning outcomes and assessment results?
4. How can 1:1 mobile devices support students during problem solving activities and produce innovative results (intellectual capital)?
5. How can mobile devices assist engineering students to manage the learning process by organising modules of information that will lead to higher learning and problem solving skills?

The literature review was narrowed to sixty-three research studies from a total of 228 potential database or library sources, which were then categorised pre (1976-2008) and post (2009- 2017). As mobile technology became apparent in educational settings for learning, it became apparent further research would be needed. The following discussion includes the learning motivation theories and empirical studies that historically contextualise and attempt to understand the motivational variables and their influence on self-directed learners when using 1:1 mobile devices. This literature review is limited to acknowledging that early learning motivational theorist and empirical studies were reporting without the knowledge of the future influence mobile technology would have on learning, and the suppositions about the influence of mobile technology on learners’ motivations are limited to the interpretation of the authors.

## 3.0 Self-regulated and Active Learning

There is diversity of academic thinking around what constitutes student ‘self-regulated’ or ‘active’ learning and learners can be influenced to improve teaching and learning outcomes. However, further research is required to understand how ‘active learning’ principles can be applied to the use of 1:1 mobile devices for learning within engineering learning spaces.

Inter-disciplinary teaching and learning can be broadly categorised into (1) cognitive psychology, (2) motivation psychology, and (3) educational sciences (Gijbels, et al. (2014). The following research traditions have been identified from the literature, including;

(1) Deep or Surface Learning (Marton and Saljo, 1976, 1997) – where students who adopted a 'deep' learning approach’ began with an intention to understand meaning from texts, could question an author's arguments, and relate them to past knowledge and personal experience. In contrast, ‘surface’ learning occurs when students began with an intention of memorizing facts, however, without understanding its context;

(2) Learning conceptions or beliefs about learning and teaching (Saljo, 1979),

(3) Learning Styles. (Kolb, 1984);
(4) Metacognition variables of learning (Flavell, 1987);
(5) Biggs (1987, 1979 and 2003) categorized learning as 'utilizing, internalizing and achieving' study orientations. Entwistle and McCune (2004), focused on learner motivations and processing strategies via a study 'orientations' instrument tilted,'The Approaches to Studying Inventory (ASI)'; a categorization of student responses as either 'deep, surface and strategic' (Entwistle, N., 1988).
(6) Motivational aspects (Entwistle, 1988) (Boekaerts, 2006);
(7) Cognitive aspects of learning (Sadler-Smith, 1996), (Moskvina and Kozhevnikov, 2011);
(8) Aspects of self-regulation towards learning (Boekaerts, 1997);
(9) Vermunt and Vermetten (2004) used the term 'Learning patterns' to describe students' habitual ways of learning, how students cognitively process information and the metacognitive, motivational, and affective strategies applied;
(10) Study Orientations (Nieminen et al., 2004); (Richardson (1997), and
(11) Intellectual Styles. (Zhang and Sternberg, 2005);
(12) Mayer, et al. (2010) argue the 'quality' of a student could be determined by their ability to use cognitive operations to organise and review meaningful learning into packets of knowledge to support higher cognitive learning.

Post the year, 2009, with the advancement of technology, the engineering education literature has considered 1:1 mobile devices as primarily a communications tool, or as a means to access online information, however, not as a learning and motivation tool to facilitate higher order thinking. This presents a unique opportunity for the engineering educational sector to discuss the validity of curriculum design that supports engineering students' use of 1:1 mobile devices within engineering learning spaces.

## 4.0 Student approaches towards learning

Traditionally, how a student approaches their learning is viewed as being influenced by factors within the learning environment, students' perceptions of these factors and student characteristics (see Figure 1 – General Model of the Student Approaches to Learning).

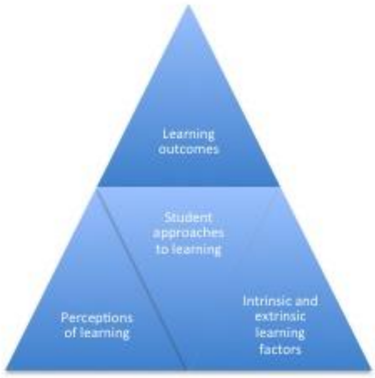


Figure 1 – General Model of the Student Approaches to Learning.
Gijbels, D., Donche, V., Richardson, T., and Vermunt, J., (2014) - Learning Patterns in Higher Education- Dimensions and research perspectives. Routledge – Taylor and Francis Group London and New York. p.28

However, a generalist theoretical view does not explain what is occurring in a student's thought processes during formal and informal learning. Schunk (1986) argues that students are active in cognitive processes while completing learning activities, and therefore curriculum design needs to ensure problem-solving is occurring rather than relying on direct instructional models of learning. Performance and development criteria for engineering curriculum delivery will need to show how the learning sequence will motivate and achieve higher order thinking amongst engineering students when active learning is applied while using 1:1 mobile devices technologies.

**7**

## 5.0 What is self-regulated and active learning?

Schunk and Zimmerman (2008) define self-regulated learning as a process by which learners personally activate and sustain cognitions, affects, and behaviours that are systematically orientated towards the attainment of learning goals. In contrast, 'Active Learning' is a broad term to describe students who are engaged in learning activities in the engineering learning space (Koch et al., 2014). Problem and project-based learning are specific forms of active learning where a problem is the starting point of interdisciplinary, student-centred learning in groups (De Graff, and Kolmos, 2003). The benefits of active learning allow students to develop skills including teamwork, collaboration and conflict management, problem-solving skills, self-regulation skills and professional skills (Palmer and Hall, 2011). To achieve active learning, students need to be supported with a curriculum design and the technology tools (1:1 mobile device) to instil confidence to develop higher order thinking skills. The discipline of studying students' 'Self-regulated Learning (SRL)' came from research showing that learner' skills and abilities did not fully explain student achievement, but maybe influenced by self-regulation and motivational factors (Schunk and Zimmerman, 2008).

Early self-regulation research in education focused on cognitive strategies and behaviours, such as monitoring, organizing, rehearsing, managing time, and establishing a productive work environment. However, the roles of personal goals linked to a student's future (reactive outcome measures including academic grades or standardized test performance and proactive measures, such as goal setting and choice of learning strategies), attributions, self-efficacy, outcome expectations, self-concept, self-esteem, social comparisons, emotions, values, and self-evaluations are now routinely considered (Schunk and Zimmerman, 2008).

> *'Self-regulation refers to the process, internal and/or transactional, that enable an individual to guide goal-directed activities over time and across changing circumstances (contexts). Regulation implies modulation of thought, affect, behavior, or attentive via deliberate or automated use of specific mechanisms and supportive meta-skills. The processes of self-regulation are initiated when routinized activity is impeded or when goal-directedness is otherwise made salient (e.g. the appearance of a challenge, the failure of habitual action patterns – (Karoly, 1993).'*

Zimmerman (2001) states self-regulated learning theories assume that students can (a) personally improve their ability to learn through selective use of metacognitive and motivational strategies; (b) proactively select, structure, and create advantageous learning environments; and (c) play a significant role in choosing the form and amount of instruction they need. For engineering curriculum designers and educators, this implies the importance to place a priority on student learning motivations, as a matrix of considerations when designing and an engineering curriculum. Also, it may imply that priority should be given to enable engineering students to chose their own technologies such as 1:1 mobile devices to support them within their engineering learning spaces.

## 6.0 Self-regulation motivational variables

Self-regulated motivational variables are explained as thought processes an engineering learner uses during active learning. Zimmerman and Risemberg, (1997) conducted research using a fourteen (14) self-regulation learning strategy inventory to guide research around student trends in student motivations. The inventory included the following variables;

1. Self-evaluation
2.Organizing and transforming (rearranging and restructuring instructional materials)
3. Goal setting and planning
4. Seeking information (from non-social sources such as a book)
5. Keeping records and monitoring
6. Environmental restructuring (rearranging the physical setting to make learning easier.)
7. Self-consequating (arranging for rewards or punishment for success or failure)
8. Rehearsing and memorizing.
9 to 11. Seeking assistance from peers, teachers, and adults.
12 to 14. Reviewing test, notes and texts.

Schunk and Zimmerman (2008) identified cognitive, affective, and behavioural processes that influence students to ‘activate and sustain’ self-regulated learning (Boekaerts, Pintrich and Zeidner, 2000). Note, this early research did not consider the benefits of using 1:1 mobile devices as a motivational tool.

Keppell et al. (2006) argue peer learning, sharing ideas, interacting to encourage interdependence motivates students to interact beyond the learning space, which provides opportunities for ‘deep learning’ and improved academic performance. Peer learning extends to using social media APPS (Facebook, Twitter, Messaging services, shared learning spaces like Blackboard, Edmodo, Desire) on their 1:1 mobile device, where students can interact using messaging services, access and create online quiz and tests and use and create expert peer discussion groups to encourage curiosity, sharing of resources and ideas, and encourage critical thinking and problem solving skills (Tlhoaele, M., Suhre, C., and Hofman, A., (2016). Is it possible to consider in the near future a trend where traditional learning spaces will become virtual reality spaces as an integrated platform for learning (e.g. Second-Life). It would seem innately logical to realise the importance of 1:1 mobile devices as an unexplored learning space and motivational tool for learning that needs to be ‘normalised’ as an essential component of any engineering curriculum design?

## 7.0 Structured v’s unstructured classroom learning

Challenging the notion of what constitutes a learning space is critical to understanding what challenges and motivates engineering students to become higher order thinkers and innovators within the discipline of engineering and more broadly. Schunk and Zimmerman (2008) argue that within a controlled classroom environment, students could be influenced by the teacher to recognise their poor self-regulation and replace this with effective learning goals and strategies, to encourage self-monitoring and self-assessment of an individual student’s progress. Replacing these with attributes of a productive learning environment including been encouraged to seek assistance and to be encouraged to demonstrate flexibility, by redefining their current goals and or set with new ones (Boekaert and Niemivirta, 2000).

Schunk and Zimmerman (2008) acknowledged that where a less-structured environment existed, it could not achieve the same learning cognitive, affective, and behavioural processes, and hence, the researchers recognised there must be other underlying unidentified student self-perceptions influencing student motivation to engage with their learning; such as goal orientation, personal competence causality regarding personal outcomes (attributions) Whilst, self-monitoring is a cognitive process, where a student remains motivationally inattentive to feedback, this monitoring is unlikely to be sustained and/or enhance learning outcomes. (Boekaerts and Niemivirt, 2000). This observation implies that when integrating 1:1 mobile devices for student learning as an integral tool within a curriculum design, it will require monitoring of its use with the learning space.

Locke and Latham, (2002) found students who are highly motivated and who are given the opportunity to choose their own learning tasks linked to higher order thinking goals, are more likely to show a greater perseverance to complete the set task successfully. For example, a student who is motivated towards a career in maths, practises in their spare time to gain mastery of the maths language and regularly receives positive feedback from maths tests, is more likely to experience success than a less motivated student who has no interest in the subject but has the ability (Schunk and Hanson, 1985). A second example, research shows that self-regulatory reading strategies can be mastered with practise, however, a passive reader will not willingly engage with the reading interventions and therefore, not achieve the expected learning outcomes compared to others (Schunk and Pajare, 2005). In contrast, a student who is encouraged by the curriculum design to actively use a 1:1 mobile device for learning purposes, may derive an educational advantage over a student who uses the same device to socialise and listen to music, may be distracted from engaging with the learning within the same learning space.

## 8.0 What is motivational conflict?

Imagine an active and vibrant learning space where engineering students are encouraged to bring and use a 1:1 mobile device, to collaboratively identify a real-world problem, research background information, discover possible solutions, link up with experts online and demonstrate higher order thinking skills, however, half of the class could not afford a 1:1 mobile device and was unmotivated to use technology. Whilst, the intention of the curriculum design had facilitated learning by using 1:1 mobile devices, a conflict has arisen between the curriculum design for learning and student motivations within a self-regulatory process. Instead half of the class are inactive, creating a need for the educator to run alternative activities to appeal and motivate students who have formed a perception that aspects of the learning are boring and repetitive (Schunk and Zimmerman, 2008).

Similar concern has been expressed about using tangible rewards or prizes to motivate student learning, where, if the reward is insufficient (infrequent, or too frequently given) then the student may become unwilling to engage in the task (Figure 2 – Freyer and Elliot, 2008) - Achievement Goal Endorsement) (Deci and Ryan, 1987). Where autonomy is allowed for student to pick their own task, ‘Cherry picking’ may occur where students choose ‘superficially fun’ activities (playing strategy games on a 1:1 mobile device during learning time) but do not develop important depth of understanding to demonstrate expected competencies (Schunk and Zimmerman, 2008).


Figure 2 – Achievement Goal Endorsement – Ref. Freyer, J., and Elliot, A., (2008) – Stability and change in achievement goals. Journal of Educational Psychology. In, Schunk, D., and Zimmerman, B. (2008) - Motivation ad self-regulated learning – Theory, research and applications. Taylor and Francis Group LLC. p. 60

Elliot and Harackiewicz (1996) described those students who are either 'approach-performance' or 'avoidance-performance'. Students who are performance goal orientated will try to outperform other students and demonstrate in a public way competence and superiority, whereas, the 'avoidance-performers' will set themselves the goal of avoiding failure by looking incompetent. Unintentionally, engineering students with a spectrum of undiagnosed autism and/or other known learning disability may be at higher risk of performance issues. Vlachou and Drigas (2017) stated an autistic student can appear to be closed off in their own world, a world in which normal social skills are impaired, and is resistant to collaborative external interaction and communication. Werry and Dautenhahn (1999) states an autistic person does not attempt to get attention unless it is to fulfill a need, which would therefore need to be provided by another person. In particular, where the curriculum design is intentionally encouraging students to use 1:1 mobile devices for collaborative learning, the device can become a source of 'escapism' from realising personal responsibility for their own learning.

## 9.0 Setting motivational learning goals

1:1 mobile device can be a motivator for learning, however, a clear discussion about how and when the device is to be used is essential. Midgley, Kaplan, and Middleton (2001) states that students with a learning approach that is goal orientated, report more self-monitoring and more use of deep processing strategies during learning than students with a learning-avoidance goal orientation (Pintrich and De Groot, 1990).

Vygotsky (1978) states goals must be meaningful, personalized and specific to the individual; activities that are within the individual's Zone of Proximal Development (ZPD). Students who can personalize their learning goals are more likely to develop intrinsic values towards been self-motivated and sustain this over time. This means that to sustain student motivation when using 1:1 mobile devices for learning, engineering educators need to model how to set personalized learning goals and provide regular feedback to demonstrate to students how to effectively use their 1:1 mobile device for learning and set a 1:1 mobile device personal learning goal.

Schunk and Zimmerman (2008) in Figure 3 – attempts to contextualize Vygotsky (1978) ZPD as Self-Entity verses Incremental motivational variables. This attempts to explain how students see themselves within the learning space.

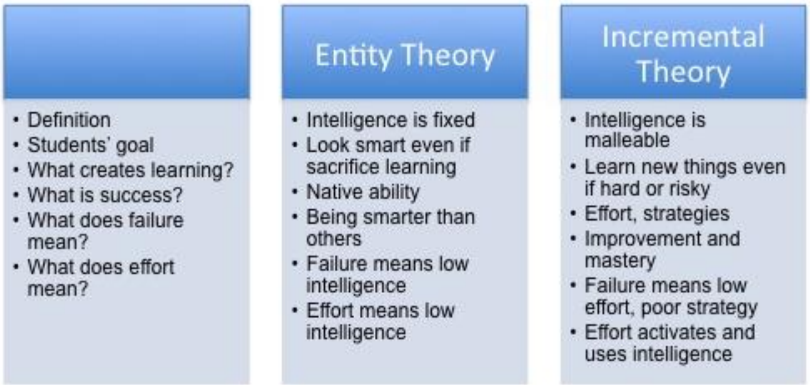


Figure 3 – Self-Theories – Entity Theory v's Incremental Theory]
(Ref: Schunk, D., and Zimmerman, B. (2008) - Motivation and self-regulated learning – Theory, research and applications. Taylor and Francis Group LLC. p. 33)

Using a 1:1 mobile device can be perceived as an extrinsic reward. Kamil et all (2008) argue providing extrinsic rewards to students may increase students' initial motivation to participate and explore the world. Earning tangible rewards, such as toys, food, and prizes, and avoiding punishments were found to have more detrimental effects than receiving verbal rewards. Kamil et al. (2008) argue verbal rewards or praises for student educational performance can be categorized by focus: ability or effort. Praising students for being smart, fast, or knowledgeable can lead to students' perception that their achievement is an indicator of their intelligence or ability. Kamil et al (2008) states students who have an ego-centric view are likely to develop performance goals for example, the goal of achieving good grades. When faced with failure, students with performance goals might infer that they do not have the required ability and seek only those opportunities that make them look smart. On the other hand, students praised for their effort might view ability as an expandable entity that depends on their effort. These students are likely to develop learning goals for example, the goal of enjoying explorations and challenges or acquiring new skills and knowledge. They might interpret failure as an indicator of their lack of effort rather than lack of ability.

Kamil et al. (2008) argues that when an educator leader stresses performance outcomes, students develop performance goals. Likewise, when an educator puts more emphasis on the learning process and provide a supportive environment where mistakes are viewed as growth opportunities instead of failures, students are more likely to develop learning goals. Students who have learning goals are more motivated and engaged and have better test scores than students who have performance goals (Kamil et al., 2008). Setting an expectation for engineering students to use 1:1 mobile devices to set, access and monitor personal performance goals is a way to enable students to achieve personal growth. Learning goals can be set weekly to align with the engineering curriculum design, and provide intervals for feedback to be monitored and accessible via the 1:1 mobile device learning space.

## 10.0 Engineering career motivational factors

Personal career goals are a key motivator for students and 1:1 mobile devices can be used to encourage students to source career information and monitor employment trends. Bandurra (1997) states students' career expectancies are linked to course choices. A student who is highly motivated with a high self-efficacious about their maths and writing skills may not seek a higher education because of its high cost and the low perceived benefits on graduating with a degree that will not return an appropriate career path or financial reward. Ensuring appropriate career information is freely available will minimise post-dissonance following a course enrolment decision. Encouraging students to regularly update the careers goals will motivate students to persevere in the chosen course, minimising perceptions of personal failure.

Setting individual performance goal orientations as a supportive self-directed learning strategy fosters positive judgements of personal competence, and this leads to self-sustained motivation towards learning. Schunk and Zimmerman (2008) acknowledge the challenge for educators is to promote a culture of self-improvement rather than favourable social comparisons with others. Integrating career pathway information, off-site industry visits and/or guest speakers from relevant engineering industry groups may support intrinsic values and sustained learning motivation.

## 11.0 Social orientation supports motivation

Newman (1990) states, students who rely on a social context for their self-directed learning strategies are dependent on their level of self-efficacy. The decision to seek help can be daunting for a student because such requests can lead to increased anxiety, a feeling of rejection or ridicule rather than assistance and praise. Newman (1990) suggests students need a high level of self-esteem to admit their limitations to others and it is the responsibility of the educator to provide a supportive environment where students perceive the benefits to seek help outweigh the embarrassment of not seeking help.

At the time, Newman (1990) did not identify 1:1 mobile devices as a tool to support the learning process, particularly to aid communications between lecturers and students in the form of ongoing feedback during informal and formal assessment.

'Incremental learning' occurs where a student accepts responsibility for their learning goals, and seeks out support mechanisms to achieve an outcome. 1:1 mobile devices that are perceived to 'add value' through software tools, become an important partner when undertaking difficult course material and needing to understand cultural differences quickly. Hong et al. (1999) demonstrated that students could be motivated even though there may not be an academic improvement in course outcomes. For example, University of Hong Kong, an elite university who only offered courses and examinations in English, offered to all enrolled students English tutorials with the motivation that it will improve their learning outcomes. The study identified two groups of students; those who valued learning (Incremental learning theory) accepted the offer, and those who had a higher self-entity perspective of their learning (already had a grasp on the language barrier). (See Figure 4 – Schunk, 2008) - Practices that promote an incremental versus Entity Theoretical Approach of Learning). Those with a high self-entity were less likely to enrol in the English tutorials than those students who valued 'incremental learning'. The study implied that students who perceived they had the ability did not need to make any additional effort. 'If you are good at something, you shouldn't have to work hard at it.' However, self-entity motivated students were less likely to seek out learning strategies to improve the learning outcomes on not been successful, rather would consider cheating on future tests to justify their lack of willingness to adopt 'incremental learning' strategies (Hong, et al., 1999).

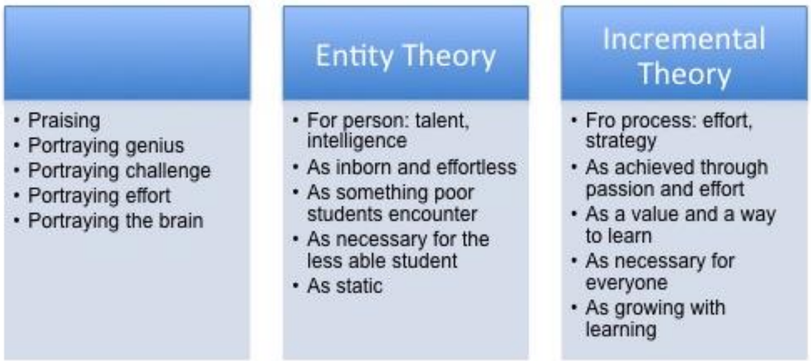


Figure 4 - Schunk, D., and Zimmerman, B. (2008) - Motivation ad self-regulated learning – Theory, research and applications. Taylor and Francis Group LLC. p. 41

## 12.0 Gender stereotypes

1:1 mobile devices can be personalised to appeal to an individual's interests and motivations. Madon et al. (1998) states avoiding gender stereotypes is critical when making judgements about students' interests and competencies. Engineering educators need to not over estimate girls' efforts in mathematics, which may lead girls to attribute their successes more to effort than to ability. Weinstein (1989) argues that students of all ages are quite skilled at interpreting messages they receive from teachers about their abilities. Seeking feedback from students about how they are finding the course delivery is essential, particularly concerning how students are prioritising their learning tasks. Normalising the use of 1:1 mobile device as non-gender specific tool will ensure its safe and collaborative use. Modelling appropriate values when using a 1:1 mobile device needs to be considered to align with student motivations.

## 13.0 Teacher Role Models as Motivators

Weinstein and McKown (1998) states educators have a unique role to play in fostering self-concepts of ability, motivation, and academic performance for all students. This means teachers need to form accurate perceptions of their student's abilities based on the student's behaviour and performance in the classroom rather than preconceived ideas about male and female abilities (Schunk and Zimmerman, 2008).

Schunk and Zimmerman (2008) developed a research model that attempted to quantify self-regulatory sources (variables) of motivation. (See Figure 5 and 6 – Schunk and Zimmerman (2008) - Sources of Motivation and their Role in Self-regulatory Learning (SRL).) These are shown and are identifiable by the following variables;

| Self Regulatory Role | | | |
|---|---|---|---|
| Source of motivation | Precursor | Mediator | Concomitant or exclusive outcomes |
| Goal orientation | X | X | X |
| Interests | X | X | X |
| Self-efficacy | X | X | X |
| Outcome expectancy | X | | |
| Future time perspective s | X | | |
| Task values | X | X | X |
| Volition | X | X | X |
| Intrinsic motivation | X | X | X |
| Causal attributions | X | X | X |
| Goal setting and self-reactions | X | X | X |
| Social motivation | X | X | |
| Gender identity | X | | |
| Cultural identity | X | | |

Figure 5 – Sources of Motivation and their Role in Self-regulatory Learning (SRL). (Ref: Schunk, D., and Zimmerman, B. (2008) - Motivation ad self-regulated learning – Theory, research and applications. Taylor and Francis Group LLC. p.7)

| < LESS Emphasis | MORE Emphasis > |
|---|---|
| Competing for grades | Improving and understanding subject matter content |
| Teaching curriculum | Teaching students |
| Teacher control | Supporting students as independent learners |
| Teacher lectures | Student discourse |
| End of unit/chapter tests | Frequent assessments and feedback |
| Passive learning | Active, cooperative, and inquiry learning |
| Teacher as dispenser of knowledge | Facilitating and encouraging students directed learning |
| One instructional strategy | Various instructional models |
| Memorisation and ROTE learning | Goal setting, self-monitoring, reflection and other metacognitive strategies |
| Correct answers | Effort, persistence, and thinking processes related to the correct answer |

Figure 6 – Changing Instructional Approaches for Self-regulated Learning (Ref - Schunk, D., and Zimmerman, B. (2008) - Motivation ad self-regulated learning – Theory, research, and applications. Taylor and Francis Group LLC. p.356)

## 14.0 Pre-conditioning motivation in students using 1:1 devices

Malone and Lepper (1987), motivation is a necessary precondition for student involvement in any type of learning activity; what and how effectively students learn may be influenced by their level of motivation. Vogel and Kwok (2009) claimed that students' motivation plays a significant role in engaging and sustaining students to use 1:1 mobile devices for learning purposes.

## 15.0 Extrinsic and intrinsic motivation

Understanding the learners extrinsic and intrinsic motivations for wanting to use a 1:1 mobile device for learning and personal needs will help the curriculum designer to develop learning interventions suited to the technology platform that will be widely accepted. Deci and Ryan (1985) has noted that self-determined learner behaviour can stem from both intrinsic motivation (i.e., the learner engages in an activity because it is interesting or enjoyable) and from extrinsic motivation (i.e., the learner engages in an activity because he or she desires the outcome and wants to achieve some instrumental end such as earning a reward). Extrinsic motivators including activities performed for reward, or avoidance of feelings of guilt (Introjected regulation), activity performed because of its importance, value, or utility (Identified regulation), and activity motivated by own values system, interest and need (Integrated regulation). Marton and Siijo (2005) argues reliance on extrinsic rewards that rely on 'surface' learning result in unsatisfactory performance due to an absence of intrinsic cognitive process. Modelling appropriate strategies to show how a 1:1 mobile device can be used for learning will help learners to adopt values that are commonly shared within and outside of the learning space.

Malone and Lepper (1987) proposed that the following elements make an activity both intrinsically and extrinsically motivating for a learner: challenge, curiosity, control, cooperation, competition and recognition. Malone and Lepper (1987) claimed that learners are more motivated when goals are clearly defined and when challenge is balanced in such a way that the learning process is neither too easy as to bore the learner, or too difficult such that success seems impossible. Malone and Lepper (1987) claim the goal is to develop learners who are self-directed and self-motivated, both because the activity is interesting in itself and because achieving the outcome is important. Where intrinsic motivation to learn is the educator's ultimate goal, extrinsic motivators such as cooperation, competition and recognition may be considered when designing learning environments or selecting instructional materials. Mupfiga et.al (2017) identified 'Flipped Learning' where students can watch videos made by their lecturers before they come into class, or record lectures as they are being done and later look at them during their study sessions. They could post them on their own blogs and have discussion with other classmates. Lecturers assume a facilitating role by proactively adopting 'flipped learning' whereby they upload more material beyond what is to be presented throughout the course, allowing students to download and study on their own using their 1:1 mobile device so that when they come into class there is more of discussing rather than presenting.

## 16.0 Allowing choice as a motivator

The nature and marketing of 1:1 mobile devices supports the student's perception of freedom of choice. Chou, Block, and Jesness, (2012) state the ability to adjust content to student level and allow self-paced learning may thus lend 1:1 device technologies as an ideal tool for implementing differentiated instruction in the classroom. What this suggests is there is an onus on the curriculum to differentiate the learning activities to allow for a number of entry levels that appeal to engineering students who are progressing through the course. This raises questions about the effectiveness of formative assessment to indicate a measure of learning, rather than pass or fail. Using a 'Bell Curve' of results as evidence of effective teaching may be counterproductive, if used in isolation to measure a student's motivation towards their learning performance goals.

## 17.0 Performance feedback motivates learning

Choice is also linked to individual learning progress. Using a 1:1 mobile device to complete tasks and receiving personal feedback via the device's messaging software. Malone and Lepper (1987) argue performance feedback and score keeping allows the individual to track progress towards desired goals. Valk, Rashid, and Elder (2010) states many 1:1 device games and apps are programmed to provide immediate feedback and thus provide continued motivation for those who are not motivated by traditional educational settings and assessment. Encouraging students to take short reward breaks during the learning by playing games on the 1:1 mobile device may not necessarily be counterproductive to the curriculum design and individual learning goals.

Malone and Lepper (1987) states cognitive curiosity occurs when learners discover that their knowledge is incomplete or inconsistent, prompting the user to explore and attain new information and competence with the technology. Technology-enhanced environments afford individuals with almost limitless opportunities for exploration and ready access to information to support both sensory and cognitive curiosity (Malone and Lepper, 1987).

## 18.0 Collaboration as a motivator

1:1 mobile device technology facilitates collaborative learning. Johnson and Johnson (2003), cooperation (compared with competitive and individualistic efforts) promotes greater effort exerted to achieve and greater productivity; more 'on-task' behaviour, higher quality of relationships among participants (e.g., greater interpersonal cohesion, task-oriented and personal support) and greater psychological adjustment (e.g., greater social competencies, higher self-esteem).

Chou et al. (2012) states students can learn at their own pace, collaborate with others and offer advice to each other through various 'Apps' run on 1:1 mobile devices. Utilizing student-centred learning interventions and associated software Apps that support the curriculum design can encourage student collaboration and creativity, and a student centred, socially interactive classroom. This means making greater use of social media, like 'Facebook', Google Classroom, Edmodo and similar Apps during the learning process via a student's own 1:1 mobile device. Engineering curriculum design incorporates in-house systems that facilitate social interaction, although in many student spaces these are not compatible with a student's normalized learning environment. Niemlec and Ryan, 2009 state, consideration must be given to authentic collaborative opportunities with outside organizations to maintain student-learning motivation. The need to feel connected to other people to experience satisfaction, support and belonging in the environment where they learn is important to maintaining learning motivation.

## 19.0 Recognition as a motivator

Malone and Lepper (1987), states learners enjoy having their efforts and accomplishments recognized and appreciated by others. In order for an environment to engage the motivation variable for recognition, the results of the individual's activities must be visible to other people. Malone and Lepper (1987) states, this can be done in several ways: (1) the process of performing the activity may be visible, (2) the product of the activity may be visible, or (3) some other result of the activity may be visible. Using a 1:1 device as a tool to facilitate motivation for recognition seems logical. Students choosing to make a social statement about their motivation to learn through the choice of 1:1 device. Covili (2017) explains how Google are investing significant resources into shifting the fundamental understanding of what constitutes a learning space. Collaborative spaces accessible across the globe may prove appealing to motivate transnational and local students to collaborate. Engineering curriculum design to be relevant may need to incorporate a greater focus on establishing a collaborative international learning environment. Why can't classes include collaborative spaces across campuses to share knowledge and to equip students with an awareness of the importance of their contribution to the 'Bigger Picture' of engineering career and education research? Whilst the question is rhetorical, it is essential to be willing to challenge traditional understanding of what constitute an effective learning space to appeal to what is motivating engineering students.

## 20.0 Environmental factors as motivators

Introducing a culture where 1:1 mobile devices can be accessed and understood as a valuable learning tool takes time, however, where it is necessary to implement structural changes to achieve learning outcomes, students and staff are able to accept change. Baeten et al. 2010; Entwistle et al. (2003); Vermunt and Vermetten (2004) have indicated that a large number of personal and environmental factors are linked to students' learning patterns. Supporting empirical studies have identified variables to explain how students cope with learning in specific learning situations. It is not solely determined by their general preferences but is the result of an interaction between their perceptions of the learning context, their disposition and other learner characteristics (Gijbels, et al., 2014).

Donche (2010), and Vermetten et al., (1999) has shown that some learning pattern characteristics are to some degree variable across course contexts and throughout time in higher education settings (In Gijbels et al., 2014). Gijbels and Dochy 2006; Vermunt and Minnaert (2003) states, inducing changes within students' learning patterns has, however, proven to be difficult in studies that took place in learning environments designed for that aim (In Gijbels et al., 2014). Donche and Gijbels (2013) state as part of the explanation for conflicting results in this latter domain of research may be generated by the conceptual base and measurement of student learning in these studies (In Gijbels et al., 2014). Recent empirical contributions in the domain of learning pattern research stress the need for further clarification of vital components of students' learning patterns. Gijbels et al. learning conceptions (Richardson, 2011) and learning strategies (Vermunt and Endedijk, 2011) and how these patterns develop in higher education in the 21st century (Vanthournout et al., 2011) (Gijbels et al., 2014).

This also brings in important questions concerning how differences and changes in student learning can be validly measured (Coertjens et al., 2013) and which future research perspectives are needed to increase our present understanding of student learning and development (Richardson, 2013) (Gijbels et al., 2014). Further research would need to be conducted to measure the impact of student and staff perceptions, should a focus be placed on using 1:1 mobile devices to improve student-learning motivations.

## 21.0 Discussion

Since 2009, 1:1 mobile device are an emerging technology that supports individualised learning goals, and presents as an opportunity for curriculum designers to rethink how to redesign learning interventions and spaces that will improve student motivation and learning outcomes. The premise of 'active learning' and freedom of choice are democratic values inherently included within engineering education learning spaces. Supporting these values will be how 1:1 mobile devices can be leveraged, where students can develop their curiosity and higher order thinking skills to solve problems and become part of a global learning community. Enabling an individual to engage in goal-directed activities over time and across changing circumstances (contexts). Learners perceive the importance of equipping themselves with the ability to use cognitive operations to organize and review meaningful learning into packets of knowledge to support higher cognitive learning by using 1:1 mobile devices, is an important pathway to transitioning into a successful career pathway. In the future, traditional learning spaces will become virtual reality spaces as ongoing education and the workplace become integrated. The importance of 1:1 mobile devices as the future access point will become the norm, and will play a pivotal role in personal and professional socialisation. Unstructured learning environments will play an important role in developing perceptions of what constitutes life-long learning values. The 1:1 mobile device community is driving change and is generating a need to re-evaluate traditional teaching and learning models.

## 22.0 Conclusion

Motivational variables play an important role in shaping how a student perceives the engineering learning space. Importantly, its relevance to the enabling of higher education students to use 1:1 mobile device to source learning resources and identify relevant performance goals for continuous feedback. Setting learning expectations through effective role modelling, supports fostering of a culture of 'normalisation' where 1:1 mobile devices are considered an effective learning tool. Finally, encouraging a discussion amongst higher education curriculum designers and the wider engineering sector to encourage ongoing research around how to best support emerging technologies such as 1:1 mobile devices into the future and within virtual reality engineering classroom spaces. Connecting curriculum design to understandings of learner motivations and strategically placed learning interventions will improve student engagement and foster higher order thinking skills that are essential to the future success of the engineering and other sectors' intellectual capital.

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**Figure 2 – Achievement Goal Endorsement** – Freyer, J., and Elliot, A., (2008) – Stability and change in achievement goals. Journal of Educational Psychology. In, Schunk, D., and Zimmerman, B. (2008) - Motivation ad self-regulated learning – Theory, research and applications. Taylor and Francis Group LLC. p. 60.

**Figure 3 – Self-Theories – Entity Theory v's Incremental Theory -** Schunk, D., and Zimmerman, B. (2008) - Motivation and self-regulated learning – Theory, research and applications. Taylor and Francis Group LLC. p. 33.

**Figure 4 – Practices that promote an incremental versus Entity Theoretical Approach of Learning -** Schunk, D., and Zimmerman, B. (2008) - Motivation ad self-regulated learning – Theory, research and applications. Taylor and Francis Group LLC. p. 41.

**Figure 5 – Sources of Motivation and their Role in Self-regulatory Learning (SRL)**
- Schunk, D., and Zimmerman, B. (2008) - Motivation ad self-regulated learning – Theory, research and applications. Taylor and Francis Group LLC. p.7)

**Figure 6 – Changing Instructional Approaches for Self-regulated Learning** (Ref - Schunk, D., and Zimmerman, B. (2008) - Motivation ad self-regulated learning – Theory, research, and applications. Taylor and Francis Group LLC. p.356)

# Optimization of Handover in Mobile System by Using Dynamic Guard Channel Method

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## Abstract

*Handover process is a very essential process in the Global System for Mobile Communication system (GSM). Its study is one of the major key performance indicators in every GSM network, and its linked to the quality of service of an each service provider strives to attain. The failure of the handover process is regarded as the drop of quality of service which in turn dissatisfies the customers. This study, contributes more on improving call drop rate in general, reduce handover failure rate and thus save on upgrade costs, this will be beneficial to GSM service providers to easily optimize their network faults relating to the resource management. In this paper, dynamic guard channel algorithm is presented that was developed using JAVA Software. This algorithm prioritizes the handover calls over the new originated calls. All handover calls are ongoing calls and if they are dropped it causes frustrations. Matlab was used to compare simulated results to the other schemes by use of graphs and charts. From this paper we were able to establish and come up with a definitive solution to the handover crisis befalling telecommunication companies.*

**Keywords:** GSM, handover failure rate, call drop rate, dynamic Guard channel, JAVA, Quality of Service (QoS).

## 1. INTRODUCTION

Conventionally, after network infrastructure deployment, a few unforeseen problems are met. We start to notice the process where a person is able to migrate from a cell area to another and still maintain the network availability. This process is called “handover process”. As [1] described, handover is a process that transfers or shifts an active call from one cell area to another cell area as the subscriber goes through the coverage location of a cellular wireless network. Noerpel [2] suggested that, for a handover to be successfully processed, the new base station (BS) selected, must have an idle available channel that is open to handle the new handover call. Otherwise, the handover call will be dropped. Rather than dropping the call to the current mobile station (MS), the mobile switching centre (MSC) that is serving currently may decide to handover or shift this call to another available and better serving base station system or in some times to another mobile switching centre [3]. By doing this, GSM ensures a greater retention of calls thus improving the quality of service (QoS). Handover process is therefore very critical where improper handover process can result to call drops. If the rate of dropped calls increases, the subscriber becomes annoyed and dissatisfied and sooner or later he/she moves to another network. In addition to that, as [4], [5] acknowledged, new calls usually have low sensitivity to delay than a handover calls because handover calls need continuity for voice and message transfer.

## 2. RELATED WORK

### 2.1 Types of Handover Mobile System

The word handover is largely used in Europe, where handoff is inclined to be used in North America [6]. Handoff and handover refer to the same mechanism. There are four scenarios for handovers calls; within the second generation system there are four categories of handover calls that can be done for GSM networks [7]:

#### *2.1.1 Intra-BTS handover (between channels)*

In this kind of handover, handover occurs when a fresh channel in the same base transceiver station (BTS) is allocated to the mobile station. Intra- BTS handover, occurs when a new frequency is needed because of interference, or other reasons [8]. The procedure is performed independently by the base station controller (BSC), but the MSC may also be in charge. It is important to emphasize that an Intra-BTS handover is consistently synchronized, since all transceivers (TRXs) of a BTS have to use the same clock [9]. Figure 1 illustrates Intra-BTS handover.

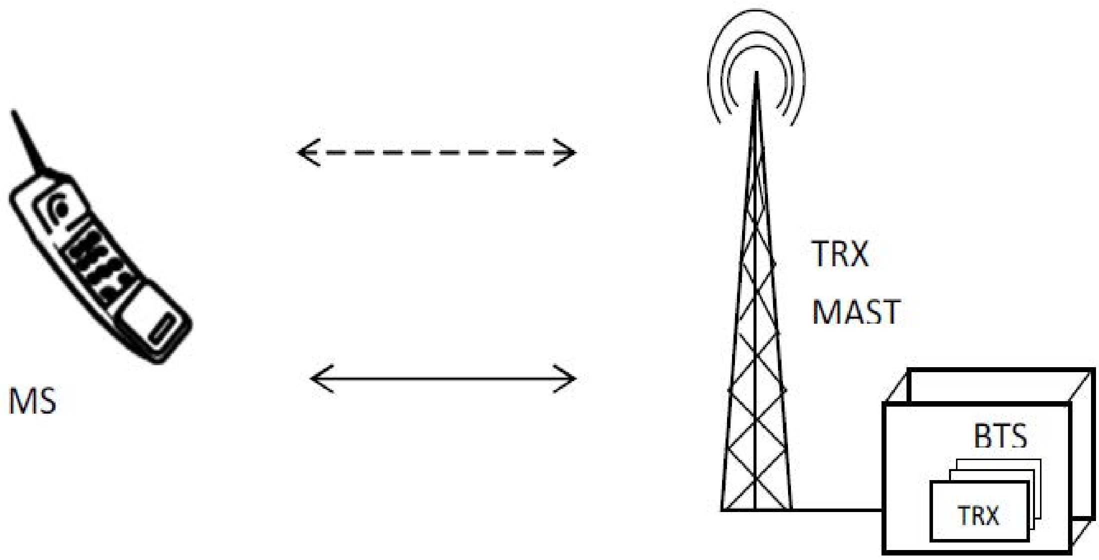


Figure 1: Intra-BTS handover [9]

### *2.1.2 Intra-BSC handover (between cells)*

This kind of handover occurs when the call is relocated from one BTS into another BTS coverage area under the control of the same BSC, as illustrated in Figure 2. In this case base station controller can do a handover and it allocates a fresh channel before dismissing the discarded BTS from communicating with the handset [8]. This handover may be done independently by the base station controller without the intervention of the mobile switching centre [9]. Moreover, the MSC is alerted when the handover has occurred.

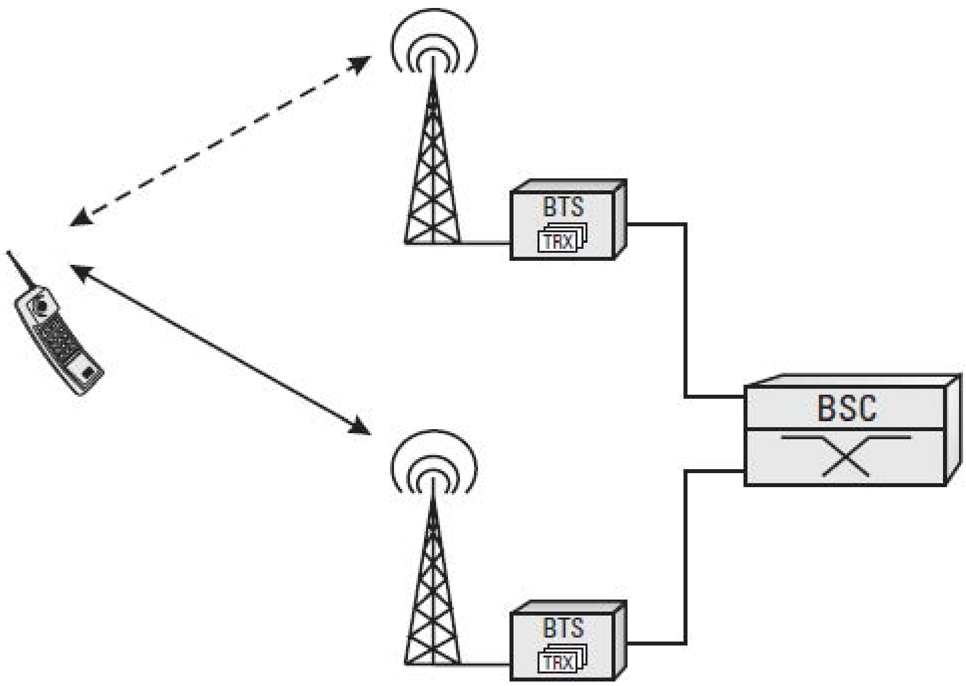


Figure 2: Intra-BSC handover [9]

### *2.1.3 Intra-MSC Handover (between BSCs)*

Whenever the cell or mobile moves outside the range of the cells under the control of one base station controller, a more complicated procedure of handover may be executed, handing over the call not only from one base transceiver station to another but also from one BSC to another [9], or, in other words, In this handover, the mobile station changes the base station controller and the base transceiver station, as well, as illustrated in Figure 3. Unlike to the Intra-BTS handover and the Intra-BSC handover, this handover is controlled by the MSC. The role of the MSC is not processing the capacities of the BTS or MSC but just to achieve the handover. When the resources are allocated the MSC initiated to access the fresh channel and the call is relocated to the new BSC [7].

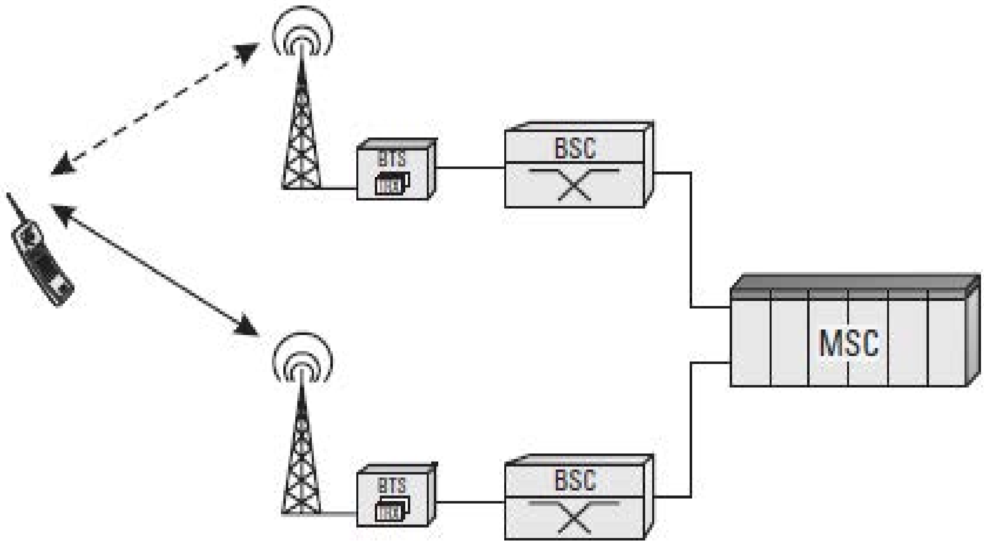

Figure 3: Intra-MSC Handover [9]

### *2.1.4 Inter-MSC Handover (between MSCs)*

It occurs when there are two cells which belong to different MSC in the same system [9]. This is illustrated in figure 4. For an inter-MSC handover the old (current serving) MSC is mostly referred to as the anchor the MSC and the new (target) MSC is referred to as the relay MSC [10].

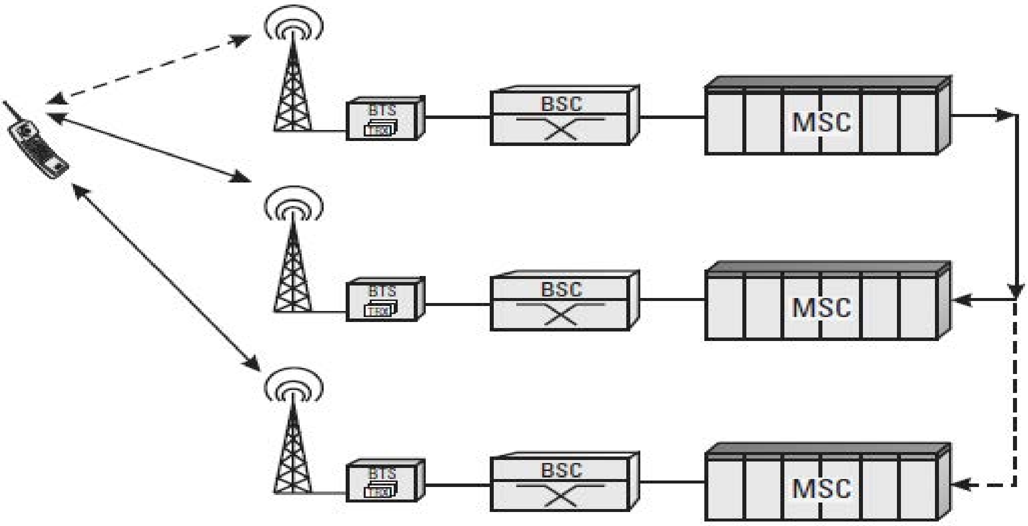

Figure 4: Inter-MSC Handover [9]

## 2.2 Handover Protocols

Usually the Handover request is originated either by the MS or by the BS. Handover decision protocols are categorized into four basic types as briefly described below.

### *2.2.1 Network Controlled Handover (NCHO)*

In this technique, the MSC is accountable for the whole handover decision [11]. In network-Controlled Handover protocol [12], the MSC creates a handover decision depending on calculations of the RSS (Signal Received Strength) from the mobile station at a number of base transceiver stations. At occasion when the system creates a linkage between the current and target BTS and this reduces the time period of handover. Generally, the handover process takes 100–200 milliseconds and creates obvious impact in the conversation [13]. Statistics about the quality of the signal for all subscribers is found at MSC. The information enables resource assignment. Therefore [14], the total delay may be about 5–10s. This kind of handover is not fitting for a dynamic condition and congested customers as the result of the associated delay. This protocol is used in 1$^{st}$ generation analogue systems like AMPS &NMT [13].

### *2.2.2 Mobile Assisted Handover (MAHO)*

As [12] indicated a mobile assisted handover (MAHO) procedure allocates the handover decision process. Here the Mobile Station is in charge of discovering the BS where the strength of the signal is closest to it. The Mobile Station calculates the signal strength and bit error rate values occasionally in the neighbouring base station.

Based on the obtained parameters, the MSC and BSs decides when to perform handover [15]. According to [14], there is a possibility of a delay of 1 sec. MAHO is currently being used in GSM.

### *2.2.3 Soft Handover (SHO)*

Soft handover is creating a connection to another station before breaking it, which is, the link to the current base station (BTS) is not destroyed till the link to the target BTS is made. Soft handover utilizes the method of macroscopic diversity [16]. The same concept can be used at the MS too. When a MS is in the overlapping area of two neighbouring cells then a soft or softer handover can occur. The user will therefore have a dual concurrent connection to the UTRAN portion of the network, utilizing various air interface channels simultaneously [17]. This protocol is for CDMA.

### *2.2.4 Mobile Controlled Handover (MCHO)*

In this protocol [12] the mobile station is totally in control of the handover process. This kind of handover has a quick response (about 0.1 s) and is appropriate for micro-cellular systems [14]. The Mobile Station measures interference levels on all channels and the strength quality of the signal from the neighbouring BSs. A handover is originated when the strength of the signal which is serving the base station becomes lesser than the signal of another BS by a definite threshold. The targeted BS is therefore requested by the MS for a channel which has the least interference.

This protocol is the highest level of handover devolution. There are several advantages of handover decentralization, where some of the handover decisions may be done fast, and the mobile switching centre doesn't need to do handover decisions for all mobile or cells, which are very complicated duty for the mobile switching centre of high volume micro-cellular schemes [18]. This protocol is used in the DECT. The handover decisions are made by the mobile station. Both inter cell and intra cell handovers are possible. The handover time is around 100 Ms [12].

**2.3 Handover Schemes**

In GSM system supporting handover, there is a main element in present to guarantee that there is a continuity of connections and the Quality of Service observed by subscribers. The handover process is then accomplished by the purported handover methods; the main importance is focused on them. The handover methods can be generally categorised into Prioritization and Non-Prioritized Schemes as in figure 5 [11].

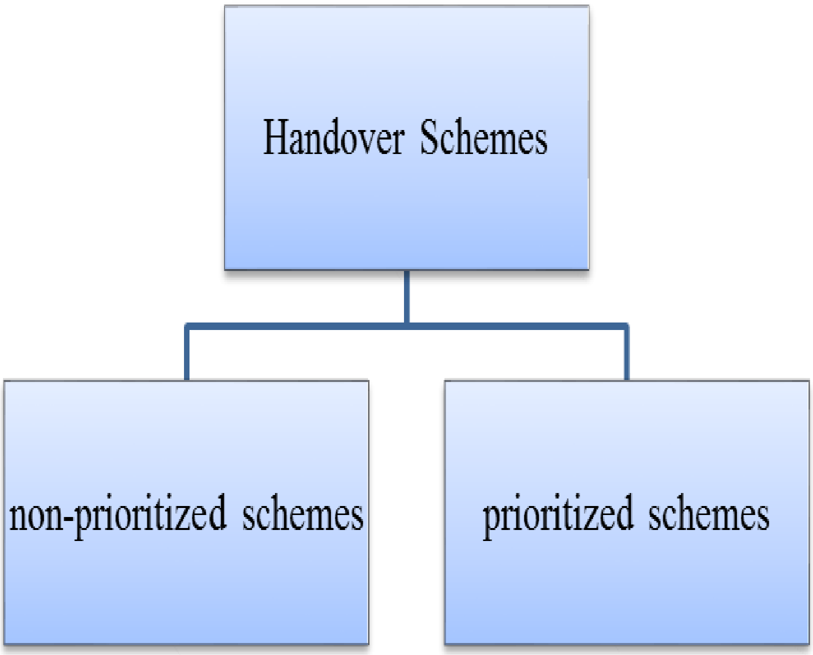


Figure 5: Classification of the handover schemes

***2.3.1 Non-Priority Handover Scheme***

For non-prioritization scheme originated calls and handover calls are to be handled using a similar approach. The moment the BS has a free channel, it is allocated according in a first arrive first serve technique irrespective of if the present call is a fresh call or handover call. If there aren't any idle channels, then the request will be rejected instantly. One of the disadvantages of this method is that, because there isn't any precedence that accorded to the handover request calls over new calls, the handover dropping rate is quite higher than it is basically estimated [12].

From the subscriber's view point, the unintended end of a call which is on-going is more irritating than the blocking of originated call that hasn't even started [13]. Subsequently, the handover dropping and the involuntary dropping probabilities need to be reduced. To attain these requirements, various handover prioritizing methods have been suggested.

***2.3.2 Handover Prioritization Schemes***

The mobile device usage, rapid increase necessitates the needs to meet QoS requirements of the subscribers. These requests nevertheless, allocation usually cause network congestion and call drops. The Different concepts and methods are presented to lessen the handover dropping rate. One of the used techniques is to minimize the percentage of handover failure rate which gives handover higher priority than fresh calls [7]. This prioritization method has a major effect on the handover call drop rate and originated call rejected probability. Therefore such a system works by allowing a high consumption of capacity while ensuring the QoS of handover calls is maintained [8].

Handover prioritization schemes offer a better performance at the cost of a falling in the sum of accepted load traffic and upsurge in the rejected call probability of originated calls [14]. Nonetheless, the enhancement in efficiency is normally associated with the way that each technique provides precedence to handover requests.

**2.4 Channel Allocation Schemes**

According to [15] Channel allocation technique can be categorized into a various types along the foundation of contrasting plans, they devised for allocation of channels. There are three fundamental channel assignment methods in cellular networks.

***2.4.1 Fixed Channel Allocation Scheme***

In this method, a group of channels is permanently allotted to each base station in such a way that the frequency reuses control can hardly be disrupted. Each cell only can use its channels. The FCA strategy, originated call or a handover call can only be accepted if there are free channels available in the cell; or else, the call must be dropped or rejected [11]. In this algorithm, the capacity will get wasted if all the assigned channels neither in use nor freely available at that moment bandwidth won't be allotted [16]. The main advantage of FCA scheme is its lack of complexity, but it is not flexible to varying traffic environments. The major disadvantage of FCA scheme is high blocked calls, because of lag of flexibility in the scheme [15].

This algorithm is useful and well functioned when the demand is not dynamic. However, in the real world the traffic is irregular and changes dynamically with time. This method lacks flexibility to satisfy the dynamic requirement of channels [17].To get a solution of this drawback Dynamic Channel Assignment (DCA) method has been proposed.

***2.4.2 Dynamic Channel Allocation Scheme***

This method doesn't assign any channel to each cell [17]. In DCA method, channels are dynamically assigned to cells [15], this is in contrasts to fixed channel allocation. In DCA, The mobile switching centre manages all channels in a region of many cells. When a call comes to these cells, the BS of the cell will request for a channel to MSC. If the centre has any open channels, then it will accept this call. If not, then this call will be blocked [17]. Also, a base station does not own any specific channels and it is returned to the central chosen cell when a call is finished.

In DCA method [18], when the traffic is congested in a cell, additional bandwidth are provided to that cell, and when the traffic become slight, assigned channels are minimized. Dismissed channels are made available to other cells which need extra channels. This reflects reducing the call setup failure rate in these high traffic load cells. This channel readjustment process needs the cells to have loads of communication and data exchange. Consequently, a DCA approach must be applied in a way that necessitates the lowest info being exchanged among BSs to reduce the signalling overhead and complexity.

### *2.4.3 Hybrid Channel Allocation Scheme*

HCA combines both of features of DCA and FCA methods. HCA algorithm allocates other channels dynamically and some channels statically. This algorithm [16], total bandwidth are divided into two clusters. One is static and the other one is dynamic. In [18], the frequencies included in the static channels are allocated to each cell via the FCA methods. But, the dynamic settle of channels is shared by the BSs. When a mobile station needs a channel to handle a call, and the frequencies in the static set are all occupied, then a request from the dynamic set is sent [18]. This technique therefore gives fewer loads to centre than DCA and provides more flexibility than FCA [17]

### *2.4.4 Comparison between FCA and DCA*

Table 1: Comparison between DCA and FCA

| **Evaluation Parameter** | **FCA** | **DCA** |
|---|---|---|
| Average handover blocking rate | High | Low |
| Average call dropping probability | More | Less |
| Minimize the interference | Not good | Good |
| The load in the network traffic | Un balance | Balance |
| Resources utilization | Less | More |
| Channel Al location | Do not modify during processing of calls | Changing Dynamically |
| Complexity | Less | More |
| Flexibility | Less | More |
| Implement at ion Cost | Low | High |

### 2.5 Types of Handover Management Schemes.

Basic methods of handover prioritization methods are handover queuing schemes, call admission control (CAC), and guard channels (GChs). At times some of these schemes are joined together to find better results [19]. The main goal of any handover technique is on how call dropping or the unexpected dropping probability can be minimized.

### *2.5.1 Handover Queuing Prioritization Schemes*

Handover queuing scheme (HQS) allow either the handover to be queued or both the new calls and handover requests to be queued [11]. In HQPS, this method lines the handover calls when there is no available channels in the BSC. If one of the calls are finished and the channel is dismissed in the BSC, then it is allocated to one of the handover call in the line. This method minimizes the unexpected termination probability at the cost of the augmented call setup failure rate. As [19] stated, Queuing is performing well when handover requests come in bunches and the traffic load is light. When handover requests occur uniformly, no need for queuing. The FIFO technique is one of the most common queuing methods.

In HQS method when the RSS of the BSC in the under usage cell extends to certain predefined threshold then the call is queued from service a neighbouring cell. Originated call request is allocated to the channel frequency if the queue is unoccupied and if there is any of idle channel in the BSC [8].

#### *2.5.2 Call Admission Control*

CAC is a method that is used to maintain the Quality of service by estimating the originated call blocking rate and handover unexpected termination probability where average channel holding time is very important term to calculate this quality of service (QoS). These measurements may be specified in cellular systems that the handover call terminated rate is lower than 5%, for voice calls [20]. The CAC method [21], is responsible to decide and view whether originating call requests are going to be accepted into the system or not. This algorithm, the arrival of originated call is assessed constantly and when they are of a higher threshold than the advanced declared threshold point then the calls are cleared and rejected regardless if a frequency is free or full to minimize the rate of handover dropped calls. There is a transaction between the Quality of Service level supposed by the subscriber and the utilization of unusual network resources.

There exists various techniques and expressions to estimate these QoS parameters where following presumptions are generally utilized: and call arrival is a Poisson process [22], the channel holding time, and the call holding time those are supposed exponentially distributed, the cell residence time. In call admission control method both the handover calls and new calls have a permission to use all the available channels. And when the originated call cannot get a free channel then the call is rejected instantly [21].

#### *2.5.3 Guard Channel Scheme (GChS)*

The quality of service is not satisfactory if the handover dropping rate is same as originated call blocking rate. In the GChS policy, static numbers of frequencies in each cell are allocated mainly to support handover calls. The GChS improve the probability of a successful handover because they take the highest priority by assigning a static or dynamically adjustable number of channels only for handovers among the total number of channels in the network, while the remaining channels can be shared equally by handover and originated calls [23].The arriving calls can be categorized into two classes, the originated new calls, and the handover calls; which are handovered from the adjacent cells, as shown in figure 6.

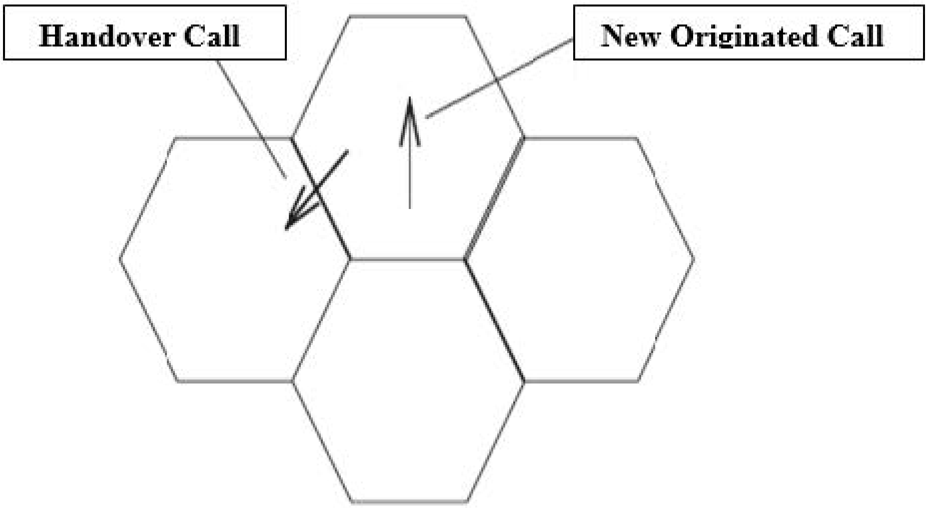


Figure 6: New call and handover call

It is worth to notice that to drop the handover call is more destructive than to block the new call, because the handover call is an existing and working call. To drop a handover, call means to disconnect a communicating call [17].

In fixed GChS, the higher priority calls such as voice and video calls have been given more priority than data. So by ignoring some resources of the lower priority classes the rejected call probability of the higher priority classes can be reduced. In this case the channel utilization falls. Because in this scheme if the number of higher priority traffic arrival rates are low; then some channels remain empty and these channels cannot be used by the lower priority traffic classes. It causes the reduced utilization of channels [24].The fixed GChS normally offers acceptable performance under nominal stationary traffic loads, but actual traffic loads are rarely fixed or have the same level as the nominal. Based on that, in this paper, dynamic guard channel algorithm was developed using JAVA Software.

## 3. SIMULATION MODEL AND RESULTS

### 3.1 Dynamic guard channel model description

This method uses threshold to explain the present state of traffic. If channels occupied are less than the stated threshold, the load traffic is light; otherwise, the load traffic is heavy. The channels used in the cell can also be divided into two parts: the guard channels "for handover calls only" the shared channels" for both" as shown in the figure 7.

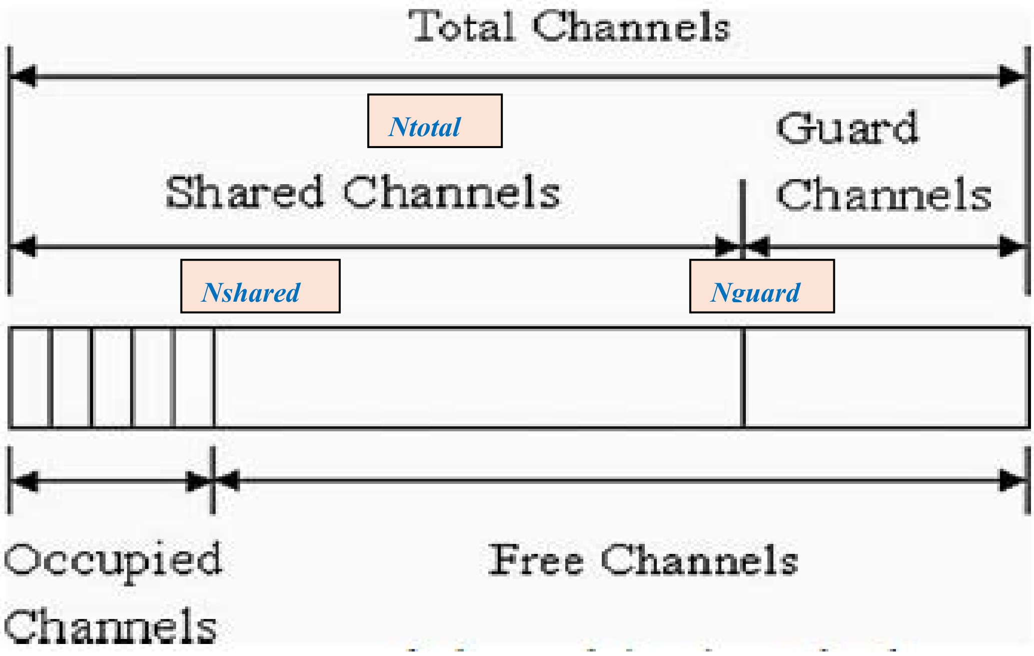

Figure 7: Channel Assignment structure with Priority for Handover Calls

For instance, when new incoming calls can admit the idle channels limited by the selected number of shared channels, the incoming handover calls can then access all the total channels as illustrated in the above figure.

The model mathematically described as:

$$N_{total} = N_{shared} + N_{guard} \qquad (1)$$

$$N_{shared} = N_{total} - N_{guard} \qquad (2)$$

$$N_{guard} = N_{total} - N_{shared} \qquad (3)$$

Where

*Ntotal :* the total amount of available channels.

*Nshared*: the number of shared channels.

*Nguard:* the number of GChs.

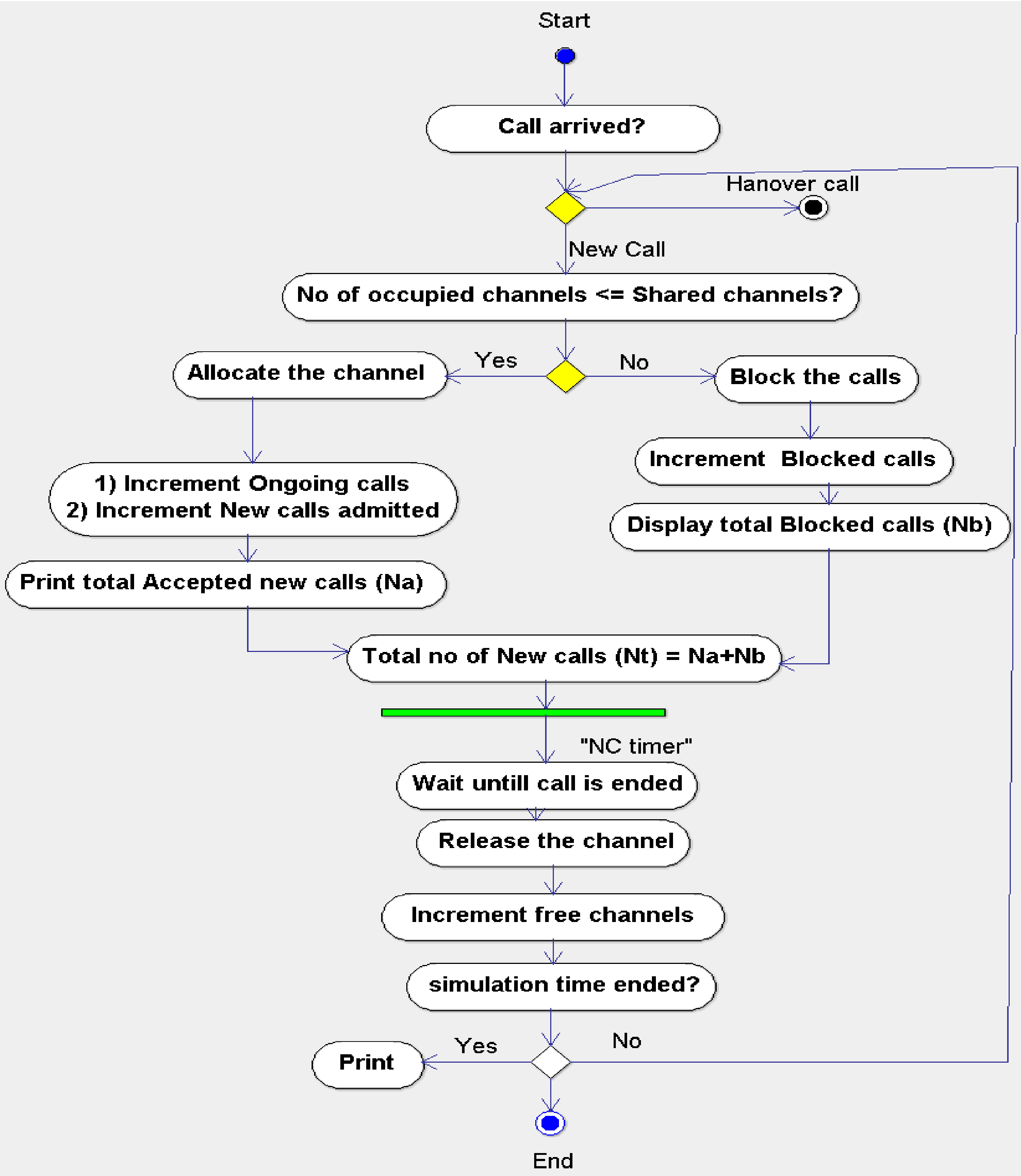


Figure 8: Flowchart for New Calls

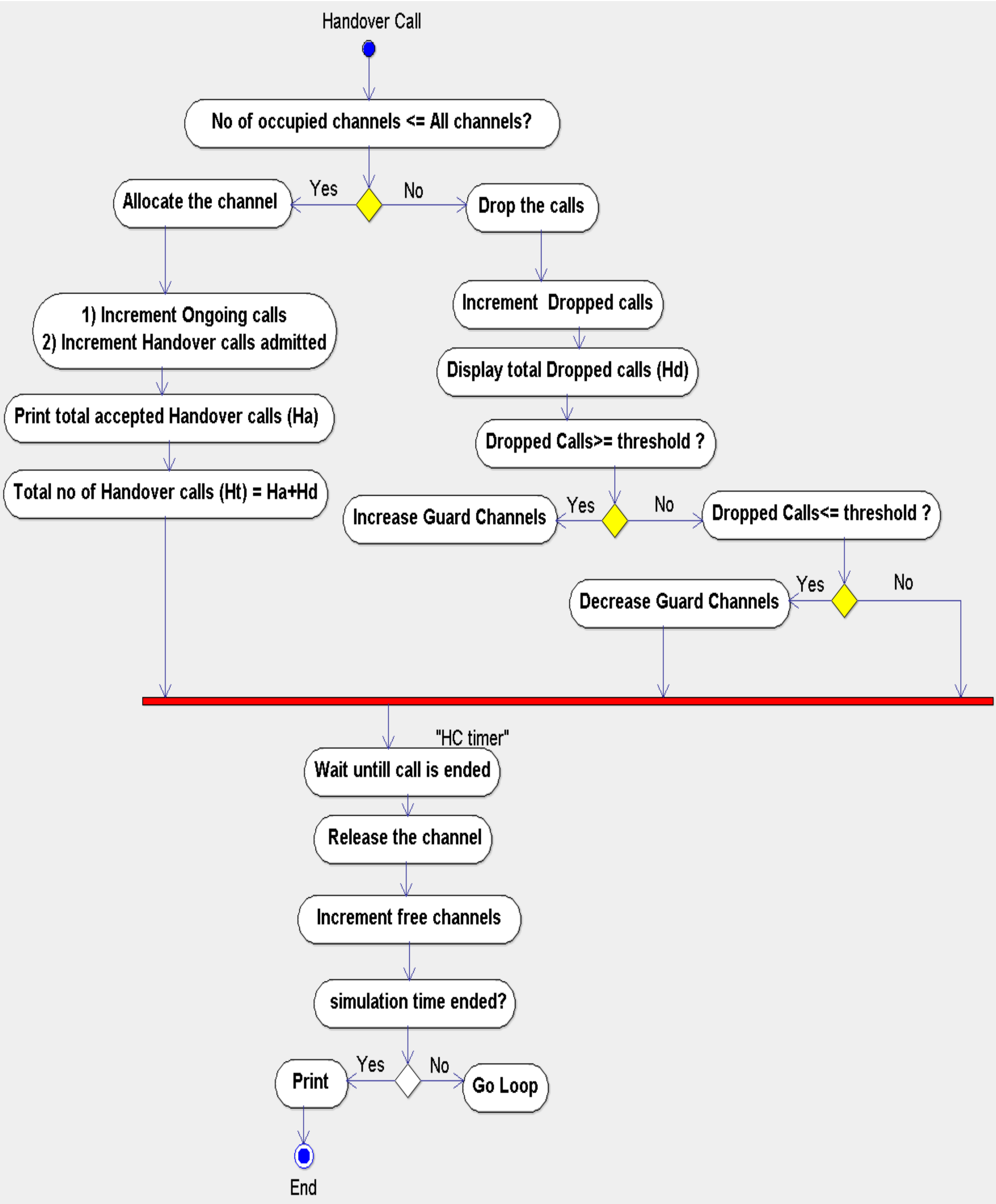


Figure 9: Flowchart for Handover Calls

### 3.2 Simulation results

To show the efficiency of the dynamic guard channel algorithm, performance indicators such as handover success rate, handover call dropping probability, originated call blocking probability and channel utilization are calculated. New originated and handover calls need to be analysed independently, because handover call dropping probability has a much greater influence on the quality of service than the probability of originated call blocking. Also new originated calls have low sensitivity to delay than a handover calls because handover calls need continuity for voice and message transfer [5]. Moreover, for the purpose of analysing the performance of our algorithm, with a holding time of 3 seconds and 3.2 seconds per call for new originated calls and handover calls respectively, an additional 2 guard channels are factored in.

Table 2: Average Simulated results

| No of Channels | Simulation Time (Min) | No of Calls | New Calls | Handover Calls | Call Setup Success Rate (%) | Handover Success Rate (%) | New Call Blocking Probability | Handover Call Dropping Probability | Channel Utilization |
|---|---|---|---|---|---|---|---|---|---|
| 120 | 1 | 50 | 34 | 16 | 100 | 100 | 0 | 0 | 100 |
| 120 | 2 | 112 | 72 | 40 | 100 | 100 | 0 | 0 | 100 |
| 120 | 3 | 172 | 128 | 44 | 94.77 | 100 | 0.0523 | 0 | 94.767 |
| 120 | 4 | 233 | 176 | 57 | 81.55 | 100 | 0.1845 | 0 | 81.545 |
| 120 | 5 | 294 | 227 | 67 | 75.85 | 99.66 | 0.2415 | 0.0034 | 75.510 |
| 120 | 6 | 355 | 275 | 80 | 69.86 | 99.44 | 0.3014 | 0.0056 | 69.296 |
| 120 | 7 | 415 | 284 | 131 | 65.31 | 98.55 | 0.3469 | 0.0145 | 63.855 |
| 120 | 8 | 475 | 367 | 108 | 62.53 | 99.37 | 0.3747 | 0.0063 | 61.895 |
| 120 | 9 | 535 | 381 | 154 | 62.62 | 98.88 | 0.3738 | 0.0112 | 61.495 |
| 120 | 10 | 596 | 437 | 159 | 60.24 | 99.66 | 0.3976 | 0.0034 | 59.899 |
| 150 | 11 | 652 | 461 | 191 | 62.88 | 98.62 | 0.3712 | 0.0138 | 61.503 |
| 150 | 12 | 712 | 493 | 219 | 60.95 | 98.03 | 0.3905 | 0.0197 | 58.988 |
| 150 | 13 | 772 | 523 | 249 | 59.59 | 97.67 | 0.4041 | 0.0233 | 57.253 |
| 150 | 14 | 832 | 592 | 240 | 58.29 | 98.80 | 0.4171 | 0.0120 | 57.091 |
| 150 | 15 | 893 | 469 | 244 | 58.23 | 98.81 | 0.4177 | 0.0119 | 57.11 |

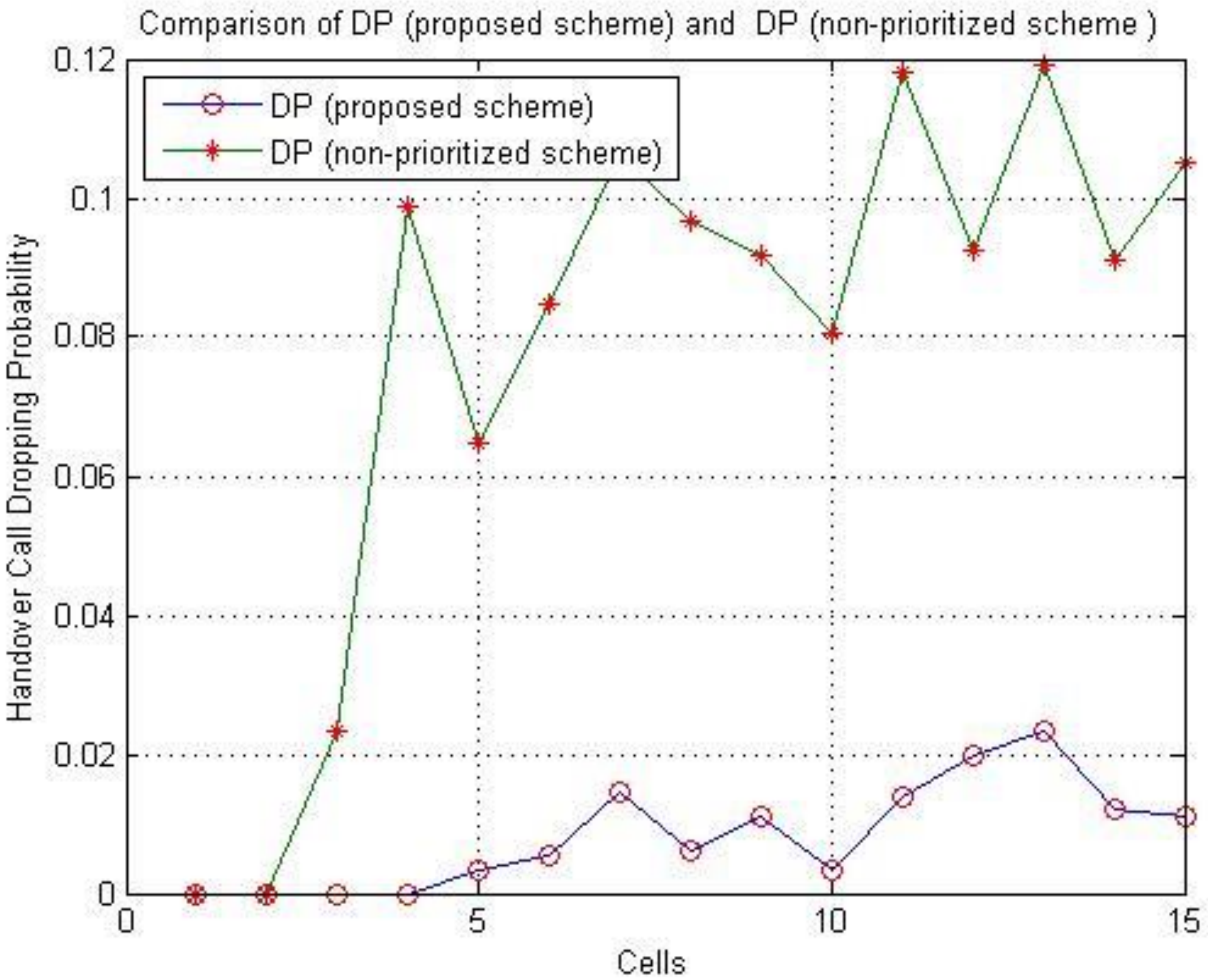


Figure 10: Handover call dropping probability (proposed scheme) vs handover call dropping probability (non-prioritized scheme)

Handover call dropping probability shows the probability that a new initiated handover call will be dropped. This value should be as small as possible an average of 0.02. The smaller the number is, the better the networks' quality of service would be, for both handover call dropping and new call blocking probability. Figure 10 shows the comparison between handover call dropping probability (non-prioritized scheme) and proposed handover call dropping probability. It's clear from the figure that the proposed algorithm outperforms and reduces the dropping probability of handover calls in comparison to other schemes, since the channels are reserved for handover calls based on the current estimate of terminating probability of handover purposes.

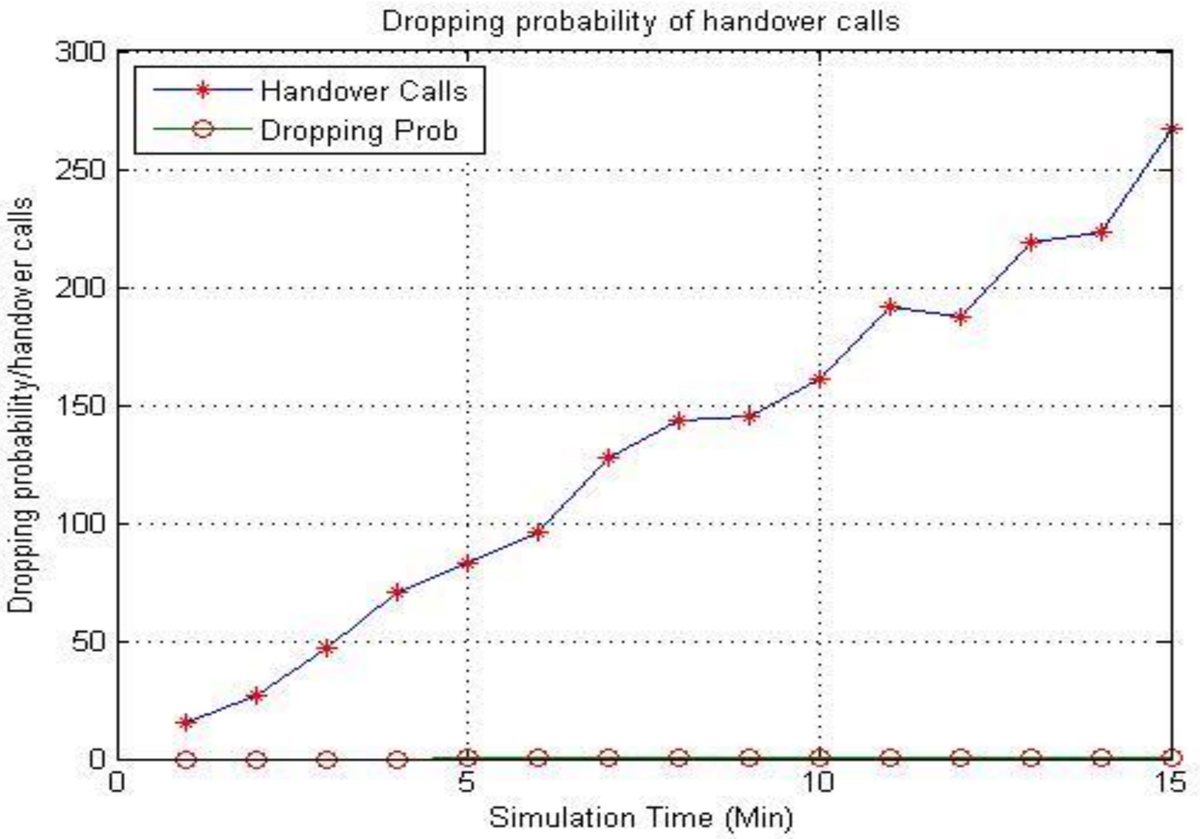


Figure 11: Handover call dropping probability

It's clear from the figure 11 that the number of handover calls gradually increased with time, but handover call dropping probability is maintained between 0 and 0.02**.** It was found that even though handover calls are increased almost three hundred, still handover call dropping probability is at the acceptance level. It is demonstrated in figure 11, that the number of handover calls dropped is much less in number even during in a heavy traffic.

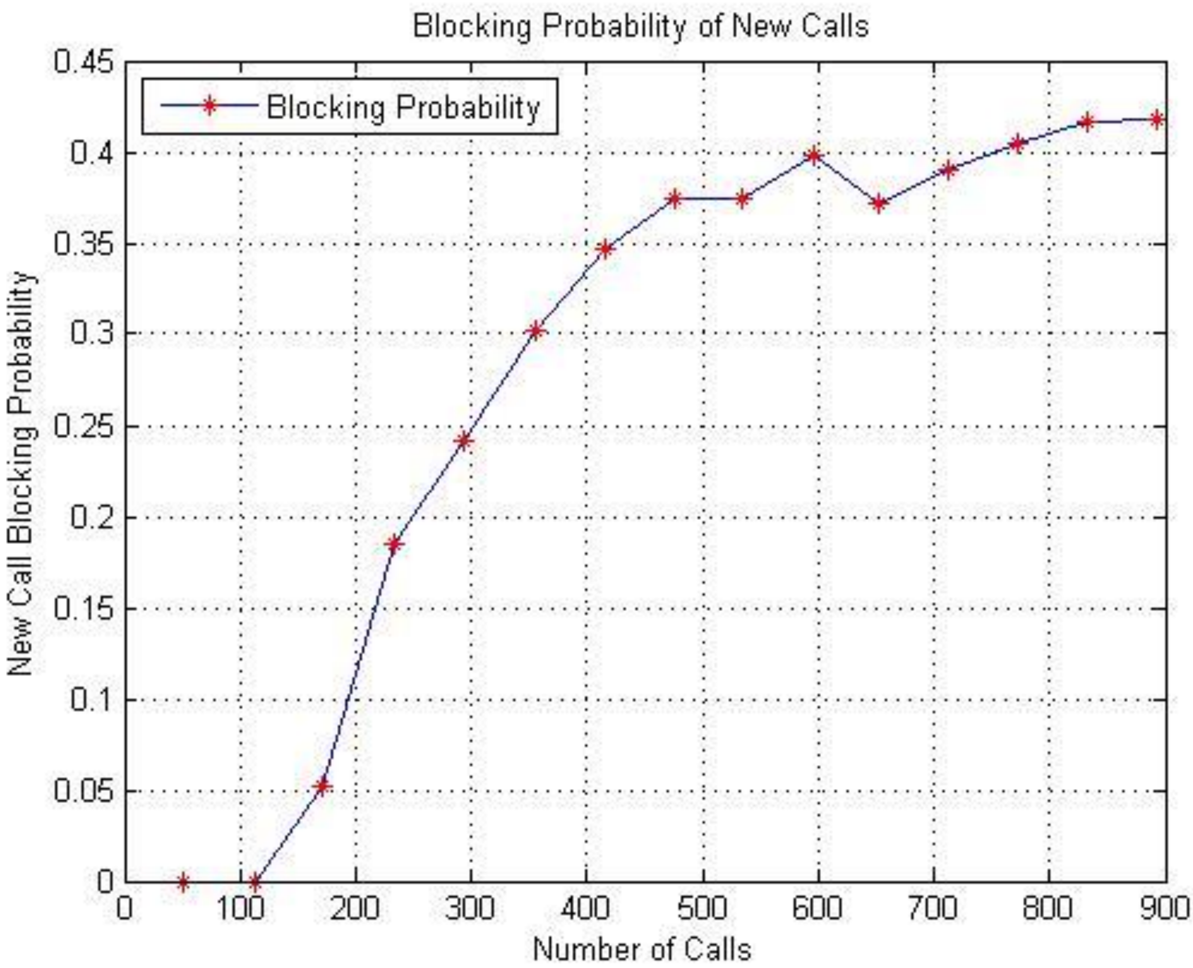


Figure 12: New call blocking probability

The dynamic guard channel method reduces significantly the blocking probability in comparison to the static guard channel algorithm. The call blocking probability shows the possibilities in which a new originated phone call may be dropped before it is admitted to the system. Each base station is different from the next and this probability should be kept as low as possible. It's observed from Figure 12, when the number of calls increases then the chance of getting a channel by the originated calls decreases and this fact results in more new call blocking probability taking place. In order to maintain a blocking probability smaller than this simulated result, the arrival rate of originated calls would have to be less.

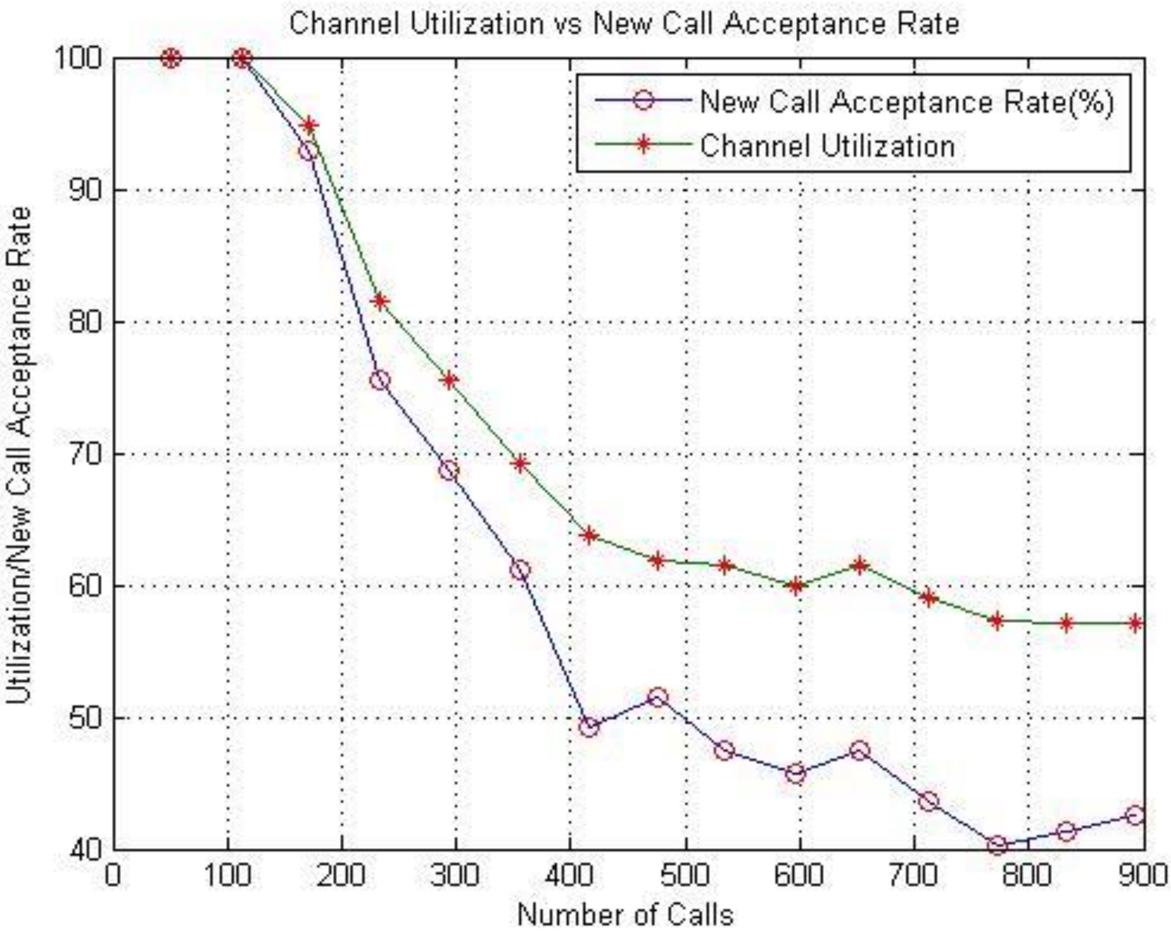


Figure 13: Channel utilization with new call acceptance rate

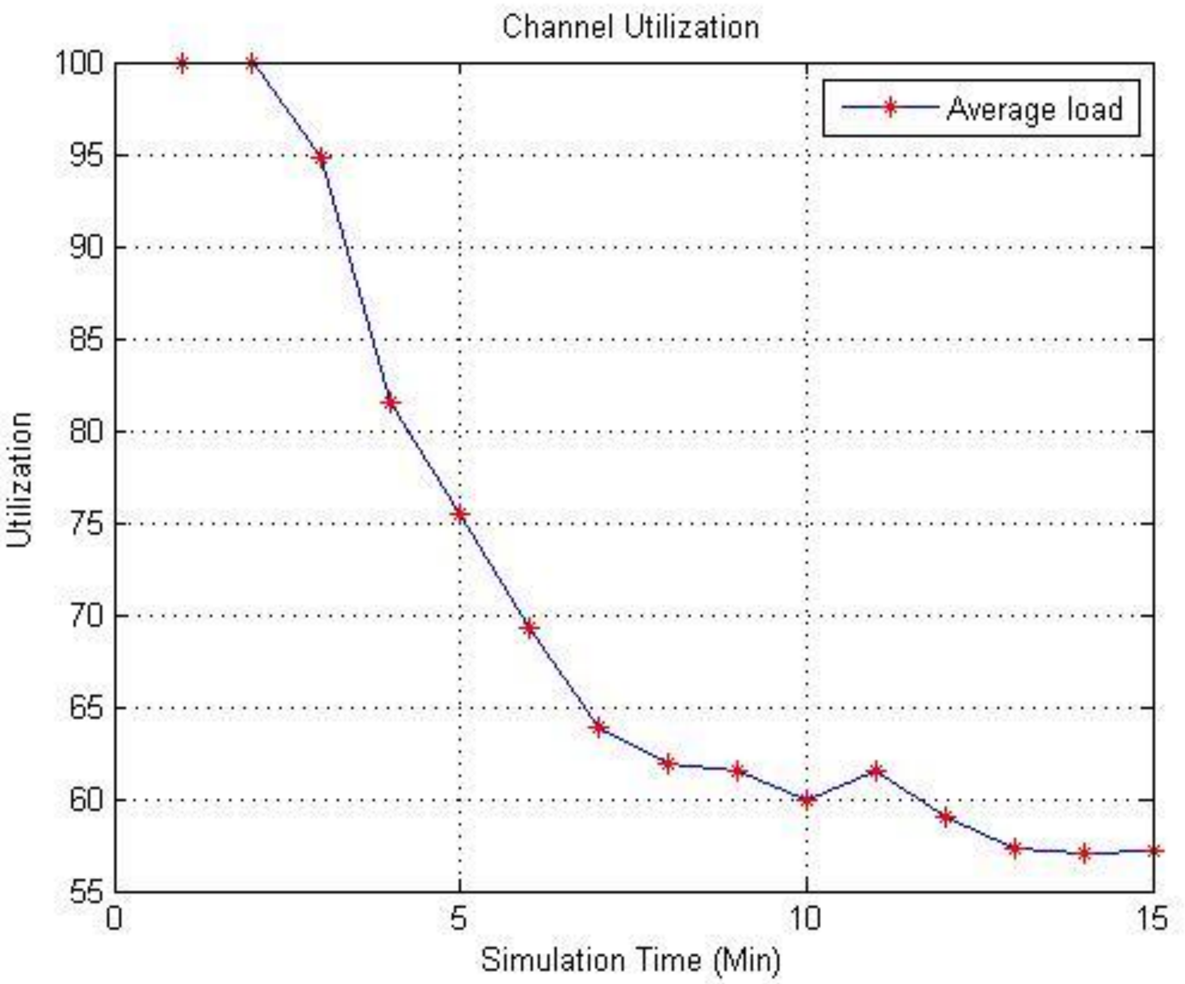


Figure 14: Channel utilization

Channel Utilization is able to monitor the general and overall performance of a network and how the resources are being utilized and if there is too much traffic it affects the overall experience that a user gets. In figure 13, it's observable that with the increment of new originated call admittance rate the utilization of the channels is increased. Generally it's also noticed that acceptance rate below fifty percent has a propensity to lessen channel utilization because of a slight drift to increase the blocked probability. New originated call admittance rate of any value more than 60% has satisfied channel utilization. Our algorithm shows a nearly constant value of channel utilization regardless of the variant of mobility and the time as presented in figure 14, and the use of dynamic GChS can attain a better channel utilization since the number of guard channels is dynamically allocated.

## 4. Conclusion and Further Work

In this paper, a dynamic guard channel scheme has been proposed. In comparison with the other algorithm, like non-prioritization (no guard channels) scheme we have seen our algorithm was able to deliver better performance and utilization. Our algorithm maintained the handover call dropping probability at (<=0.02) while constraining the new call blocking probability within acceptable level and optimizing the channel

utilization. Even in the heavy traffic, the handover call dropping probability are at the acceptance level. Moreover, with this algorithm, one hundred percent channel bandwidth are utilized and wastage of bandwidth are avoided, which will allow the service providers to generate more revenue.
Till now, this research deployed just one cell, further research may deploy several cells and run simultaneously. So that when a new or handover call enters or evacuates a cell, the directly related cell notifies its neighbour cells, and if the is admitted (either a handover call or a new call) in a chosen cell, say x, each of cell x's neighbouring BSs, say y, reserves a channel for incoming call in either direction.

While establishing the algorithm, we found out that balance is an important factor in order to improve or to reduce performance of the system. Following repetitive testing and also stress testing of different variations, there are some given limits whereby the system runs effectively and efficiently where other times it isn't. A major factor in these equations was the traffic load, which shows how the system is responding to certain pressure points. In the future research and study, the impact of the channel holding time on the quality of service can be studied and analysed.

Studying, analysing and figuring out advantages of other forms of algorithms where we may be able to improve or merge the Guard channel algorithm with another to make a better algorithm.

## 5. Acknowledgement

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# Sensory evaluation of gluten-free chicken pasty made with cassava (*Manihot esculenta* Crantz)

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## Abstract

*Celiac disease is a condition in which genetically predisposed people have an autoimmune reaction to gluten proteins found mainly in wheat. Celiac disease patients have few and expensive options of gluten-free food products. The aim of this study was to produce a gluten-free alternative to the wheat chicken pasty, a food largely consumed in South American countries. The main ingredient used for the elaboration of gluten-free pasty was cassava, a cheap and quite available raw ingredient, which after cooked results in a soft mass. This product was compared to the traditional wheat version by means of a sensory analysis, considering general aspects, consistency, flavor and aroma, and also a comparison of the production costs of the two products. General aspects, flavor and aroma did not differ significantly between the two products. Consistency was the only characteristic that differed significantly between them, the evaluation being more favorable to the cassava pasty. These results validate the gluten-free product regarding its*

*sensory acceptability. The cost of production of the gluten-free product was lower than that of the traditional one. This product can be a cheap and attractive alternative for celiac disease patients.*
**Keywords:** Celiac Disease, New Products, Sensory Acceptability.

## Introduction

Adverse reactions to foods can be broadly divided into those with an immune basis – food allergies and celiac disease, or those without an immune basis – termed food intolerances (Turnbull et al., 2014). These diseases may impose the adoption of different eating habits by those who have these genetic predispositions. These habits generally include food restrictions that are difficult to adopt due to the scarcity of food products that are restrictive in one or more components and at the same time appetizing.

Celiac disease is a condition in which genetically predisposed people have an autoimmune reaction to gluten proteins found in all wheat types and closely related cereals such as barley and rye. This reaction causes the formation of autoantibodies and the destruction of the villi in the small intestine, which results in malabsorption of nutrients and other gluten-induced autoimmune diseases (Ciacci et al., 2007). Although considerable scientific progress has been made in understanding celiac disease and in preventing or curing its manifestations, a strict gluten-free diet is the only treatment for celiac disease to date (Niewinski, 2008). However, a lot of other vegetable and animal foods such as fish, poultry and meats, as well as fruits and vegetables, are permitted and rice, corn and potatoes have been widely used as substitutes for gluten-containing grains (Saturni et al., 2010).

In this study, a new gluten-free product has been created, using cassava (*Manihot esculenta* Crantz) in its composition as an alternative to wheat. The product, a chicken pasty, is a food created in Bolivia and typically consumed in all the countries of South America. Cassava is one of the most important sources of commercial production of starch in tropical and subtropical countries, with 73.7 to 84.9% of starch in its dry root weight (Sánchez et al., 2009). The sensory profile and production cost of the product was compared to that of its wheat counterpart.

## Material and Methods

The main raw ingredient used for the making of gluten-free pasty was the flesh of yellow cassava. Whole cassava was purchased at the Porto Velho street market. The other ingredients were purchased in local supermarkets. The products were taken to the Laboratory of Dietary Practices of the University Center São Lucas - UniSL, where the pasties were made.

For the production of the doughs and filling, the dry ingredients were weighed on a scale (Tomate® SF400) with graduation 0.1 g and the liquid ingredients were measured in graduated beakers.
The filling used in the two kinds of pasty was the same (Table 1). To make the filling, chicken breast was cooked with garlic, salt, colorific (Kitano® - cornmeal, salt, seeds of *Bixa orellana* and vegetable oil), oil

and water in a pressure cooker for 30 minutes (Table 1). After the pressure cooker cooled completely, it was opened and the chicken breast was shredded. The broth was reserved. The shredded chicken was placed in a pan along with the broth, onions, bell peppers, potatoes, carrots, chives, dehydrated parsley, green olives, raisin and cumin powder cut into small pieces. This sauce was cooked for 20 minutes. Corn starch was added to give consistency to the sauce, which was cooked for more five minutes. The sauce was put in a glass container that was placed to cool in a domestic refrigerator at 12°C for two hours.

Table 1. Ingredients of the filling of both pasties with and without gluten, for the preparation of 1,000 grams of chicken pasty.

| **Ingredient** | **Weight (g)** | **Ingredient** | **Weight (g)** |
|---|---|---|---|
| Chicken breast | 217.83 | Dehydrated parsley | 0.59 |
| Water | 23.78 | Corn starch | 2.97 |
| Onion | 30.91 | Green olives | 16.64 |
| Potato | 29.72 | Raisin | 9.51 |
| Carrot | 27.34 | Salt | 2.97 |
| Bell pepper | 17.24 | Cumin powder | 1.04 |
| Garlic | 7.43 | Colorific | 0.59 |
| Chives | 7.43 | Oil | 4.60 |

For the preparation of the cassava dough, the root was peeled, cut into cylindrical pieces of approximately 5 cm in diameter x 5 cm in length and cooked together with salt, garlic and saffron (Table 2) in an ordinary pan on a domestic stove for 30 minutes to obtain the texture to be kneaded. After cooling, xanthan gum was added. Oil and colorific were heated in a frying pan. This mixture was added to the cassava, which was kneaded until it did not stick to the hands. This dough was wrapped in PVC film and kept in a refrigerator at 12°C for two hours. Subsequently dough balls of 25 g were flattened by using a rolling pin into disks on which 10 g of filling were placed. Then the pastries were folded into a semi-circle and the edges were pressed together. The pasties were placed on greased baking sheets (floured with corn starch), brushed with egg yolk and baked in an electric combination oven by using dry (convection) heat at 160°C for 25 minutes.

For the preparation of the traditional dough, wheat flour, water, salt, sugar, margarine, colorific, eggs, garlic, saffron and biological yeast were mixed and kneaded until it did not stick to the hands (Table 2). This dough was wrapped in PVC film and kept in a refrigerator at 12°C for 30 minutes. Subsequently dough balls of 25 g were flattened by using a rolling pin into disks on which 10 g of filling were placed. Then the pastries were folded into a semi-circle and the edges were pressed together. The pasties were placed on greased baking sheets (floured with wheat flour), brushed with egg yolk and baked in an electric combination oven by using dry (convection) and moist (steam) heat at 160°C for 25 minutes.

Table 2. Ingredients of the dough of pasties with and without gluten, for the preparation of 1,000 grams of chicken pasty.

| **Ingredient** | **Traditional pasty (g)** | **Gluten-free pasty (g)** |
|---|---|---|
| Cassava | - | 921.32 |
| Wheat flour | 505.24 | - |
| Margarine | 188.88 | - |
| Water | 163.46 | - |
| Eggs | 29.72 | - |
| Sugar | 16.35 | - |
| Salt | 7.43 | 7.43 |
| Oil | - | 5.94 |
| Biological yeast | 2,97 | - |
| Garlic | 1.19 | 1.19 |
| Colorific | 1.19 | 1.19 |
| Saffron | 1.19 | 1.19 |
| Xanthan | - | 0.36 |

The gluten-free and traditional chicken pasties were evaluated sensorially in the Laboratory of Sensory Analysis of the Nutrition course of the University Center São Lucas (UniSL). The 78 participants in the study were students, teachers and employees of the institution. They were male and female, non-trained, non-celiac disease patients, aged 18 to 60 years old, who regularly consumed chicken pasties. The evaluation was in the afternoon, which is the usual time of consumption of this product. Prior to the test, the evaluators were given instructions about the general procedures.

Two samples weighing approximately 30 g were presented to each evaluator in disposable dishes identified with random numerals using the methodology described by Dutcosky (2013) and served at 47°C±1°C (IAL, 2008). Mineral water was offered to cleanse the palate. The evaluators attributed rates according to a hedonic scale of seven points, ranging from 1 - extremely disliked to 7 - extremely liked, regarding the attributes - general aspect, consistency, aroma and flavor (Minim, 2006). The results obtained in the sensory evaluation were submitted to analysis of variance and the averages compared by Tukey test (5%), by using the Assistat 7.5 statistical program. This research was approved by the Permanent Research Ethics Committee of the University Center São Lucas - UniSL (CAAE: 34041314.4.0000.0013). All participants in the study were informed about the procedures and voluntarily participated in the study, signing a Term of Free and Informed Consent.

Additionally, the final production costs of each product were estimated, by a price survey of each ingredient at the local markets and supermarkets.

**Results and Discussion**

In Table 3 are presented the average rates obtained at the sensorial analysis of the traditional wheat pasty and the cassava gluten-free product. General aspect, flavor and aroma did not differ significantly between the two products. Consistency was the only characteristic that differed significantly between them, being more favorable to the cassava pasty. These results validate the gluten-free product regarding its sensory acceptability.

Table 3. Sensory evaluation of traditional wheat pasty and gluten-free cassava pasty.

| Sensory characteristics | Traditional | Gluten-free |
|---|---|---|
| General aspect | 5.44 a | 5.09 a |
| Consistency | 4.23 b | 5.03 a |
| Flavor | 5.36 a | 5.33 a |
| Aroma | 5.19 a | 5.27 a |

*Averages followed by the same letter in the rows do not differ significantly at 5% probability by Tukey's test.

The consistency of the gluten-free product had a higher rate than that of the traditional one. It is important to note that the dough of pasties function as an envelope and does not need to be so aerated as in a bread, for example. This can explain the good acceptability of the consistency of the cassava product. This is in agreement with the study of Fiorda et al. (2013), who achieved a pasta with good texture, adequate firmness and not very sticky, by using a pre-gelatinized flour made from cassava starch and dehydrated cassava bagasse (70:30), cassava starch and amaranth flour (10:60:30). Opposite results have been found by researchers working with bread, for instance, in which the aeration of the dough is essential. Pasqualone et al. (2010) compared wheat bread to cassava bread and found that the inability of cassava dough to retain $CO_2$ and consequent lack of an alveolate structure leads to an unappealingly stiff consistency. Defloor et al. (1991) enhanced the air uptake in cassava bread supplementing the batter by incorporating extruded starch and glyceryl monostearate in the formula.

The flavor and aroma of the cassava pasty was well evaluated, in agreement with the study of Pasqualone et al. (2010), who found a sensory perception of the typical cassava odor in cassava bread tending to be more sweet than bitter and pungent. The authors mentioned that the addition of olive oil or egg in the mixture can reduce the distinctive cassava odor. In general, the aroma of cassava has good acceptability in food preparations, except when it is fermented and can confer an objectionable odor to the mass, as mentioned by Ohochuku & Ballantine (1983).

In the present study, the gluten-free product was less expensive than the traditional one - the cost of the gluten-free pasty is US$2.00/kg, and that of the traditional pasty is US$2.46/kg. This is of great significance, for in general gluten-free products are much more expensive than their traditional counterparts. Stevens (2008) made a comparison between costs of 56 gluten-free products and their reciprocal regular foods, and found that all the labelled gluten-free were significantly more expensive (on average 242%) than the regular ones. This may impact on compliance to a gluten-free diet, with potential nutritional and clinical consequences, together with an increased risk of complications (Singh & Whelan, 2011).

Another relevant aspect is the availability of raw material for gluten-free products. As mentioned by Alvarez-Jubete et al. (2010), several gluten-free sources exist, such as the pseudocereals amaranth, quinoa and buckwheat, but they are difficult to obtain, limiting the options for celiac disease patients. On the contrary, cassava is the main source of carbohydrates in developing countries (Alves et al., 2008) and, in Brazil, it is cultivated in all states, is the ninth product of the country in terms of cultivated area and the sixth in terms of value of production (Ceni et al., 2009). Besides, according to Montagnac et al. (2009), because cassava is drought-tolerant and its mature roots can maintain their nutritional value for a long time without water, it may represent the future of food security in some developing countries.

## Conclusion

A new gluten-free food product was produced and validated regarding its sensory acceptability in comparison to its counterpart – a wheat chicken pasty largely consumed in South American countries. The basis of the new product is cassava, an inexpensive and quite available ingredient. This product can be a frugal and attractive alternative for celiac disease patients.

## Acknowledgement

The authors thank to PAP-UniSL (Programa de Apoio à Pesquisa do Centro Universitário São Lucas) for providing financial support and scholarship to Santos, I.H.V.S. and Oliveira, T.W.

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# IN AND ON SERVICE TRAINING CONCEPTUAL MODEL BASED ON ANDRAGOGYTO IMPROVE THE COMPETENCY OF SUPERVISOR OF EARLY CHILDHOOD EDUCATION PROGRAM (PAUD)

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## Abstract

*In Gorontalo Province, the role of Supervisors of Early Childhood Education (PAUD) is not as optimal as has been expected. We stated this based on the results of interviews done by researchers to the PAUD managers and tutors, which few supervisors have obstacles in guiding tutors to manage to learn and in guiding principals to manage early childhood institutions. The problem might cause by the improper recruitment of supervisors which was not involving the standardization, qualification, and competence of the supervisors. Consequently, it is necessary to improve the competence of PAUD supervisors by, one of them, education and training. Hence, In and On Service Training model based on andragogy presented here.*

*The initial stage to develop this model is to provide the conceptual model. Therefore, the purpose of this early stage of research is to build the conceptual model of in and On service training based on Andragogy and its tools to improve the competence of PAUD supervisors.*

*The method used in this research is development research, includes: (i) theoretical and regulatory study of supervisory, no formal education, and also education and training, (ii) surveys and identification of supervisor competency profiles, (iii) construction of conceptual model by workshops, and (iv ) Model validation.*

*The result of the model consists of (i) Design of training models, tools, guides, and assessment instruments, (ii) teaching materials, (iii) supervisory evaluation tools, (iv) academic supervision tools, and (v) Managerial, supervisory material.*

**Keywords**: In and On Service Training model; andragogy; competence; PAUD supervisor;

## 1. Introduction

The role of supervisors is necessary for an Early Childhood Education (*Pendidikan Anak Usia Dini* /PAUD) program. The institution of PAUD, according to the Regulation of the Minister of Education (*Peraturan Menteri Pendidikan Nasional*/Permendiknas) and Culture Number 146 of 2014 Chapter 2, is regulated by age groups, which are(i) Childcare Park or similar units (*Satuan PAUD Sejenis*/SPS) for ages 0 - 6 years,

(ii) Playing Group (*Kelompok Bermain*/KB) for age 2 - 4 years, (iii) Kindergarten (*Taman Kanak-Kanak*/TK) or similar institutions (*Raudhatul Athfal*/RA, *Bustanul Athfal*/BA, etc.) for age 4-6 years. To provide facilities for the quality improvement of early childhood, a standard of qualification and competence required. It mentioned in Permendiknas Number 12 of 2007 about Supervisory Standard of School. The qualifications include (i) education level, (ii) certificate for the educator as teacher or principal of kindergarten, (iii) rank, (iv) age, (v) competency test and (vi) selection. The supervisory competencies include (i) personality competence, (ii) social competence, (iii) academic supervision competence, (iv) managerial supervision competence, (v) education evaluation competence, and (vi) development research competence.

According to survey results conducted on PAUD supervisory in Gorontalo province, we found that some recruitment for a supervisor does not comply with the applicable regulations. There had been proof that some PAUD supervisors are not from early childhood tutors/principals or related profession. Also, some supervisors recruited because of the non-job of structural positions. Based on this fact, it assumed that the competence of supervisors in guiding the tutors/principals is quite low. Consequently, supervisors need to improve their competence in improving the quality of PAUD program implementation. The improvement of competence made through education and training, which in this research, is planned to be developed by "In and On Service Training" model based on andragogy. The strategy of this model done by steps in service training I - On service training and in training II.

Model development activities based on job training concepts. In training, there are two types of training, namely: (i) conventional training and (ii) On the Job Training. Conventional training is defined as a classical training method and contains theories that intersperse with samples in reality. This training model used as in service training I and Service training II.

The concept of On the Job Training interpreted as a training activity in the workplace. On the Job Training is defined as"training with work instructions" (Kamil, 2010: 35; Fuad & Ahmad, 2009: 77). Also, according to Verizon (in Ahmad, 2009: 77), the definition of On the Job Training is as "training where workers or prospective workers placed in real work conditions under the supervision of instructors or supervisors. This On the Job Training used as On Service Training. Furthermore, In Service, I am about the content of the theory of PAUD supervisory competence as well as preparation of implementation and On service. Then, In Service II is discussing the implementation and reflection of On Service. Lastly, On Service activities are implemented to provide the content of competence material obtained on in Service I.

The model discussed here contains in and On Service Training based on andragogy. Andragogy defined as adult advocacy. According to Knowles (Depdiknas, 2008: 8), entitled "The Adult Learner, A Neglected Species," the proper learning theory for adults is andragogy. The term andragogy comes from the Greek word "and" which means adult and "agogos" which means to guide or nurture. Thus, andragogy realized as a way of science and art to help adults to learn. Also, the main principle of andragogy is: "what learners learn, not what teachers teach," which means what an adult obtains from an educational or training meeting. Thus, In and On Service Training model based on andragogy is the in and On Service Training model used with adult learning approach.

In this paper, the discussion focused on developing the conceptual model of in and On Service Training model based on Andragogy. The aspects presented include: (i) learning models (ii) teaching materials (iii) learning tools (iv) assessment guides, (v) evaluation instruments, (vi) academic supervision instruments, and (vii) managerial supervision instruments. Lastly, this model includes the development of Supervision and Supervisory Instrument.

## 2. Method

The development of a conceptual model refers to the educational research and development method modified by Sugiyono (2009: 409). In principle, the development of conceptual model design begins with the preliminary study stage which the activities include (i) theoretical and regulatory studies and (ii) the assessment of the problem focus and the initial data collection. Based on the results of the theoretical studies up to the initial data collection, for the model development stage, a conceptual model design consists of (i) draft learning model (ii) teaching materials (iii) tools and curriculum (iv) assessment guide, (v) evaluation instrument, And (vi) supervisory instruments, done by workshops attended by (a) Experts and practitioners of PNF (training), (b) Expert Team and PAUD Practitioners, and (c) Education Management Experts and Management Team. Finally, the conceptual model design validated by a Team consisting of Expert Lecturer of PNF and Training Practitioner from Educational Quality Assurance Agency of Province (*Lembaga Penjaminan Mutu Pendidikan Provinsi*/LPMP).

## 3. Conceptual Model Design

The conceptual design draft was done by doing a workshop which then had been validated by the Expert Team. The conceptual design made includes (i) training devices design, (ii) teaching material design, (iii) evaluation program device design and its instrument, (iv) academic supervisory device design and its instrument and (v) Managerial, supervisory program device design and its instrument.

### *3.1. In and On Job Service Training devices design*

In and On Service Training is designed as follows

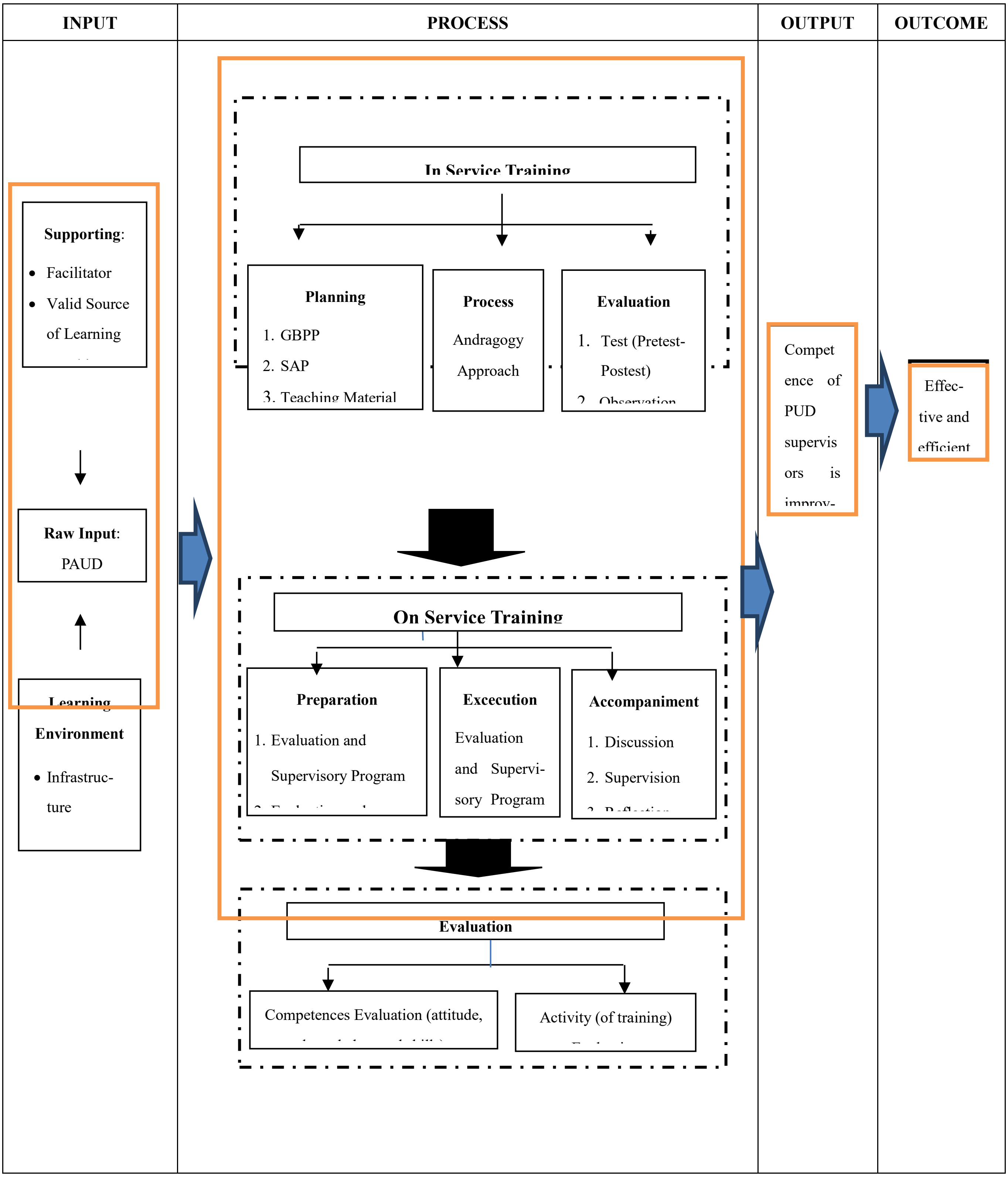


Diagram 1. Schematic of conceptual design Model in and On Service Training Based on Andragogy

According to Diagram 1, the ins and On Service Training consist of 4 (four) major components, namely: (i) input, (ii) process, (iii) output, and (iv) Outcome. In input component, the raw input is PAUD supervisor. The supporting input is qualified facilitators, fine learning system, teaching materials based on the competence of PAUD supervisors, learning facility based on andragogy approach, and the ability of PAUD supervisors. Last Input is learning environment, focused on the availability of decent infrastructure and conducive learning surroundings.

The process steps divided into 3 points, which are (i) in service training, (ii) On service training, and (iii) evaluation. In service, training activity is an indoor training for 45 minutes for each 30 Learning Hours (Jam Pembelajaran/JP). Then, On Service training activity is an activity where the supervisors improve their competence in their PAUD institutions. Lastly, evaluation of the training program done by evaluating the competence of supervisors such as attitude, knowledge, and skills.

The output step will see after the training finish. The expectation will include the improvement in supervisors' competence (attitude, knowledge, and skills), which can conclude from the questionnaire result (for the attitude), the pretest and post test results (knowledge) and the observation result of both In service training and On service training activity (skills). The outcome of the training will see the results of supervision of teachers, PAUD tutors about the effectiveness and efficiency of learning.

Training activity did by supporting input such as Main points of the training program (Garis-Garis Besar program relation /GBP) and training Requirements (Satuan Acara Pelatihan /SAP) like Teaching Material, syllabus, and Training Participant Worksheet. Each inputted normative structure and systematic. Finally, the content of the input based on the training that will teach.

### *3.2. Material Devises Design*

Teaching material developed as teaching materials used in the training activities based on andragogy contains material descriptions within the scope of supervisory competence and andragogy. Validation of teaching materials includes (i) material content, (ii) teaching material structure, and (iii) language.

### *3.3. ManagerialSupervisory Program Devices Design*

This design is about devices for managerial, include (i) supervision program, (ii) supervisory instrument, (iii) supervisory report. Furthermore, the supervisory instrument covers: (a) managerial supervision instrument, (b) monitoring and guidance instrument for principal, and (c) guidance instrument for a teacher to educate learners. The survey result shows that most of these devices not prepared by some supervisors, especially PAUD supervisors. Therefore, these devices are attempted to provided through the development of this model.

### *3.4. Academic Supervision Program Devices Design*

Similar to the previous design, the devices for academic supervision program also includes (i) supervision program, (ii) supervisory instrument, (iii) supervisory report. Furthermore, the supervisory instrument covers: (a) managerial supervision instrument, (b) monitoring and guidance instrument for principal, and (c) guidance instrument for a teacher to construct teaching syllabus and devices. The survey result shows that some of the supervisors do not prepare most of these devices.

### *3.5. Educational Evaluation Program devices design*

Educational evaluation program devices include: (i) evaluation program, (ii) evaluation instrument, (iii) evaluation report. The evaluation instruments include (a) instrument for principal performance appraisal, (b) instrument for learning monitoring and students report, and (c) instrument for teacher coaching in managing assessment in school. These instruments are also not provided by the PAUD supervisors. Therefore, the devices are necessary to be developed.

## 4. Closing

### *4.1. Conclusion*

The conceptual designs developed in this research include (i) training devices and design, (ii) teaching material design, (iii) evaluation program device design and its instrument, (iv) academic supervisory device design and its instrument and (v) Managerial, supervisory program device design and its instrument.

### *4.2. Suggestion*

This conceptual design needs further investigation to give more effective and efficient model.

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# Laboratory Course Modular Design for Learning Magnetic Components in Power Conversion Applications at Taipei Tech

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## Abstract

*The main theme of this paper is to present the laboratory course modular design for learning and hands-on magnetic components in power converters. The objective of the course is to give the students to model the converters, realize magnetic components and test the implemented converters via the hands-on work in order to improve practical skills of students under the insufficiency of regular course training. This designed course is based upon the modular concept of five modules in common use which include forward converter, flyback converter, push-pull converter, half-bridge converter and full-bridge converter. The controllers for these converter modules include voltage mode control and peak current mode control.*
*The specifications for each converter module are the same, 48V/12V, 60W and 100 kHz of switching frequency. The designed modular curriculum has been applied to the Industrial Technology Research and Development Master (ITRDM) Program sponsored by the industry and government. And excellent acknowledgment from students is received for providing practical training and covering the wide range of magnetic components in power conversion applications.*

**Keywords:** power conversion; magnetic components; converter; designed modular course; learning and hands-on

## 1. Introduction

The Industrial Technology Research and Development Master (ITRDM) Program [1] is mainly sponsored by the government and companies. This program is aimed at providing graduate-level engineering workforce in high-tech industry and increasing the competitiveness of technology industry in Taiwan. The students received such sponsorship have the obligation to serve in the sponsored company for 2-4 years, depending upon the contract and content of sponsorship. Therefore, the final decision to accept the student to join this program is the sponsored company rather than the university. Under this circumstance, both hands-on skills and elementary knowledge trainings are important since the students assumingly receive job offer aiming at R & D as they join this program.

The power electronics industry is one of the most promising industries in Taiwan. As reported [2], Delta Electronics, Inc. was the first place of power supply market in the world and some of power supply manufacturers, such as AcBel Polytech Inc., Sunpower Technology Corp. and Lite-On Technology Corporation etc., are founded and locate in Taiwan. Therefore, the R & D workforce in power electronics is especially heavy in demand.

Taipei Tech. has established ITRDM program in power electronics since 2006. The related industry sponsors focus either power supply or motor drives industry. The course "Practice of Power Electronics System" is one of the optional courses for those who will join power supply industry. Therefore, the course is designed to help the students of ITRDM Program to fully appreciate the components of power conversion, converter design and hands-on experience.

It is well known that magnetic components are one of the most important elements in power converter applications. The magnetic components are used as energy storage, energy conversion and driver as shown in Fig. 1. Using DC/DC power converter as an example, the voltage level cannot be changed by transformer for not being able to produce time variant magnetic field without the assistance of switching components. By the switching devices, electrical energy of DC source is chopped and converted to time variant magnetic one and stored in the magnetic components on primary side and then transferred to the secondary side. The magnetic energy is finally converted to electrical energy to meet the desired voltage level by controlling the duty ratio of switching device.

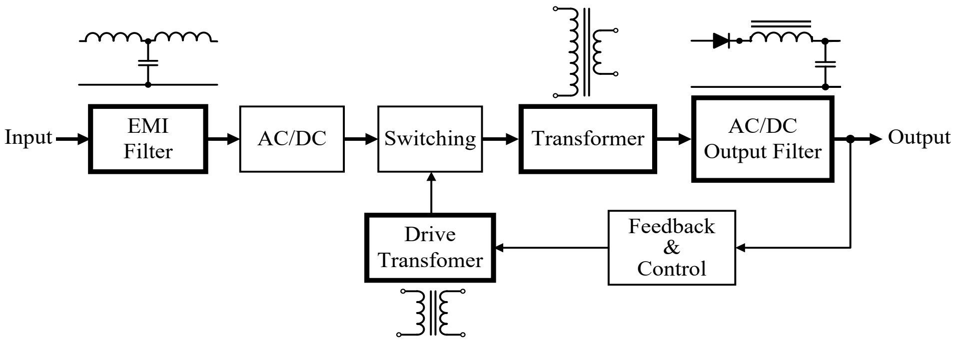



Fig. 1 Magnetic components in energy conversion system

The main theme of this paper is to present the laboratory course design for magnetic components learning and hands-on for ITRDM Program [3]. Recently, some reports have developed the software-based training program and tools, including new methodological approach to teaching power electronics converter experiments using LabVIEW [4], interactive rectifier educational tools using Java [5], graphic tool programmed in MATLAB for ac/dc and dc/dc switched-mode power supplies [6, 7] and e-learning platform for electrical circuit courses [8]. Some project-oriented programs have also been developed to enhance the students with hands-on experience in power electronics. These programs include project-oriented adjustable speed drive design course [9], project designed course for power electronics and motor drives using programmable intelligent computer (PIC) microcontroller and an H-bridge converter [10], and project task in power electronics based on a flyback test board [11]. Similar software-based tool and "learning-by-doing" course for control have been shown in [12-14], respectively.

Comparing to previous software-based work and project-oriented hands-on course, this paper will present the laboratory course modular design for magnetic components learning and hands-on [15, 16]. The design and applications of magnetic components include inductor, drive transformer, and transformer with and without center-tapped windings. The designed modular curriculum is based upon modular concept and the modules include forward converter module for inductor and transformer with center-tapped winding, flyback converter module for transformer with air-gap core acting as inductor and transformer, push-pull converter module for transformer with center-tapped winding, and full-bridge converter module for drive transformer.

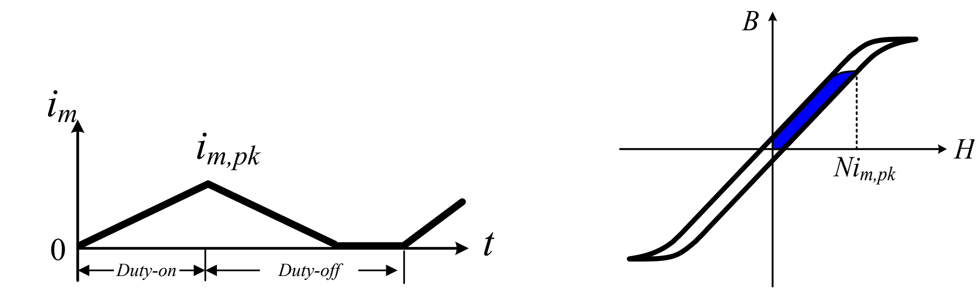
The specifications for all converter modules are the same, 48V/12V, 60W and 100 kHz of switching frequency. The designed modular curriculum has been applied to the ITRDM program sponsored by the government and companies. It will be shown that excellent acknowledgment is received for providing practical training and covering the wide range of practice of magnetic components in power conversion applications.

## 2. Designed Laboratory Modules for Magnetic Component Learning

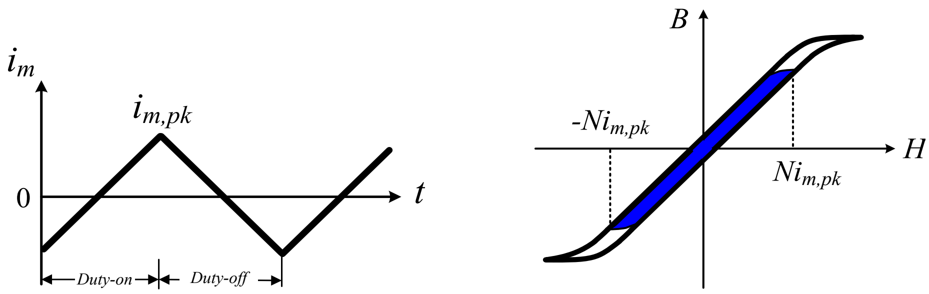
### *2.1 Basics to the Magnetic Component for Power Conversion*

As shown in Fig. 1, the magnetic components for power conversion include: transformer, driver and inductor. For transformer applications, one is called uni-directional excitation and the other is named bi-directional excitation as shown in Fig. 2. The former is applied to both forward and flyback converters, in which magnetizing current is provided only in one direction. The later one is used in push-pull, half-bridge and full-bridge converters in which magnetizing current is either I or III quadrant in B-H curve.

Moreover, the transformer for uni-directional excitation in flyback application also acts as an inductor. Its stored energy is released in the duty-off period other than duty-on duration. In contrast, the energy stored in the transformer of forward converter is pumped to the output side in the duty-on period.




(A) Magnetizing current, uni-direction (B) B-H curve, uni-direction




(C) Magnetizing current, bi-direction (D) B-H curve, bi-direction

Fig. 2 Magnetizing current and B-H curve of transformer, $i_m$ = magnetizing current, $i_{m,pk}$ = peak value of $i_m$, $N$ = number of turns of winding

### *2.2 Special Features of the Designed Laboratory Course*

Table 1 summarizes the special features of the designed laboratory course related to the magnetic components for power conversion applications. As shown in Table 1, both transformer and inductor components are included for forward converter module. However, the transformer in this module is with third winding for de-magnetizing. For flyback converter module, the transformer is different from that for the other modules since it is used as both energy conversion and storage. Therefore, the design should be considered air-gap in order to avoid the flux saturation. Moreover, for push-pull converter module, the transformer has center-tapped windings on primary and secondary sides. In contrast, the half-bridge module transformer is with center-tapped winding on the secondary side only. For the full-bridge module, transformer, inductor as well as drive transformer are considered. Therefore, in the 18-week, 3-hour per week course, the students are motivated to learn how to design these magnetic components and their implementation. And these modules can cover the courses requirement of magnetic components for power conversion applications.

To provide a laboratory work while not invoking safety regulations, 48V/12V is specified for input and output voltage rating. Without requiring high power source and electronics load, the power rating for each module is 60W. However, to respect the students to fully appreciate the importance of layout, the switching frequency is 100 kHz. The specifications of each module are summarized as follows.

- Input Voltage: 48 V
- Output Voltage: 12 V
- Output Current: 5 A
- Output Power: 60 W
- Switching Frequency: 100 kHz

Table 1 Special features of the designed laboratory course related to the magnetic components for power conversion applications, Tr. = transformer

| | Forward | Flyback | Push-pull | Half-bridge | Full-bridge |
|---|---|---|---|---|---|
| Transformer | √ | √ | √ | √ | √ |
| Inductor | √ | | √ | √ | √ |
| Drive transformer | | | | | √ |
| Special Features of magnetic components | Uni-direction Tr. with 3rd winding for de-magnetizing | Uni-direction Tr also acts as inductor | Bi-direction Tr. with center tapped windings | Bi-direction Tr. with center tapped winding on secondary | Bi-direction Tr. with center tapped winding on secondary |

### *2.3 Forward Converter Module*

Fig. 3 shows the circuit diagram of forward converter. This module is designed to help students to get familiar with the inductor and transformer design. The special feature of the designed transformer is with the third winding as shown in Fig. 3. As mentioned in the sub-section of Sec. II, the transformer for forward converter is uni-directional which is magnetized in the duty-on period. In order to provide a de-magnetizing mechanism to avoid the flux saturation, a third winding is required.

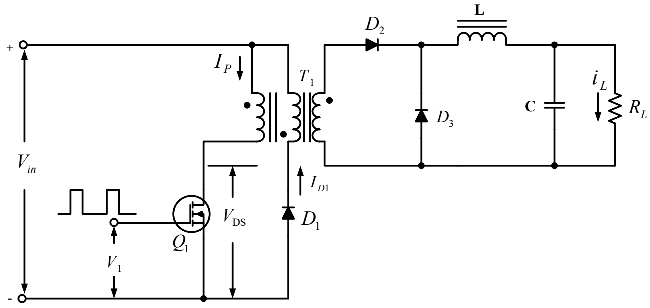



Fig. 3 Circuit of forward converter

### *2.4 Flyback Converter Module*

The circuit of flyback converter is shown in Fig. 4. Obviously, the magnetized energy is stored in the exciting duty cycle and released in the remaining duty-off period. Therefore, the transformer also acts as an inductor. To provide a demagnetizing path to clamp the voltage spike, RCD clamping circuit [17] consisting of resistor, *R*, capacitor, *C*, and diode, *D* connected in parallel with the primary winding of transformer is used as shown in Fig. 4. Moreover, since the transformer acts as well as inductor which stores the energy, air-gap is required in its magnetizing path for avoiding saturation.

Therefore, this module is designed to facilitate the students to learn the design and implementation of a transformer with air gap. In short, the required magnetic component for this module is totally different from those in the other modules. Moreover, without causing too much leakage and loss in the air gap, the design of air gap is essential to the success of this module.

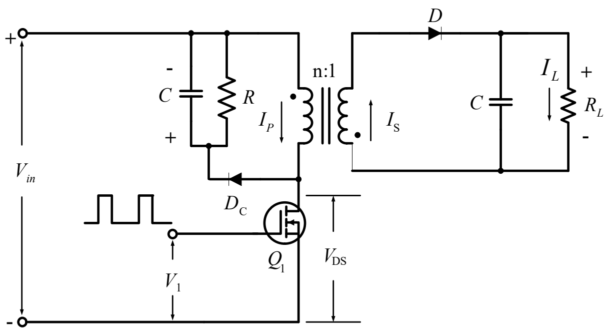



Fig. 4 Circuit of flyback converter

### *2.5 Push-pull Converter Module*

This module is aimed at assisting the students to fully appreciate the design of transformer with center-tapped windings on both primary and secondary sides as shown in Fig. 5. Moreover, it will help students to understand the operation of bi-directional magnetic component. As compared with Fig. 3 and Fig. 4 for uni-directional magnetizing transformers, neither de-magnetizing winding nor clamping circuit is required for such bi-directional one. Another advantage for push-pull converter is its simplicity and excellence of driver circuits for two MOSFETs due to their common-ground features. By this module, the students will discover these special features as well as magnetic component design and implementation.

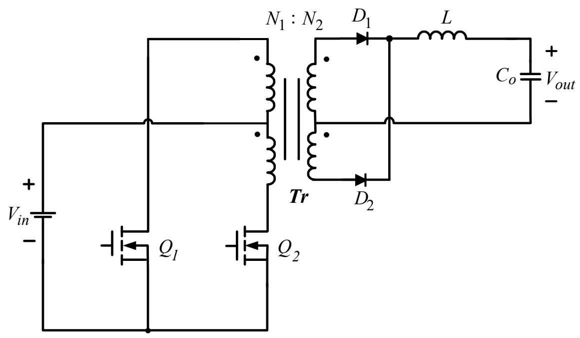



Fig. 5 Circuit of push-pull converter

### *2.6 Half-bridge Converter Module*

Fig. 6 shows the circuit of half-bridge circuit which will give students the understanding of the transformer with only center-tapped winding on its secondary side. In this module, students will learn how to use the boot strap driver IC to drive the high-side and low-side MOSFET. Moreover, the voltage balance between two DC-link capacitors is also highlighted in this module. Without causing magnetic saturation due to the voltage un-balance of DC-link, a capacitor, $C_B$, is used to block the DC component as shown in Fig. 6.

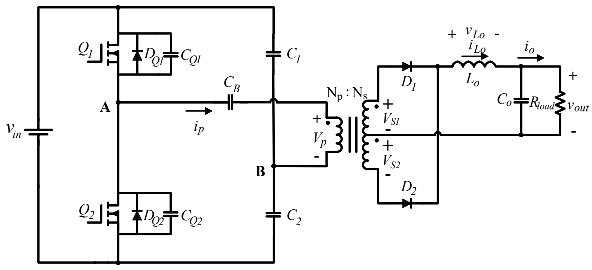



Fig.6 Circuit of half bridge converter

### *2.7 Full-bridge Converter Module*

Fig. 7 shows the circuit of full-bridge converter. As shown in Fig. 7, the special feature of the transformer is the same as the half-bridge converter. Since full-bridge converter is applied to high power in general, its driver circuit consists of transformer driver rather than using boot strap driver in order to provide galvanic isolation between primary and secondary sides of transformer. Therefore, the objectives of this full-bridge converter module include introducing the transformer design used in driver circuits for both high-side and low-side MOSFETs. Fig. 8 shows the schematic diagram of drive transformer used in full-bridge converter.

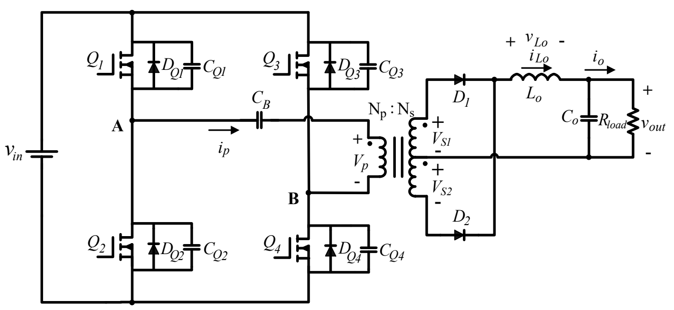


Fig. 7 Circuit of full-bridge converter

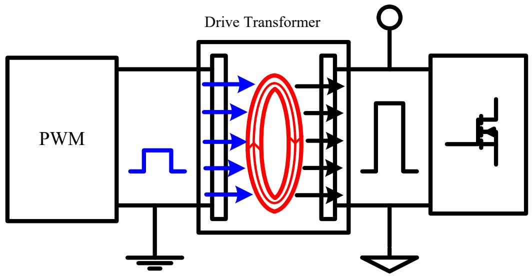
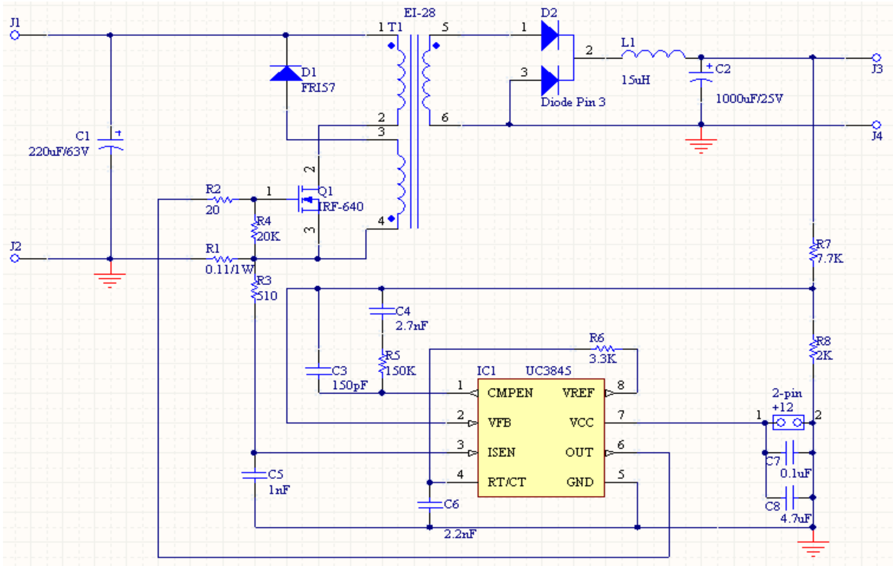



Fig. 8 Schematic diagram for drive transformer

## 3. Example of Design and Implementation

Fig. 9 shows the details of the circuit of the designed forward converter module. As shown in Fig. 9, the magnetic components include a transformer with the third winding and the output inductor. Moreover, UC 3845 [18] is used as the controller. And the output voltage is sensed by the voltage divider consisting of $R_7$ and $R_8$. The parameter of voltage controller is determined by the *RC* network, $R_5$, $C_3$ and $C_4$. The module details are introduced as follows.



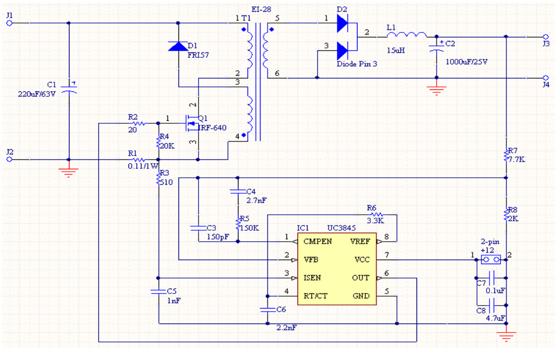



Fig. 9 Details of the circuit of the designed forward converter module

### *3.1 Design of Transformer*

The design of transformer includes the turn number of primary, secondary and the third winding for demagnetizing. In order to reduce the skin effect, the number of wires for the windings should be considered. These data are derived based upon the specifications, core of transformer and dimension of wire. The details of the design are as follows.

Calculating the peak current of primary current:

$$I_{pri} = \frac{P_{out}}{\eta V_{in,\,\min}} = \frac{60}{0.8 \times 48} = 1.56 \text{ (A)}$$

where $\eta$ = efficiency of forward converter = 0.8

Calculating the minimum voltage of secondary side:

$$V_{\sec,\,\min} = \frac{(V_o + V_f) \times T}{T_{on}} = \frac{(12+1) \times 10}{3} = 43.33 \text{ (V)}$$

where $V_f$ = forward voltage drop of output diode, $T_{on}$ = turn-on period, $T$ = switching period

Turn number of primary winding:

$$N_p = \frac{V_s \times T_{on,\,\max} \times 10^8}{B_m \times A_e} = \frac{48 \times 4.5 \times 10^3}{86 \times 273} = 9.2 \;\rightarrow\; 10 \text{ Turns}$$

$B_m$= Designed maximum flux density for the selected core, TDK PC4 core [19], which is 70% of its saturated flux density

$A_e$= Effective cross area of the selected for the selected core, TDK PC4-EI28Z [19]

$T_{on,max}$ = maximum turn-on period,

Turn number of secondary winding:

$$N_s = \frac{(V_{\sec,\,\min} \times T_{on,\,\max}) \times 10^8}{B_m \times A_e} = \frac{43.33 \times 4.5 \times 10^3}{86 \times 273} = 8.3 \;\rightarrow\; 9 \text{ Turns}$$

Turn number of the third winding:

$$D_{\max} = \frac{1}{1 + \dfrac{N_p}{N_r}} \Rightarrow 0.45 = \frac{1}{1 + \dfrac{10}{N_r}}; \quad \therefore N_r = 8.18 \;\rightarrow\; 9 \text{ Turns}$$

Number of wires of windings:

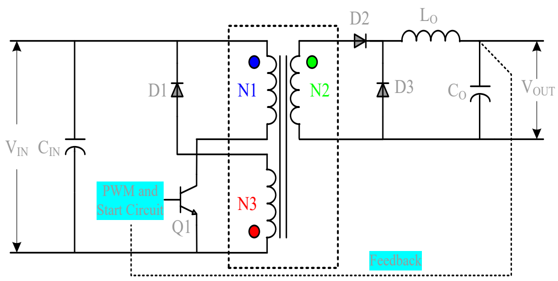
For the copper wire, the skin depth, $\delta$, indicating at which the current attenuates to $e^{-1}$ of that at the skin of conductor. The diameter of the wire should not be greater than $2\delta$ to fully utilization of the conductor. The wire with diameter meeting this criterion is called Litz wire. The skin depth shrinks as the switching frequency increases. To carry large current, more twisted Litz wires connected in parallel are required. The number of wires is calculated as follows. First, the skin depth for copper wire with switching frequency = 100 kHz is calculated.

$$\delta = \frac{6.6}{\sqrt{f_{sw}}} = \frac{6.6}{\sqrt{100 \times 10^3}} = 0.021\ (\mathrm{cm}) = 0.21\ (\mathrm{mm})$$

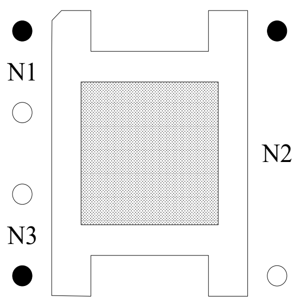
Therefore, the wire with diameter = 0.4 mm or 16 mil, and current density = 400 A/CM, is selected. The number of wire for primary winding, $k_1$, can therefore be derived as follows. Similarly, the number of wires for secondary side is 9.

$$k_1 = \frac{400 \times 1.56}{\frac{\pi}{4} \times 16^2} = 3.10 \ \rightarrow \ 3$$

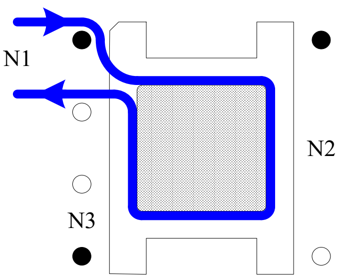
To facilitate the students to fully appreciate the implementation of the transformer, Fig. 10 shows the circuit, transformer implementation process and the photo of implemented transformer. To follow the above-mentioned design stages and this detailed process; see Fig. 10 (A) to Fig. 10 (G), the students can easily implement the transformer as illustrated in Fig. 10 (F).



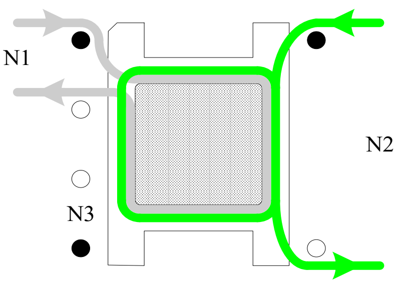

(A) Circuit of forward converter



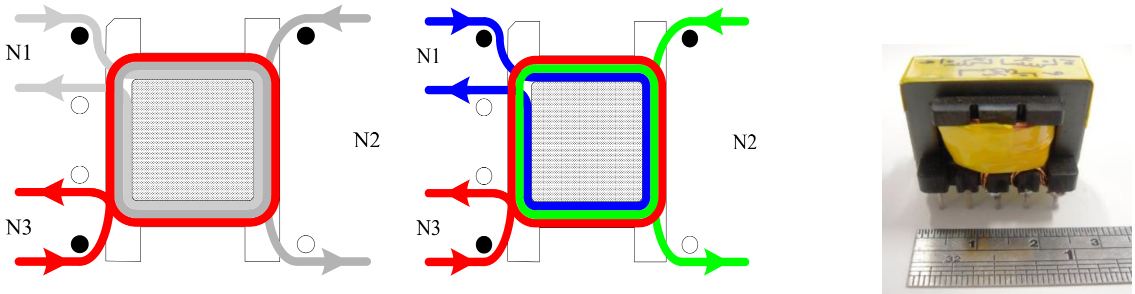

(B) Bobbin and core,




(C) Primary winding,




(D) Secondary winding




(E) Third winding, (F) Completion of transformer, (G) Photo of transformer

Fig. 10 Illustration of transformer implementation, forward converter

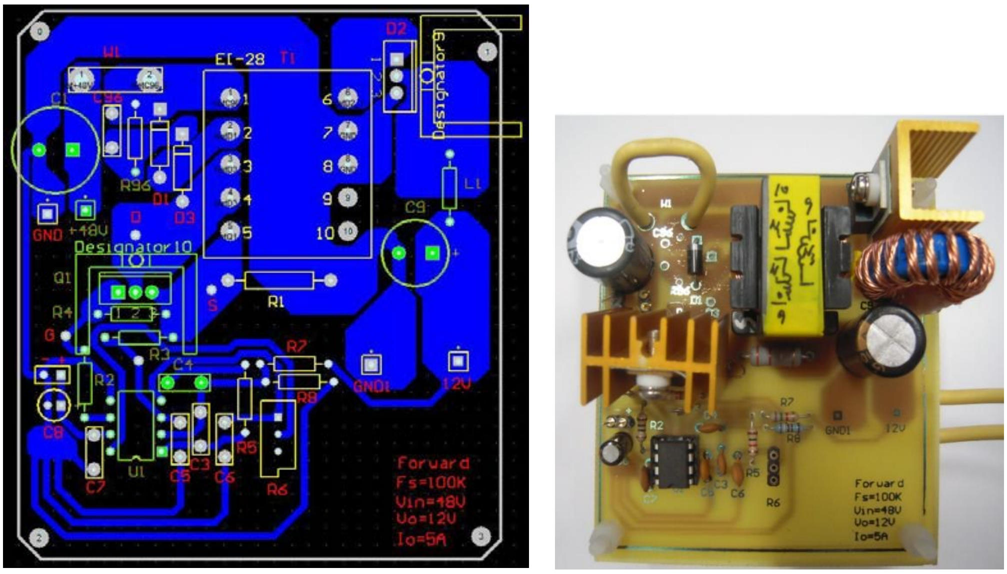
### *3.2 Design of Inductor*

The core for inductor design and implementation is MS-080060-2, MPP core, ARNOLD. By the datasheet [20], the inductance factor, *mH* for 1000 turns, $A_L$ = 32 mH/N$^2$. Therefore, for the inductor current = 5A and inductance = 15 μH, the number of turns is 22 and the number of wire is 10. Fig. 11 shows the implemented inductor which is designed and made by the student taking this course.

Fig. 11 Photo of inductor, made by student

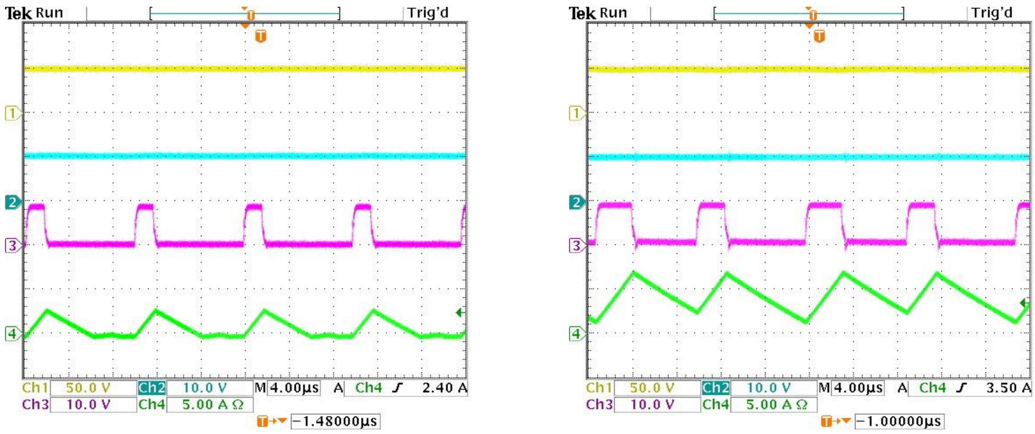
### *3.3 Assessment of Design and Implementation*

Fig. 12 shows the layout and photo of the implemented forward converter; both are made by the student taking this course. For the switching frequency = 100 kHz, layout is important to the success of the implementation. To help the students to further confirm the design and implementation [21, 22], some test results are required as illustrated in Fig. 13. As shown in Fig.13 (A) and Fig. 13 (B), the output voltage can be well regulated at 12 V. Moreover, the duty; see Ch 2 in Fig. 13, increases and the inductor current goes to continuous conduction mode from discrete conduction mode as the load increases. These results are measured by the students from their implemented module for confirmation. Another measurement related to efficiency as shown in Fig. 14 is required to help students to understand the importance of converter design and implementation.




(A). Layout, (B). Photo

Fig. 12 Results, forward converter module made by students




(A) Output = 1A, 20% load, (B) Output = 5A, 100% load

Fig. 13 Measured results, forward converter, output voltage and inductor current, Ch 1 = input voltage, Ch 2= output voltage, Ch 3 = Vgs of MOSFET, Ch 4 = Inductor current

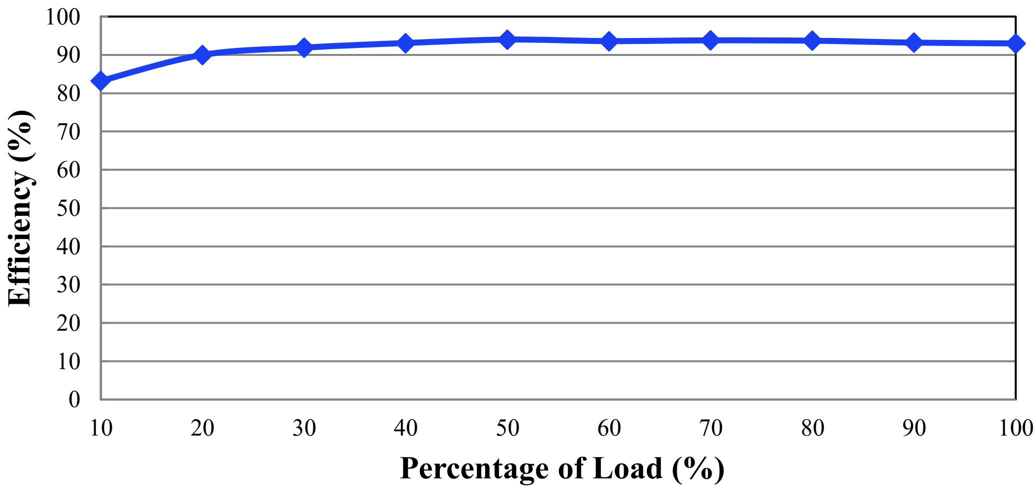
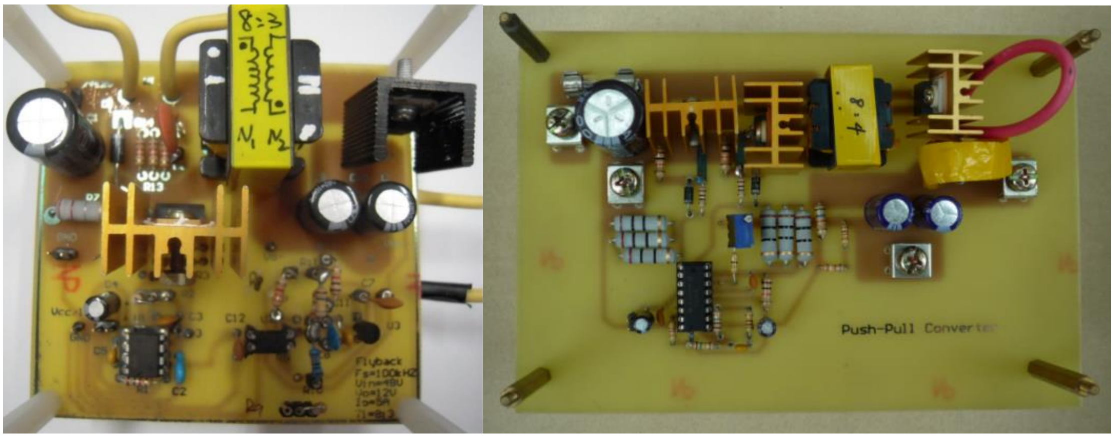


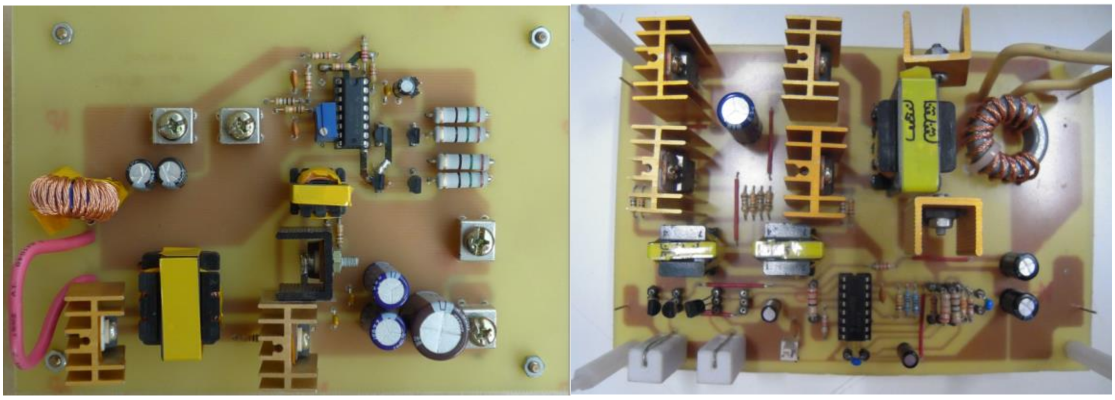
Fig. 14 Measured results, efficiency *vs.* load current

## 4. Course Implementation and Feedback

The other modules are designed and implemented based upon the same concept and development process. The students can follow the designed course to learn the magnetic components design and implementation. Similar training for layout, implementation and test are given to students to help them appreciating the special features of the required magnetic components applied to flyback converter, push-pull converter, half-bridge converter and full-bridge converter. Fig. 15 shows the photos of these converters realized by the students joined this course.



(A) Flyback converter, (B) Push-pull converter,



(C) Half-bridge converter, (D) Full-bridge converte

Fig. 15 Photos of implemented board, made by students

A survey is conducted which contains eight statements regarding the course [23-25]. Students are asked to rate these statements. Survey statements and associated responses from students are given in Table 2. The overall average is 4.61 points out of five. According to the survey, students showed really positive reaction to this course. The majority of the students are quite satisfied with this course, 4.87 points. Moreover, it is said that this course provides students better comprehension about the magnetic component design of power converters after taking this course. Another important point in this feedback is that this course helped students to learn the magnetic component implementation of power converters, 4.87 points, higher than the average. The feedback indicates that this designed course receives excellent acknowledgment for providing practical training and covering the wide range of magnetic components in power conversion applications.

Table 2 Feedback, Average points = 4.61 out of 5

| The Designed Power Electronics Laboratory Course | Strongly Agree (5 points) | Agree (4 points) | Neutral (3 points) | Disagree (2 points) | Strongly Disagree (1 point) | **Average Points** |
|---|---|---|---|---|---|---|
| I become familiar with the layout of power converters after taking this course. | 12 | 4 | | | | 4.75 |
| I have better comprehension about the magnetic component design of power converters after taking this course. | 9 | 7 | | | | 4.56 |
| This course helps me to learn the magnetic component implementation of power converters. | 14 | 2 | | | | 4.87 |
| I have better comprehension about the controller design of power converters after taking this course. | 6 | 7 | 3 | | | 4.18 |
| This course helps me to learn the controller implementation of power converters. | 8 | 6 | 2 | | | 4.37 |
| This course makes significant contributions to my hands-on test capability of power converters. | 13 | 2 | 1 | | | 4.75 |
| This course promotes my professional skill in power converter. | 10 | 5 | 1 | | | 4.56 |
| In general, I am quite satisfied with this course. | 14 | 2 | | | | 4.87 |

## 5. Conclusions

The contributions of this paper include the presentation and assessment of a laboratory course modular design for magnetic components used in power conversion applications. Five modules are designed to help students to fully appreciate the theory, hands-on work of layout, magnetic components design and implementation, and integration test. These magnetic components include inductor, transformer for power conversion and drive transformer. Transformers for power conversion include uni-direction and bi-directional applications with/without third windings and center-tapped winding(s).

The feedback from the Industrial Technology Research and Development Master Program students indicates that this designed course receives excellent acknowledgment for providing practical training and covering the wide range of magnetic components in power conversion applications. The designed course indeed facilitates the students to learn magnetic components design and implementation for power conversion applications.

## 6. Acknowledgement

The Industrial Technology Research and Development Master Program is organized and supported by the Ministry of Educations and Ministry of Economy Affairs, Taiwan. The industrial sponsorship for the power electronics course at Taipei Tech. is kindly offered by AcBel Polytech Inc., Allis Electric Co., Ltd., Chicony Power Technology Co., Ltd., Delta Electronics, Inc., Jaguar Precision Industry Co. Ltd., Leader Electronics Inc., Lite-On Technology Corporation, Rhymebus Corp., Sunpower Technology Corp. and TECO Electric and Machinery Co. Ltd., etc. since 2006. The authors also appreciate those students who joined this course and gave feedback for further improvement.

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# Heat exchange on the outside of the pipe when heat is distributed by heat networks

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## Abstract

*The article deals with the exchange of heat on the outside of the pipe when distributing heat through heat networks. This is a combined heat exchange, i.e. free convection and radiation. The calculations and outputs analysed in the article are mainly applicable to thermal networks run aboveground. In the calculation, an ambient temperature of 15 °C was measured, ranging from the temperatures corresponding to the air temperatures in the channel. The results are interpreted in the form of diagrams and tables. The calculation was performed on the secondary DN 125 pipe with PIPO_ALS insulation and the calculation was extended to all nominal diameters used in the secondary wiring for determining the influence of heat transfer, depending on the change in pipe diameter.*

**Keywords:** thermal network, heat transfer coefficient, convection, radiation

## 1. Introduction

In the supply of heat through heat networks, there are signs of thermal losses affecting the operation of the heat network and the overall economy of the heat supply. Analytical methods are currently being used to determine heat losses, in which it is necessary to perform a detailed analysis of all measured and calculated variables occurring in individual relationships. The determination of the external heat transfer coefficient consists of the determination of its part, connected to the convection (free or forced) and also to the radiation.

## 2. The Effect of Free Convection on the Heat Transfer Coefficient

To determine the coefficient of external heat exchange according to free convection αk, the following equations were used for free flow in an unlimited space:

$$\overline{\alpha}_{\mathrm{k}} = \frac{\overline{Nu}\ .\ d}{\lambda} \quad (1) \tag{1}$$

where: $\overline{Nu}$ is Nusselt's number ( $\overline{Nu} == C\cdot(Gr\cdot Pr)^n\cdot\varepsilon$) (1),

$\lambda$ - thermal conductivity coefficient ($W\cdot m^{-1}\cdot K^{-1}$),

$d$ - the characteristic dimension (m)

$Pr$ - Prandtl's criterion (1),

$Gr$ - Grashoff's criterion (1).

For the storage conditions and the character of the pipe, the constants C = 0.5, $n$ = ¼, $\varepsilon$ = 1 were chosen.

The process of the heat transfer coefficient on the outside of the pipe was analysed for the measured water flow $Q_{V1}$ = 2.68 $m^3\cdot h^{-1}$ ($Q_{m1}$ = 0.73 $kg\cdot s^{-1}$). In the calculations and graphical solutions the PIPO_ALS insulation with the prescribed insulation thickness was considered.

The progress of the Rayleigh number and heat transfer coefficient through free convection on the outside of the pipe, for the analysed heat network (DN 125) at the constant volume flow $Q_{V1}$ = 2.68 $m^3\cdot h^{-1}$, depending on the change in temperature of the transferred water, is in Fig. 1 and from the change in the surface temperature of the insulation is in Fig. 2.

Changing the water temperature in the pipe at a constant velocity ($\upsilon$ = 0.19 $m.s^{-1}$) causes a change in the surface temperature of the insulation, thereby changing Grashoff's number and thus the external heat exchange coefficient $\alpha_k$.

The physical properties of air for air temperature $t_e$ = 15 °C are in Table 1. The table also shows calculated values for $\alpha_k$ for different water temperatures, i.e. and a different temperature for insulation on its surface (DN 125).

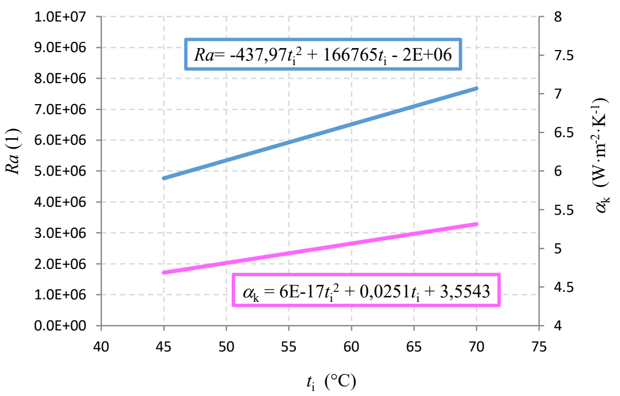



Figure 1. The progress of Rayleigh's number and the heat transfer coefficient on the outer side of the pipe depends on the change in water temperature for DN125

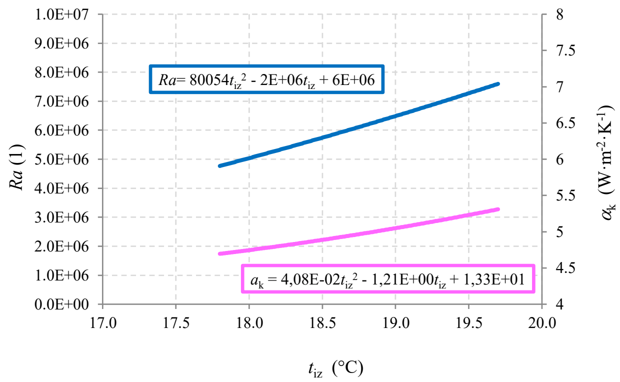



Figure. 2 The progress of Rayleigh's number and the heat transfer coefficient on the outer side of the pipe depends on the change in water temperature for DN125

Table 1. Table of physical quantities and calculated values of the heat transfer coefficient from insulation to air

| $t_i$ (°C) | $t_{iz}$ (°C) | $\rho$ (kg·m$^{-3}$) | $c_p$ (J·kg$^{-1}$·K$^{-1}$) | $\lambda$ (W·m$^{-1}$·K$^{-1}$) | $\eta$ 10$^5$(Pa·s) | $v$ 10$^5$(m$^2$·s$^{-1}$) |
|---|---|---|---|---|---|---|
| 45 | 17.8 | 1.227 | 0.9875 | 0.025 | 1.80 | 1.46 |
| 50 | 18.2 | 1.227 | 0.9875 | 0.025 | 1.80 | 1.46 |
| 55 | 18.6 | 1.227 | 0.9875 | 0.025 | 1.80 | 1.46 |
| 60 | 19.1 | 1.227 | 0.9875 | 0.025 | 1.80 | 1.46 |
| 65 | 19.4 | 1.227 | 0.9875 | 0.025 | 1.80 | 1.46 |
| 70 | 19.7 | 1.227 | 0.9875 | 0.025 | 1.80 | 1.46 |

Cont. Table 1

| *Pr* (1) | *Gr* (1) | *Gr* · *Pr* (1) | *Nu* (1) | $\alpha_k$ (W·m$^{-2}$·K$^{-1}$) |
|---|---|---|---|---|
| 0.715 | 6.62E+06 | 4733992 | 23.3 | **4.7** |
| 0.715 | 7.48E + 06 | 5347156 | 24.4 | **4.8** |
| 0.715 | 8.32E + 06 | 5951304 | 24.7 | **4.9** |
| 0.715 | 9.17E + 06 | 6555451 | 25.3 | **5.1** |
| 0.715 | 9.93E + 06 | 7096479 | 25.8 | **5.2** |
| 0.715 | 1.07E + 07 | 7637507 | 26.3 | **5.3** |

In Fig. 3, the progress of the external heat transfer coefficient is recorded, depending on the change in the pipe diameter, while maintaining the same operating conditions of the network as the water temperature, the used insulation, ambient temperature and volume flow $Q_{V1}$ = 2,68 m$^3$.h$^{-1}$. Tab. 2 shows the values of the heat transfer coefficient $\alpha_k$ for different DN pipes.

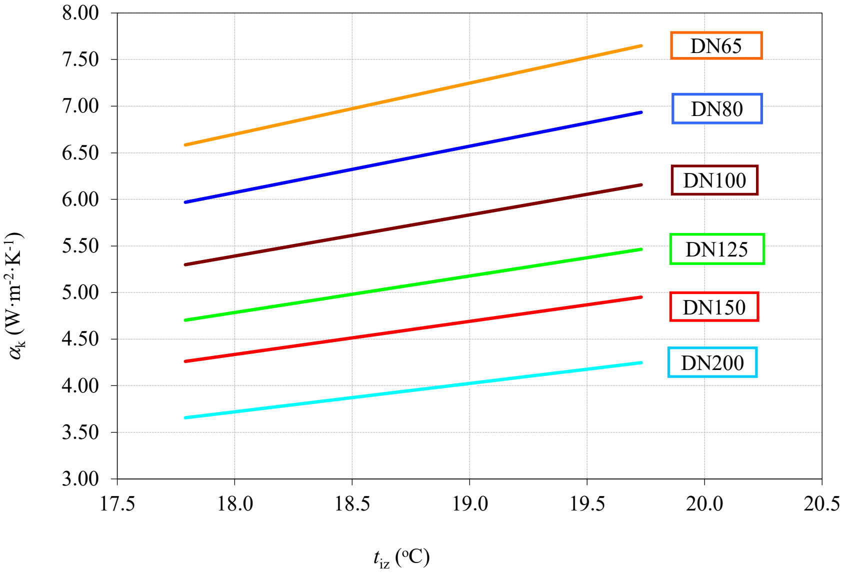



Figure. 3 The flow rate of the heat transfer coefficient on the outside of the pipe in dependence on the change of the pipe diameter at a constant flow rate

Decreasing the nominal pipe diameter means a slight increase in the heat transfer coefficient through convection at the same temperature of the transferred water. By reducing the DN, the rate increases (at a constant volume flow rate) and the temperature gradient decreases from 1 m of pipe length. At the same ambient temperature and the same temperatures of the water being transported, the heat dissipation is more intense with smaller DN.

Table 2 The heat transfer coefficient on the outside of the pipe, depending on changes in the pipe diameter at flow rate $Q_{V1}$ = 2.68 m$^3$.h$^{-1}$

| DN | $t_i$ (°C) | | | | | |
|---|---|---|---|---|---|---|
| | 45 | 50 | 55 | 60 | 65 | 70 |
| | $\alpha_k$ (W·m$^{-2}$·K$^{-1}$) | | | | | |
| DN65 | 6.6 | 6.8 | 7.1 | 7.2 | 7.5 | 7.7 |
| DN80 | 5.9 | 6.2 | 6.4 | 6.6 | 6.8 | 6.9 |
| DN100 | 5.3 | 5.5 | 5.7 | 5.8 | 5.9 | 6.2 |
| DN125 | 4.7 | 4.9 | 5.0 | 5.2 | 5.3 | 5.5 |
| DN150 | 4.3 | 4.4 | 4.6 | 4.7 | 4.8 | 4.9 |
| DN200 | 3.7 | 3.8 | 3.9 | 4.0 | 4.1 | 4.3 |

The external heat exchange represented by $\alpha_k$ is practically not dependent on the amount of the medium transferred or its pipe speed. The influence of the surface temperature of the insulation (which is, at the given quality of the insulation function, only at the temperature of the transferred water), the ambient air temperature, the size of the transport network, its diameter and the type of insulation used and its thickness are predominant.

### *2.1 The Effect of Free Convection on the Heat Transfer Coefficient*

For the heat transfer coefficient by radiating $\alpha_s$, there applies the relationship [5]:

$$\alpha_s = \varepsilon_{12}.C_0 \cdot \left[T_1^2 + T_2^2\right] \cdot \left[T_1 + T_2\right] \qquad (\mathrm{W \cdot m^{-2} \cdot K^{-1}})$$

where $T_1$ - tube temperature (K),

$T_2$ -the temperature of the basement walls (K)

$\varepsilon_{12}$ - relative emissivity (1),

$C_0$ - Stefan-Boltzman constant, C0 = $C_0 = 5.67 \cdot 10^{-8}$ ($\mathrm{W \cdot m^{-2} \cdot K^{-4}}$).

Values of the heat transfer coefficient by radiating $\alpha_s$ depending on the insulation temperature for the measured network (DN 125) are elaborated in Tab 3.

Table 3 Value of $\alpha_s$ depending on the temperature of the insulation (DN 125)

| $t_i$ (°C) | $t_{iz}$ (°C) | $t_{ss}$ (°C) | $\varepsilon_{12}$ (1) | $C_0$ ($\mathrm{W \cdot m^{-2} \cdot K^{-4}}$) | **$\alpha_s$ ($\mathrm{W \cdot m^{-2} \cdot K^{-1}}$)** |
|---|---|---|---|---|---|
| 45 | 17.8 | 15 | 0.9 | 5.67 | **4.95** |
| 50 | 18.2 | 15 | 0.9 | 5.67 | **4.96** |
| 55 | 18.6 | 15 | 0.9 | 5.67 | **4.97** |
| 60 | 19.0 | 15 | 0.9 | 5.67 | **4.98** |
| 65 | 19.4 | 15 | 0.9 | 5.67 | **4.99** |
| 70 | 19.7 | 15 | 0.9 | 5.67 | **5.00** |

Legend: $t_{ss}$ - basement wall temperature (°C), $t_{iz}$ - tube temperature (°C)

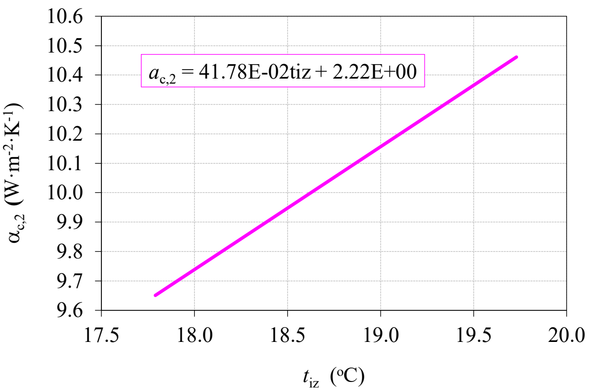
### *2.2 The Overall Heat Transfer Coefficient*

The total coefficient of external heat exchange $\alpha_{c,2}$ is a function of the heat transfer coefficient through free convection and radiation. We identify it with respect [4]:

$$\alpha_{c,2} = \alpha_k + \alpha_s \qquad (\mathrm{W \cdot m^{-2} \cdot K^{-1}})$$

Fig. 4 shows the overall coefficient of the external heat exchange at the surface temperature of the insulation for DN 125.

The progress of the total heat transfer coefficient on the outside of the pipe at constant volume flow rate $Q_{V1} = 2.68\ \mathrm{m^3.h^{-1}}$, depending on the change in the pipe diameter and the changed surface temperature of the insulation is shown in Fig. 5.



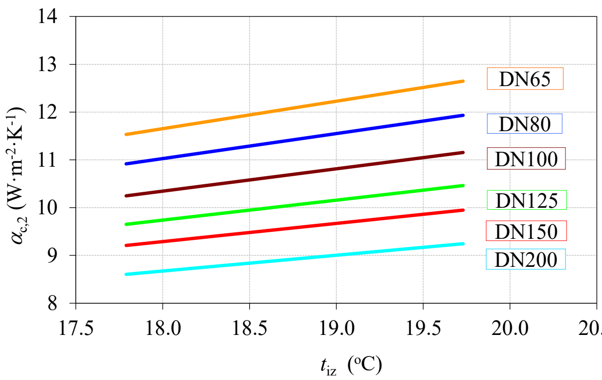



Figure. 4 Progress of $\alpha_{c,2}$ depending on surface temperature insulation for DN 125

Figure. 5 The progress of the total heat transfer coefficient on the outer side of the tube , depending on the change in the pipe diameter at the constant flow

Within the temperature range of the transferred water the value of the total coefficient of the heat transfer on the outside shifts from 8.5 W.m$^{-2}$.K$^{-1}$ (at $t_i$ = 40 °C) to 12.8 W.m$^{-2}$.K$^{-1}$ (at $t_i$ = 70 °C).

## 3. Conclusion

The analytical procedures described in the professional literature can be used to determine thermal losses of heat distribution. Based on the analysis of thermal loss, there applies that the application of the procedure according to the mentioned methodology is mainly accompanied by the complication of the expression of the linear thermal resistance of the network. This depends on the nominal pipe diameter, the temperature of the water to be transported, the ambient temperature, the quality and the thickness of the insulation and the material used for conveyance. The most complicated is the expression of the heat transfer coefficient on the side of the flowing water and the side of the environment in which the conveyance is conducted. The determination of the external heat transfer coefficient consists of the determination of its part, connected to the convection (free or forced) and also to the radiation.

## 4. Acknowledgement

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# Utilization of knowledge systems and bases for selection and evaluation of domestic electrical installations

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## Abstract

*This article deals with the use of the sophisticated methods for the selection of technical and economic solution of electrical wiring. This solution is based not only on a price but also on many other criteria such as a comfort, service, durability etc. The focus of the work is a treatise on wiring systems from a global perspective, where it is impossible to use a conventional approach for objective evaluation and selection of the appropriate electrical wiring system (because of the complexity of such systems and their interdependencies). In the article are given information of an energy consumption (the total consumption and household consumption), consumption prediction – especially for households. Following is an overview of possible measures for reducing electricity consumption in households. In the part of the article are solved the knowledge, respectively expert systems for use in an electrical engineering – especially for a suitable tool for the selection and evaluation of households wiring electrical system. The result of this work provides a possible solution for a selection of wiring electrical system for households (focusing on the intelligent wiring) – from a technical and economic point of view and with using an innovative approach. The main contribution of this work is a proposal of the main part of the knowledge base. This base could be a basis for knowledge, respectively for an evaluating technical and economical solution of an electrical wiring system – the expert system includes also a feedback function of an effective solution, use value, price etc., which would also serve as a knowledge base.*

**Keywords:** household consumption; knowledge system and basis; household management system, energy storage system, alternative energy sources, intelligent electrical wiring; ontology

## 1. Introduction

Nowadays, the house is no longer just four walls, one lamp and a television. In a modern house, it is especially about optimizing the comfort of device control and security optimization. There are lots of new systems for security, control and home comfort. There is a problem with a large number of wires, control points and very complicated wiring to achieve customer's requirements. Companies offer an almost identical product range for intelligent wiring based mostly on three major bus standards - KNX, Nikobus and LON. Basic system requirements include lighting and socket control, visualization, heating, cooling and ventilation control, blinds, awnings, shutters and hinges, windows, doors, gates, power consumption optimization and collaboration with electronic security system and fire alarm. Most companies involved in system wiring offer these features, and they usually differ only in above-standard features, price, etc., but the basic idea remains the same - increasing comfort, safety and energy savings.

Due to the large number of intelligent wiring systems, their possibilities, the types of bus lines, a number of manufacturers, etc., it is necessary to find suitable for the designers or those who are interested in the use of these installations how to choose the type and suitable functional units of the wiring according to predefined parameters. It is necessary to take into account an extensive set of criteria, both from a technical

and economic point of view. The economic aspect in electrical and power engineering is very actual today. The use of economic analyses, even simple, is a matter of course without which the technical problem can not lead to the final and optimal solution. Finance happen in the design of electrical installations almost the most important factor. It is necessary to consider not only the investment costs but also due to the constant increase in energy prices to put more emphasis on the operational costs.
Current issue not only in Europe is maximizing energy efficiency while ensuring maximum environmental friendliness. This can be achieved in several ways. One possible way is to concentrate on small customers, whose typical example is households that have shares as a whole on the resulting energy efficiency. In view of these efforts, we offer the use of efficient methods, especially multi-criteria analysis, or other economic tools for evaluating and selecting the optimal wiring solution. This wiring will thus meet not only technical requirements but also economic requirements. Climate change and the increasing lack of resources is a highly debated issue of today. Many countries around the world are dependent on energy imports - in the EU, for example, 50% of currently consumed energy is supplied. By 2030, the amount of imported energy should reach 70% of currently consumed energy. Efficient and sustainable use of energy is a necessity - fully in line with the motto created by the European Commission - "Less is more" [1].
In addition to transport and industry, the other largest appliance of energy is the operation of buildings. Heating, cooling and lighting of residential and non-residential buildings consume approximately 40% of all energy in technologically advanced countries. This is an amount requiring great attention. With regard to the EU and Czech Republic's efforts to reduce energy consumption, it is possible to study electricity savings using system wiring, their optimal design within the technical and economic solution using modern selection methods and subsequent economic and technical evaluation. This opens up the possibility of using knowledge, respectively expert systems for selecting the optimal wiring options for the household sector. In the framework of this study and the effort to make practical use of the system for the selection of household wiring, the analysis and subsequent implementation of the European directives, standards and regulations together with the other international standards should be used in order to help the designers of electrical engineering. Furthermore, this system can serve as the basis for the investor, the owner or as the support for the building energy certificate.
The result in this article should provide comprehensive selection information for home electrical wiring solutions, focusing on system installations, family houses and residential buildings from a technical and economic point of view, using innovative approaches. The aim of this work is to design a knowledge base and the possibility of using knowledge systems for evaluation of the technical solution of the wiring, whose components would also be a feedback function about the effectiveness of the solution, utility value, price, etc., which would serve as a feedback and specifying the basis of the knowledge base.

## 3. Household electricity consumption

Previously, it was valid that most of the energy consumed in the home for heating and hot water. That still applies in most cases. In recent years, however, the difference between energy consumption for heating and water heating and other energy consumption for household electrical appliances is decreasing. This is partly due to the fact that new or refurbished insulated houses often have half or a third of heat losses, while the efficiency of domestic appliances is growing slowly and, moreover, appliances in households are still increasing significantly. As a result, there is a growing number of households, where the same amount of money as heating is paid per year for electricity. The analysis is processed from [1, 2, 3].

At European level was published Directive 2002/91 / EC of the European Parliament and of the Council on the energy performance of buildings in 2002. The main requirement of the directive is to reduce energy consumption in buildings. A number of European standards have been issued for its implementation, for example EN 15232 Energy performance of buildings - Impact of Building Automation, Controls and Building Management. Building Automation and Control Systems (BACS) can have a significant impact on energy consumption of buildings and their occupants. In recognition of these facts, the European Committee for Standardization issued "EN 15 232:2012 Standard: Energy Performance of Buildings – Impact of Building Automation, Controls, and Building Management" for use in conjunction with the Energy Performance of Buildings Directive (EPBD).

The EN 15 232 standard includes the following main ideas and areas:

- A list of control, automation, and technical management functions that affect the energy performance of buildings.
- A method for defining the minimum requirements for the control, automation, and technical building management functions implemented in different types of buildings.
- Detailed procedures for quantifying the impact these functions have on the energy performance of a building.
- A simplified method to obtain an initial estimate of the impact these functions have on the energy performance of buildings.

On the graph in Figure 1 shows how electricity consumption is copied by economic developments. This trend is also due to the fact that household consumption of electrical appliances is growing with the growth of revenues and, at the same time, their consumption.

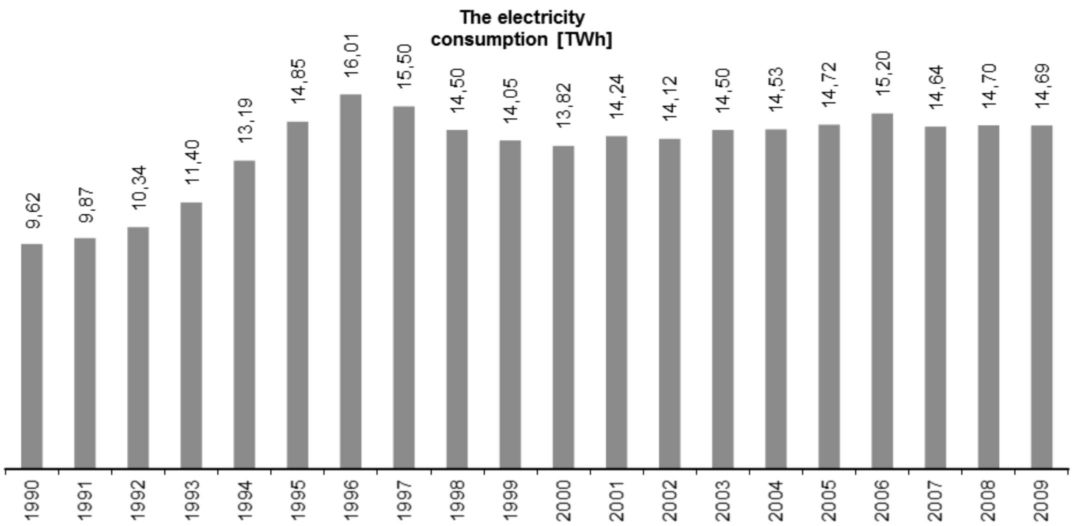


**Figure 1.** Household electricity consumption – Czech Republic

From Figure 2 shows that household electricity consumption in the EU has a steadily growing trend.

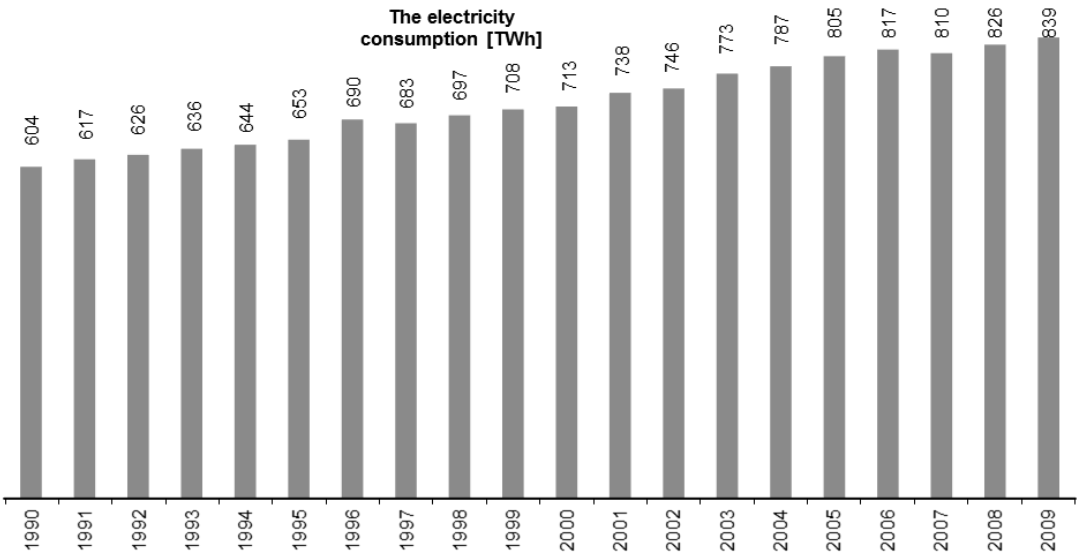


**Figure 2.** Household electricity consumption – European Union

This graph is defined as the amount of electricity consumed in households. Household consumption refers to all electricity consumption for heating and hot water and all other electrical appliances.

The Joint Research Center of the European Commission published a study according to which, in the period 1999-2004, electricity consumption grew at the same pace as economic growth. This is largely offset by the effect of measures taken to increase energy efficiency. In that period, electricity consumption increased by 11 % in households, by 16 % in the services sector and by less than 10 % in industry.

Growth in household consumption can be explained by the large use of older inefficient appliances, but also by the increase in the number of electrical appliances. Today, many households have two to three televisions, fridges and freezers, and more and more can be found clothes dryer and/or heating, ventilation and air conditioning (HVAC). In addition, the number of houses and large apartments is growing ( the residential area is growing). There is an interesting difference between the trend of energy consumption for heating and the consumption of energy for the operation of household appliances. In recent years, there has been a significant tightening of standards for the thermal properties of buildings and consequently a corresponding reduction in energy consumption for the heating of newly built or renovated houses. However, electricity consumption for normal household operation has increased. According to the average values of resources [5, 6, 7], the electricity consumption in the household is separated as follows:

**Table 1.** Average values for household electricity consumption values.

| Heating | Water heating | Another el. appliances |
|---|---|---|
| 63,4 % | 19,8 % | 16,8 % |

**Table 2.** Average values for household electricity consumption values – another el. appliances.

| Cooling | Washing | Dishwashing | Food preparation | Video system | Audio system | PC system | Lighting | Other |
|---|---|---|---|---|---|---|---|---|
| 18,0 % | 5,2 % | 7,8 % | 20,7 % | 8,3 % | 2,8 % | 13,7 % | 16,6 % | 6,9 % |

### *2.1. Intelligent electrical installation*

Various concepts and approaches are possible in optimizing the energy efficiency of buildings. In this context, the use of intelligent electrical installation (in other words also system installation) in buildings provides a proven and interesting alternative or complement that can compare cost-benefit ratio. Both the energy and the financial assessment of a similar investment must be done always individually for each building. In calculating energy savings play an important role factors such as building orientation to the cardinal, window size, color interior equipment rooms, the behavior of people in the building and others. This is also followed by a financial analysis of the investment, to which the type of lighting used or the source of heating is also widely spoken [2].

The use of intelligent electrical installation in a currently designed commercial and similar building can be decided quite simply depending on which class is to be classified according to energy performance (in accordance with Directive 2010/31 / EU). It is not desirable to build new objects not only insufficiently heat-insulated but also not equipped with perfect control systems, ensuring a very economical management of energy consumption, thus maximally avoiding unnecessary energy consumption. The current world trend is characterized by the promotion of energy-efficient technologies. The European Standard EN 15 232 has been elaborated in close connection with the European Directive 2002/91 / EC on the energy performance of buildings. The standard specifies methods for assessing the impact of building automation and building management on the energy consumption of buildings.

For the classification were introduced four energy efficiency classes (A to D). Once the building is equipped with automation and control systems, it is assigned to one of these classes. Potential savings of heat and electricity can be calculated for each class according to the type of building and its purpose. Energy class C values are then used as benchmarks for comparing energy efficiency.

In residential buildings, it is necessary first to describe the activities of all the functions used in the building as soon as possible and then decide whether to use any of the control systems. It is not only about the usual functions, including switching and dimming of lighting, including scenes, heating, ventilation and air conditioning control, including time and other programs, control of shading technology, windows and doors, switching of the socket and other power circuits. It is also a collaboration with many other areas of functions. The fact of how many different systems can go so far mostly independently designed and used, it is possible to get at least a rough idea on the basis of the following examples:

- electronic building security system,
- electronic fire system,
- audio and video control system,
- managing remote access,
- measurement of electricity, gas, water, heat, etc., and the transmission of measured data for invoicing,
- heat generation control for heating or cooling,
- sauna and pool technology,
- rainwater management and gardening,
- photovoltaic and other power sources,
- heat pumps,
- access and attendance systems,
- CCTV systems, home telephone and electric porter, etc.

The more demanding the number of these functional areas is required, the simplest the control and the maximal energy efficiency, the more advantageous the use of intelligent electrical installation and partial systems with the possibility of full communication based on open communication protocols (KNX, LON, etc.).

The Institute of Buildings and Energy Systems, part of Biberach's Applied Natural Sciences University, specializing in building automation, conducted a study "The potential for energy savings using modern electrical installations" in 2008. Under the leadership of Prof. Dr. Ing. Martin Becker studied the main literary sources, with a result oriented to the discovery of the potential for energy savings. The study was commissioned by the Central Union of Electrical and Electronic Industry (ZVEI) [4]. Based on this study, the potential for energy savings with modern electrical installations is clearly shown in Figure 3.

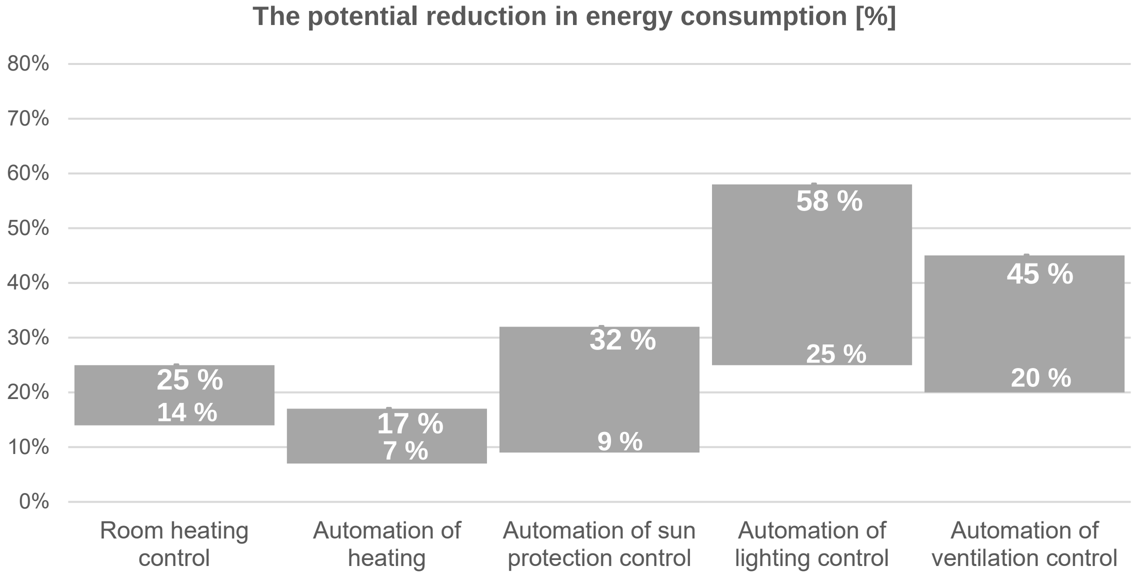


**Figure 3.** The potential for energy savings with modern electrical installations

Wide dispersion of the values given in certain areas can be attributed to a wide range of factors - applications involving multiple functions, the operational nature of the respective tests, the difference in the definition of different functions, yet the conclusion of the research clearly shows that an intelligent building management can contribute significantly to increasing the energy efficiency of buildings. Overall, the implementation of measures to optimize the management of technology in buildings moving the average value of energy savings in the range of 11 % to 31 %.

The prediction of electricity consumption in the Czech Republic is based primarily on forecasts of macroeconomic and demographic developments and respects the effects of expected savings. In the short and medium term, an increase in the use of electricity is predominantly for heating systems (the effect of tariff policy setting) but also for hot water heating.

According to sources [2, 4, 5, 6] but occurs in the short and medium term, to reduce the specific consumption for heating and hot water, increasing the consumption of the other (with the inclusion providing an increase of efficiency) and a slight increase heating facilities and hot water. Electricity consumption in the household sector (in the Czech Republic) will gradually move closer to the average level of consumption in the EU over the long term. By 2050, it is an increase of 1,5 TWh, or 10 % of consumption in 2014. Stagnation in the long term reflects the expected population decline after 2020. In households will continue to increase the amount and use of electrical appliances, as well as increase their effectiveness. Further significant energy savings for heating are expected. Household consumption is expected to grow by 10,4 % between 2013 and 2040. [2]

*2.2. Integration of alternative energy sources and energy storage systems*

Another energy saving measure can be the integration of alternative energy sources. Family houses can be equipped with both alternative energy sources and classical ones. Power, consumption and accumulation are controlled by a control unit (CU) that is connected to all power sources, heat sources, appliances and storage capacities via sensors and control elements. CU evaluates and records the received signals from the sensors and, based on this information, regulates the power and appliance settings according to the set parameters.

In most cases, the family house is not equipped with only one source, but it is a combination of more resources that complement each other. For example, a classic combination of sources for hot water heating is a combination of solar panels, a heat pump and a classic boiler. In this case, solar panels are chosen as the primary source, since they produce heat about twelve times cheaper than conventional boilers. In such a case, the control system only draws heat from the solar panels at the time when it is possible. If solar energy is not available, the CU switches to heat recovery from the heat pump, which should be able to meet the required demand. The control unit switches the boiler on when the hot water is unusually high or in the case of extremely low outdoor frosts. The control unit also controls the heat consumption. This is mainly the regulation of the heating in the rooms of the given object or, for example, the regulation of the water heating in the pool. In individual rooms, the required temperature and time are set to avoid unnecessary overheating or under cooling.

A similar situation is with the choice of energy sources. Nowadays, a small photovoltaic power plant on the roof is chosen as a classic power source. This installation can be complemented by a small wind farm and, optionally, a cogeneration unit (CGU) that produces both electricity and heat. Over time, more and more emphasis will be put on family houses with small energy sources.

Some of the elements of electrical installation can be grouped into both energy sources and appliance groups. For example, a heat recovery unit is an electrical energy appliance, but the output is energy in the form of heat, or an air conditioning unit that is used as an electrical appliance but produces cold. The heat recovery unit can, therefore, be evaluated as a source. The division of energy sources and appliances is therefore done in relation to the consumption or generation of electricity.

With the increased use of renewable energy source (RES) is more talk about the accumulation of electrical energy. This is mainly due to the fact that the energy obtained from renewable sources is dependent on conditions that one can not influence. Therefore, in recent years, with the development of renewable energy use, people have begun to have more questions about how to best store energy.

The concept of electrical energy storage can be translated as a storage or supply of electric energy or as a conservation of energy for its later use in appropriate quality and quantity. Currently, the most accumulating storage medium is the lead acid accumulator. Storage systems are irreplaceable from the viewpoint of production and consumption of electrical energy. Electrical energy is a commodity in principle very problematic and any attempt to distribute it confronts the problem of immediate demand and supply. Accumulators or other energy storage are currently under development [8].

The problem of energy storage is currently focused mainly on the solution in the field of elimination of discontinuity of electricity supply from renewable sources and is based on the principles of individual alternative energy sources and on the problems related to the time-varying power of these sources. Developments in the energy storage area are important for two main reasons:

- optimal integration of RES into the grid (classical distribution network),
- preparation for a Smart grids solution.

## 3. Knowledge system and basis

When exploring other options for selecting electrical installation using a software tool that is equipped with both technical knowledge and basic parameters, conditions and more, it is directly offered the use of knowledge systems. Therefore, the majority of problems solved in this paper focuses on the use of knowledge systems to create a knowledge base for a software tool that would serve as a user interface for selecting the house installation based on predetermined parameters, conditions and knowledge.

The use of knowledge systems is becoming more and more common in the field of electrical engineering today. A special subgroup, which should be used in our case, ie. “The choice of house wiring based on predefined parameters” and knowledge base associated with system wiring, energy savings, wiring groups according to EN 15 232 and others is a group of knowledge systems. For knowledge systems to solve professional problems, procedures requiring, unlike general, above all specific knowledge, the term “expert systems” is used.

### *3.1. Representation of knowledge*

Knowledge has become a key element of knowledge-based applications, such as expert systems. It is for the creators of the knowledge system to choose the appropriate way of visualizing (capturing, representing) knowledge, the so-called representation diagram. Such a diagram can be imagined as a set of rules and procedures to be followed to capture knowledge. The diagram should be sufficiently comprehensible and versatile for a human. They must be able to capture a wide range of knowledge - from general to more specific. It should also promote easy modularity of knowledge.

Different sources point to a similar division of types of knowledge representation. The basic types of knowledge representation are:

- procedural representation,
- declarative representation,
- schematic representation.

The main element of procedural representation of knowledge is the procedure. Here you can imagine a powerful program code that solves questions such as "How?“ not "What?" In connection with this form of representation, it is possible to speak about so-called rules (productions), which are found, for example, in production systems. It is used to transfer expert knowledge on the computer. It contains various terms and actions that are feasible to meet these conditions. The solved task in the case of procedural representation can be, for example, finding a larger number of two possible ones.

The declarative type of representing knowledge, on the other hand, answers the question "What is to be solved?“ not "How is it to be solved?". Therefore, it is not asked for example how to calculate the largest number, but how the largest number is defined. The expert system has its own procedural and declarative knowledge representation - the facts contained on the basis of facts. These facts are used by rules, for example, to derive other contexts and knowledge. Typical representatives of the declarative type of representing knowledge are logical diagrams (propositional logic, predicate logic of the first and higher order), semantic networks, and status space.

Framework schemes are a combination of procedural and declarative approaches. Declarativeness is based on the way of capturing information about real objects using slots (frame properties) and facets (frame property values). Procedurality is contained in procedures that may be part of a framework structure.

The types of knowledge representation are shown in Figure 4.

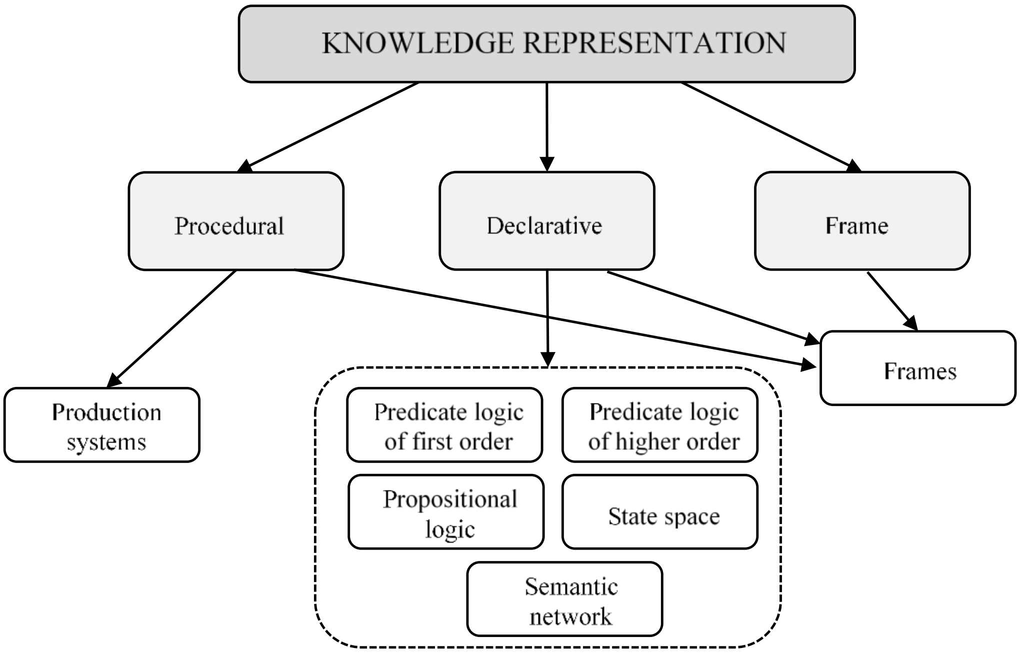


**Figure 4.** Types of knowledge representation

*3.2. Knowledge systems*

Knowledge systems respectively expert systems (ES) are defined by the most frequent occurrences in the literature as:

- a system that seeks to solve a problem within the scope of a specific set of assertions or knowledge clusters formulated by experts (experts – from here expert systems) for a specific application area [9];
- a system based on the representation of experts' knowledge that is used to solve problems [9, 10],
- a system of cooperating programs to solve a defined task class, in the most problematic areas the majority of experts [9, 10],
- a system equipped with the knowledge of a specialist in a specific area to the extent that it is able to make decisions by speed and quality equalizing the least average specialist [9, 10].

In each ES, it is possible to distinguish between the three basic components constituting its minimal configuration - the inferential (solving) mechanism, the knowledge base, and the data base (facts). The inferential mechanism (IM) consists of a system of collaborative programs providing the procedural component of the ES activity, knowledge base and facts base (KB and FB) are passive data structures.

3.2.1. The architecture of the knowledge system

The function of the communication module is to ensure interaction between the user and the expert system. The explanatory module explains and justifies the status and progress of the problem, its individual steps, and the results achieved. The results generator compiles partial results into an integral and reasoned whole, without any extra information, in the required form and understandable form [9].

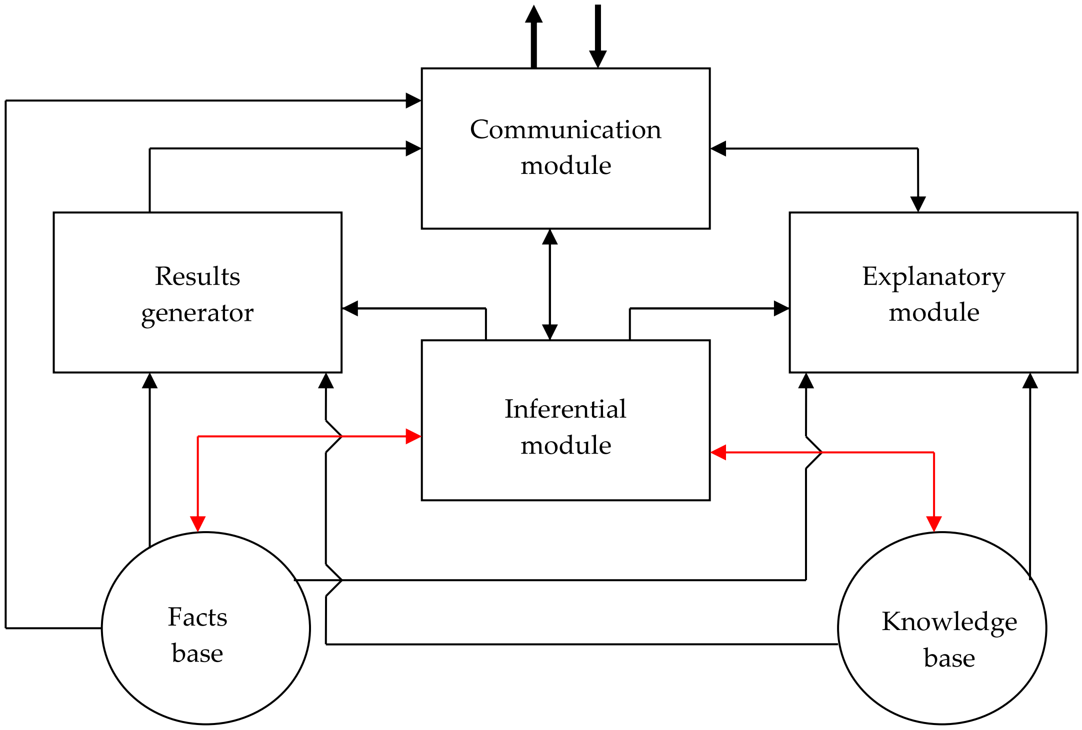


**Figure 5.** The architecture of the knowledge system

3.2.2. Knowledge base

The knowledge base represents a general model of the area description addressed by the expert system. It is usually made up of rules describing the problem. Experts' knowledge and experience are gathered here. It captures the whole range of knowledge from the most general to the very special, from the well-known to the knowledge that the expert has gained in many years of experience and who only knows that they often help him to solve similar problems.

It turns out that the extent and quality of special, often private, heuristic knowledge differ from the average worker in the problem area. This base is similar to a database. Creating a specialized expert system is a complex and time-consuming activity. One of the important components of the knowledge system is the knowledge base. The basis of this part of the thesis is, therefore, to familiarize itself with ontology, the concept of semantic web and examples of the creation of a knowledge base in the field of electrical wiring and related systems using different means.

*3.3. Ontology and modeling of knowledge*

During the 1990s, it became clear that the WWW would be a source of extraordinary information. At the same time, however, issues related to the unstructuredness and the unreliability of the information on it have arisen. It was a welcome opportunity for knowledge engineering to get closer to real-world applications. Between the years (approximately) 1996-2002, a whole group of partly related ontological languages was created. This sought to complement the formal semantics to web sites possible applications with web interface.

The concept of ontology can be found both in philosophy and in the area of the semantic web. In the original, the ontology is the doctrine of being. In relation to the semantic web, ontology is understood as a definition of terms and relationships between them. It is used to describe so-called domains of human interest/world. This area then contains the individual classes that are linked by relations. Objects in this domain and their interconnection ontology described using four elements: individuals, classes, attributes and relationships. Sometimes the fifth element is also mentioned - the event. Ontology serves to represent the knowledge base of knowledge or expert applications.

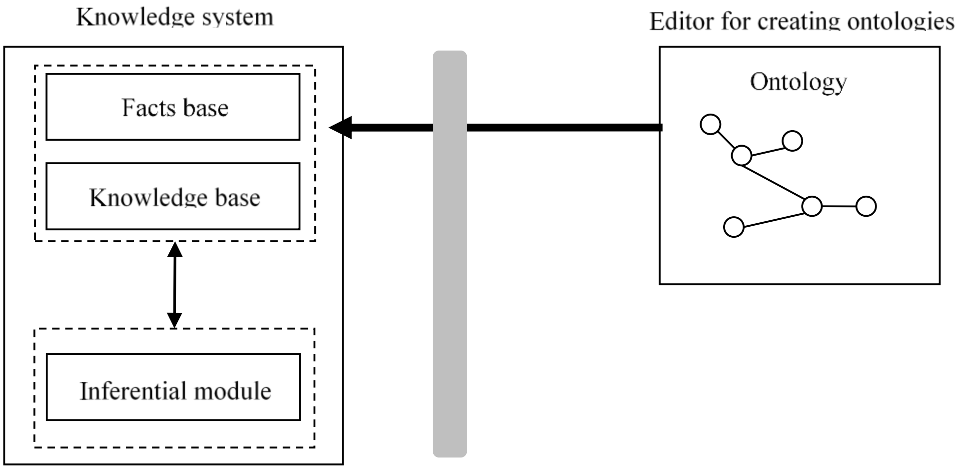


**Figure 6.** Ontology and knowledge system [10]

Ontologies can be divided according to different aspects, but most often divided according to the source of conceptualization [11]:

- generic ontology (higher order ontology) - the capture of general patterns,
- domain ontology - intended for a specific subject area (most common)
- task ontology (representative ontology or meta ontology) - focused on processes of derivation,
- application ontology - adapted to a specific application (typically including both domain and task part).

From the point of view of knowledge engineering, ontology can be understood as a knowledge structure that is built to:

- sharing information and knowledge among people,
- sharing information and knowledge between machines,
- sharing information and knowledge between people and machines,
- reuse of domain knowledge,
- the use of explicit knowledge that is made available to others,
- separation of domain knowledge from operational (procedural),
- Domain analysis [12].

Ontologies can greatly improve the functioning of the website. In the simplest case, it can be for example search precision - the search engine can focus on the pages corresponding to the given concept (and not ambiguous or even ambiguous keywords). Ontology is one of the most common approaches to recording knowledge.

3.3.1. OWL language

OWL (Ontology Web Language) is a markup language developed by W3C (World Wide Web Consortium) for creating ontologies usable in a semantic web environment. It contains a set of axioms describing classes, properties and relationships between them. Its development and expansion continue to work. [12]

For ontology creation in OWL, one of three options can be used [12]:

- OWL-Lite,
- OWL-DL,

- OWL-Full.

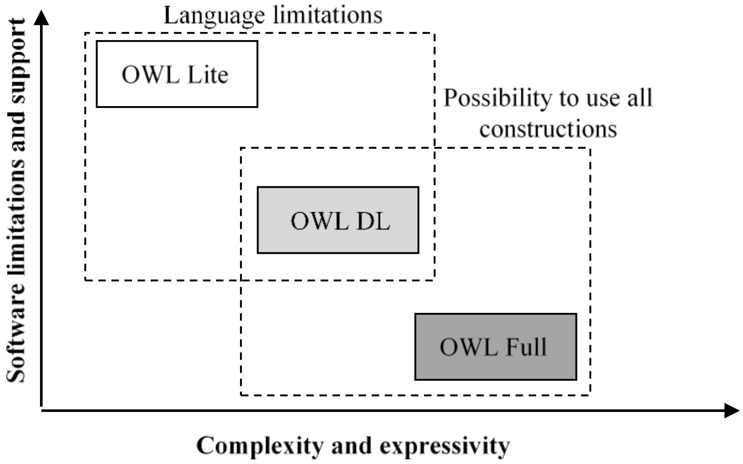


**Figure 7.** Complexity and expressivity of OWL

In order to choose from the above options, it depends on how ontology and how complex it is to create. If greater expressiveness (= expressive power, the richness of language) is required, we must take into account the available software. Greater expression power requires more capable or more complex software. When all OWL constructions should be used - OWL Full and OWL DL is a good choice. To derive rather OWL DL. Figure 7, which is taken from the source [12], describes the comparison of OWL versions of their complexity and expressiveness.

3.3.2. Ontology in Protégé

Creating OWL ontologies is possible using the open source Protégé editor, which is based on OWL concepts. This platform supports two ways of modeling ontologies, through Protége-Frames and Protégé-OWL editors. It is built on Java, is extensible and provides a plug-and-play environment that provides a flexible foundation for fast prototyping and application development. Ontologies created in Protégé can be exported to RDF, OWL, and XML formats. The basic building blocks of Protégé ontologies are:

- Classes - Classes are the major building blocks of OWL ontology. Classes are interpreted as a set containing individuals. We specify them using formal constructions that specify the exact membership requirements of a particular class. Classes can be taxonomically organized into hierarchies of subclasses and super classes where subclasses specialize their superclasses. In the OWL subclass, it implies the necessary implication, and therefore all instances of the subclass are instances of a superclass without exception.
- Individuals - Individuals represent objects of interest domain. OWL, unlike Protégé, does not assume the uniqueness of the name. For this reason, two different names may refer to the same individual, so it must be explicitly determined whether individuals are identical or different. Individuals can also be used to describe classes, specifically in hasValue restrictions and enumeration classes.
- Properties - Properties are binary relations on individuals that connect two individuals (more precisely, the instance of properties associates two individuals). In descriptive logic, properties are known as a role, and UML and other object-oriented notations are referred to as relationship. Properties represent relationships. The two main types of properties are Object properties and Datatype properties in Protégé. OWL has also a third type of property called Annotation properties, and both of the above-mentioned main types of properties can be marked as annotation properties. As with classes, it is

possible to create their hierarchy in the properties. Properties at a lower level of hierarchy specialize the properties at a higher level above them in a way similar to the superclassing of its subclass. However, under a lower-level property under another property, it is not possible to combine object properties and properties with a data type. Therefore, it is not possible to create an object property that is in the hierarchy under the property with the data type and vice versa. Figure 8, which is taken from the source [12], graphically and clearly shows the basic elements of the ontological model in the OWL language and the Protégé environment.

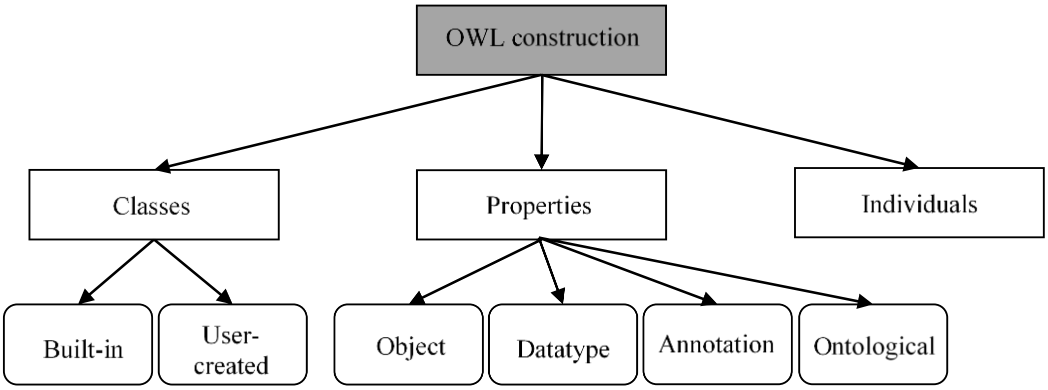


**Figure 8.** Elements of ontology in Protégé

3.3.2. Modeling in Protégé

The original aim was to facilitate the work of knowledge engineers in the development of knowledge bases. Figure 6-4 shows the connection between the Protect and the knowledge system that contains the knowledge base. Protégé is not an expert system or a program that directly serves to create them but helps to create one of their main parts - the knowledge base. By creating the knowledge base separately from creating a knowledge application, it can be better maintained and managed.

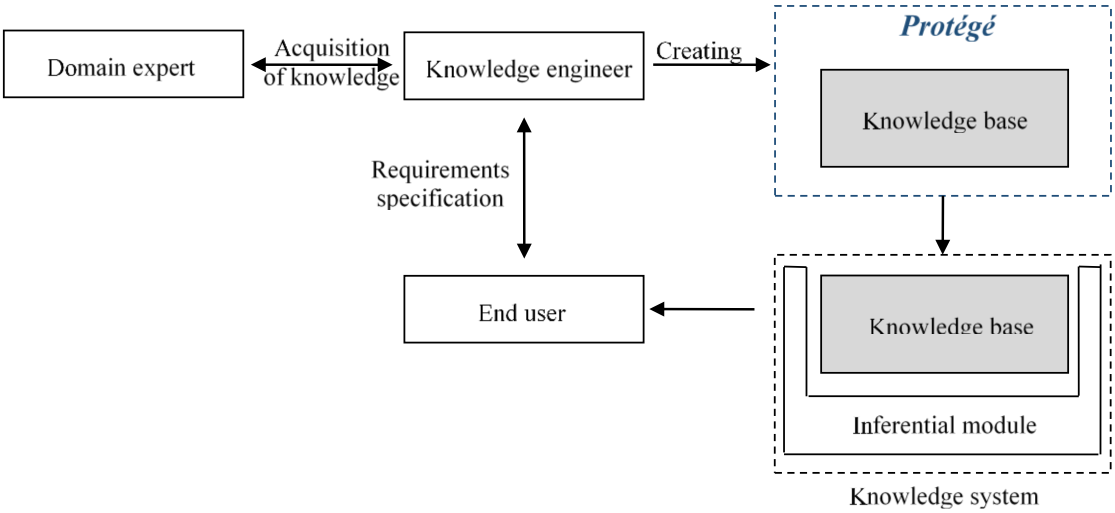


**Figure 9.** Modeling in Protégé – main idea [13]

## 4. Knowledge base for household installation

In order to create or at least partially design a knowledge base for household electrical installations, it is necessary to specify and define the concepts of construction and design of buildings. A building is defined as a material object associated with the plot, and this object is the result of a sequence of activities. The sequence of activities from the initial intention to the beginning of use is called a construction or also an investment project abbreviated to the project.

*4.1. Designing*

Designing is a set of activities in which it is proposed to solve a particular project (in terms of intent) in the various phases of its preparation and implementation. In the area of construction, designing is understood as the creation of project documentation. For each building is always developed project documentation.

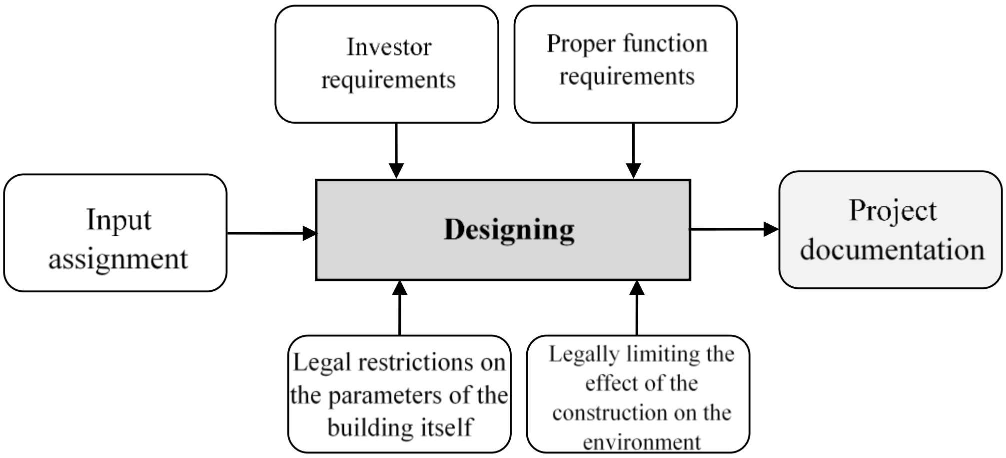


**Figure 10.** Input and limitation of designing [14]

Designing is a process where a new building is constructed from the sub-elements while adhering to the input and limiting conditions. This is a sequence of activities that create a complete definition of a building from the input. This definition can be considered the Detail Design. Input and limiting conditions can be divided into several groups.

- Investor assignment - for civil buildings, for example, it is the place of construction, the size of the areas and their utilization, the number of floors, the number of people using the individual premises of the building.
- Investor requirements - requirements that specify a technical solution such as technology, type of key equipment, the degree of automation, etc.
- Proper function requirements - Proper construction requires respect for natural and social laws.
- Legally limiting the effect of the construction on the environment - effects of the building on the environment such as noise, air emissions, and sewage. They are mostly limited by legal limits.
- Legal restrictions on the parameters of the building itself - these terms are defined in the laws, decrees and valid standards.

Project activity requires knowledge of methods and procedures for designing the proper construction function and knowledge of legal restrictions for building design. From the formal point of view, it is also necessary to authorize responsible designers with regard to the documentation for administrative management.

*4.2. BIM systems*

Civil engineering produces works of long-lasting life and high utility value. Therefore, it is necessary to be interested not only in the initial investment in construction but also in the life cycle costs. Three-quarters of the total life-cycle costs of a building fall on the period of use of the building, of which one-third is the cost of management and maintenance. For the successful execution of constructions, it is essential to structure the construction into individual parts, to define individual elements, to describe them and to sort them according to a unique classification. The basic input of the decision and control process is information that relates to the construction as a whole or some of its components.

Information about a particular event or part of a building changes and evolves throughout its life cycle. They need to be incorporated into a structured system to monitor the development of the building over time, optimize the technical and economic characteristics of the building during its lifetime, permanently update the information and generate it immediately.

All these processes can be managed in a uniform and effective way using BIM (Building Information Modeling or Building Information Management), a common IT communication tool for building process participants or other operators. The BIM model can be represented as an information database that can include complete data from the initial design, construction, building management to its demolition. BIM is a working process in which they are among the participants of the construction cycle (architects, planners, contractors, facility managers) creating and sharing information.

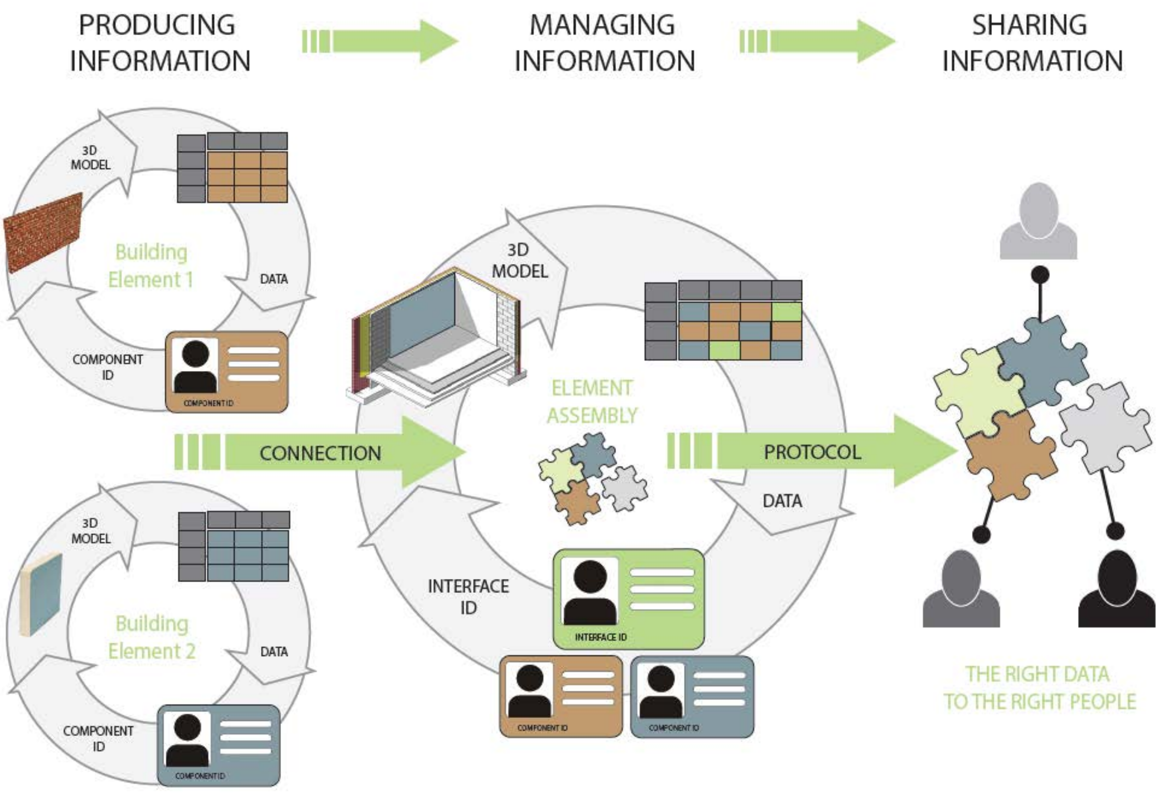


**Figure 11.** The key of BIM exchanges is the management of information [15]

For the civil engineering, the digitization and implementation of new scientific and technological knowledge are currently a priority. BIM is an option to better define the requirements for the resulting building, to electronically control the course of the building in its individual phases, to make independent assessments easier, to minimize the extra costs of building construction and to ensure better accessibility and more economical operation of buildings.

The general design of the BIM model makes it possible to increase the efficiency of construction products, to improve the quality of the project documentation, to ensure the availability of relevant building information and the equipment and systems used and to meet the energy efficiency requirements of

buildings. In order to remove deficiencies and refine the parameters, BIM systems are tested on existing building orders, but also at universities in the form of final works.
Savings due to the use of the BIM method according to surveys conducted abroad account for 20 % of the total cost of the entire life cycle of the building. With the information model of the construction, it is possible to simulate different situations on the proposed construction, to work with variants to achieve the optimized design result. Using BIM for building new buildings helps to achieve energy savings.
In international (IEC) and European (EN) standards, standards for BIM have already been issued. These standards, in view of the scale of the BIM issue, are largely interfering with the existing system of national regulations. It is, therefore, necessary that the rules for designing and using BIM systems are also embedded in Czech technical standards. Therefore, at the UNMZ, a technical standardization committee for the BIM issue was set up at the end of 2016. Its first is to translate international standards defining parameters in the universal IFC format.

*4.3. Ontology for household installation*

In the concept of a proposed extension of the natural language query processing system, the knowledge base is a stand-alone module that provides the most comprehensive descriptive information about a specific interest domain in the form of structured data. The basis for ontology development is, as a rule, the list of relevant terms, with consequent differentiation of ontological types, the specification of taxonomy as well as the creation of non-taxonomic relations, attributes and instances.
Although tools for ontology development and maintenance recorded in recent years, great progress (from text editors to graphically oriented interface) provided below the comfort level achieved in object modeling, especially in the area of user interface. Besides the later creation of the discipline, the complicated nature of the logical models seems to play - the extensive axioms can be translated hardly into comprehensible graphical formations and must be edited in a text pseudo code.
To build a functional example of ontology in the field of household installation, the already mentioned Protégé environment was used. The presented example of an ontology is based on defined relationships within the house wiring.
Each ontology concerns a particular domain (problem areas). Ontology modeling concepts that are abstract or concrete, general or specific. On the ontological modeling is difficult to choose a range of ontology that can be implemented and which will also meet the requirements of the target user. The final ontology structure is more or less flat, characterized by one main class with many objects and data properties, where one product card is equivalent to one instance of the main class. In the context of properties of given instances, ontologies may display structured data (containing semantically defined object properties) and text data (in unstructured and therefore semantically unpublished content).
From the point of view of computational processing of native language, data structured is key to achieving relevant results. On the other hand, however, the vast majority of information today is available only in pure text form and without any additional features. Without prior automatic or manual semantic annotation, it is therefore also using technology for processing queries in natural language virtually irrelevant as the results are irrelevant compared using these semantically structured data. Precision semantics is the main advantage of any well-designed ontology because it enables complex and semantic constructions to draw new facts and relationships between individual entities.

4.3.1. Taxonomy

In Figure 12 is shown a basic taxonomy describing several classes arranged in the hierarchy. Almost certainly, we will always find missing instances or classes that would, in our opinion, better capture the situation described.

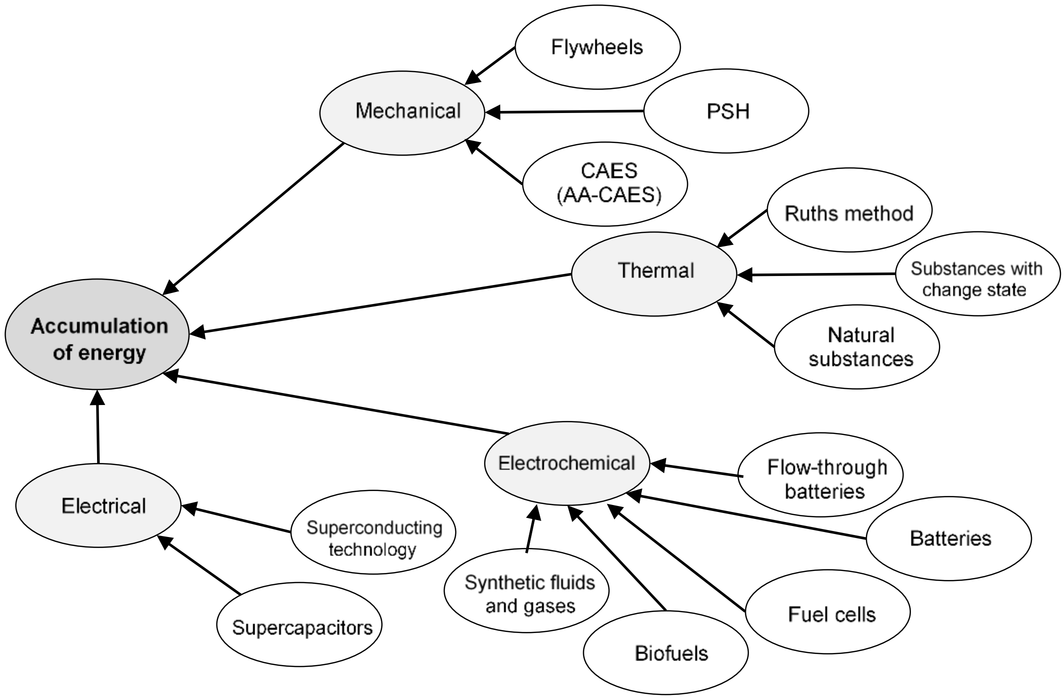


**Figure 12.** Taxonomy demonstration - Definition of classes and subclasses

Figure 12 shows the *Accumulation of energy* class is the main class, which is divided into four subclasses. These subclasses are then subdivided into other subclasses. Thus described ontology defines the basic relationships between objects. It is necessary to accept that ontology will never be complete because our world and the universe contain so many classes, characteristics and individuals that it is simply not all that can be included in the ontology. This may also be one of the reasons why ontology is divided into domain-oriented (covering only a specific, more limited domain) or generic ontology, which cover very general concepts such as space, time, thing, matter, etc.

4.3.2. Definition of relationships

Individuals need to be defined in order to be more specific. The property creates a relationship - a relationship between individuals. Assigned properties can be divided into four basic categories:

- object properties (creates links between class objects),
- data type (associates individuals with the value of a particular data type),
- annotation (extends information to individual classes or individuals in the form of metadata - comments, explanations),
- ontological (define the interrelationships between ontologies).

The use of the property notion is evident from Figure 13. It is possible to say that each energy accumulation system will have its own manufacturer. It follows that the *Accumulation of energy* class is related to the *AE Producer* class. At the same time, such individuals in the *Accumulation of energy* class as well as in the relevant subclasses such as *Accumulators, Fuel Cells* and others also have a relationship with individuals in the *AE Producer* class.

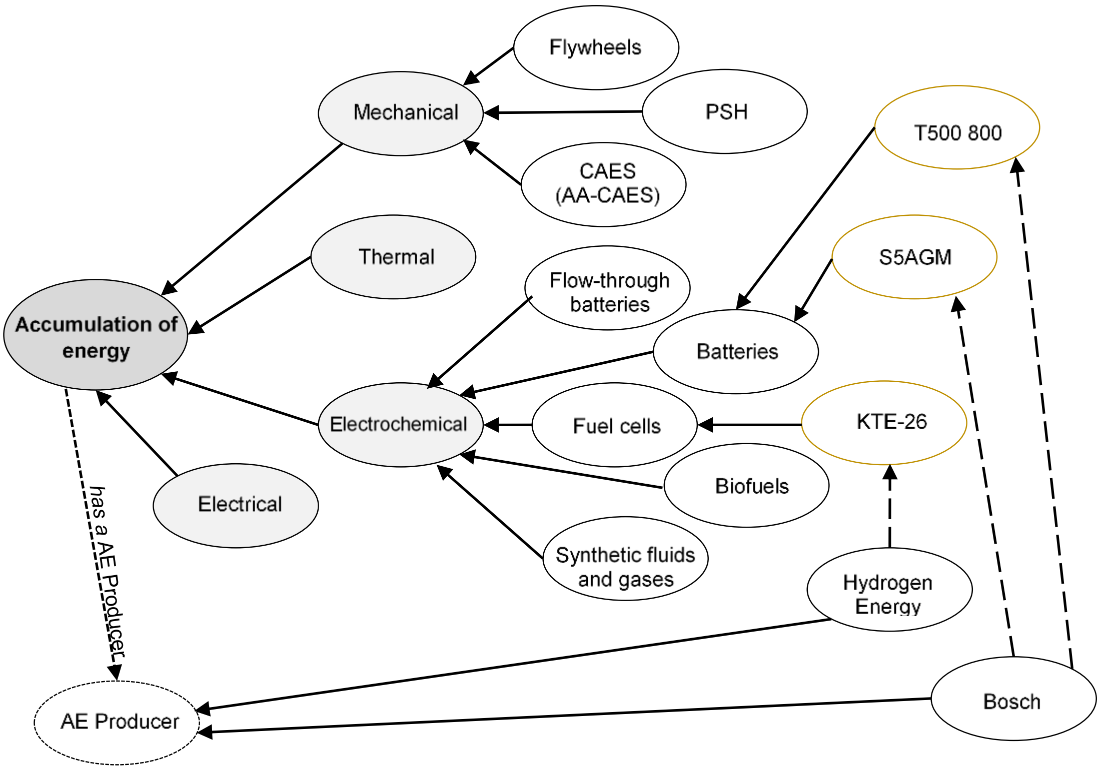


**Figure 13.** Taxonomy demonstration - Definition of relationships

With regard to the procedures defined in the previous sections of the article, a basic taxonomy for the selection of household electrical installation has been compiled, taking into account the technical possibilities summarized in the theoretical part of the thesis, which deals with the complex analysis of the electrical installation and associated systems.

The assembled semantic network contains a group of defined classes that can be seen as an overview diagram of the key association classes that are directly related to the choice of household installation. From this model, it is possible to create additional sub-models describing in detail specific components, either as other associative networks or as an ontology modeling knowledge related to a given class or production rules of behavior of the given classes.

It is also possible to define instances of given classes as specific objects with defined attribute values. This is the basis for a knowledge engineer who can communicate specific knowledge to each of these classes. The task of the knowledge engineer is also to be able to capture this knowledge with appropriate representation.

It is used associations of types ***is a*** and ***has a*** to build a taxonomy. These association types are used in the context of real simplification and utilization. However, they can not describe all the relationships between the defined classes but can serve as basic information on the procedures for selecting electrical installation and associated systems for a family house.

The semantic network does not form a complete representation of all classes. This network is only a cutout from a complex unit and serves to introduce the initial step in modeling knowledge from the installation for family houses, but also generally for other technical problems or solutions.

In this part of the solution are sought concrete answers to questions such as "What is it?", "What is included?", etc. For example, the question - "What is a battery?" - we can easily find the *Battery* association is a part of an *Electrochemical accumulation* and is part of the *Accumulation of energy* and the *Accumulation of energy* is part of the *Energy system* of a family house. A similar process can be continued further define relationships and constraints.

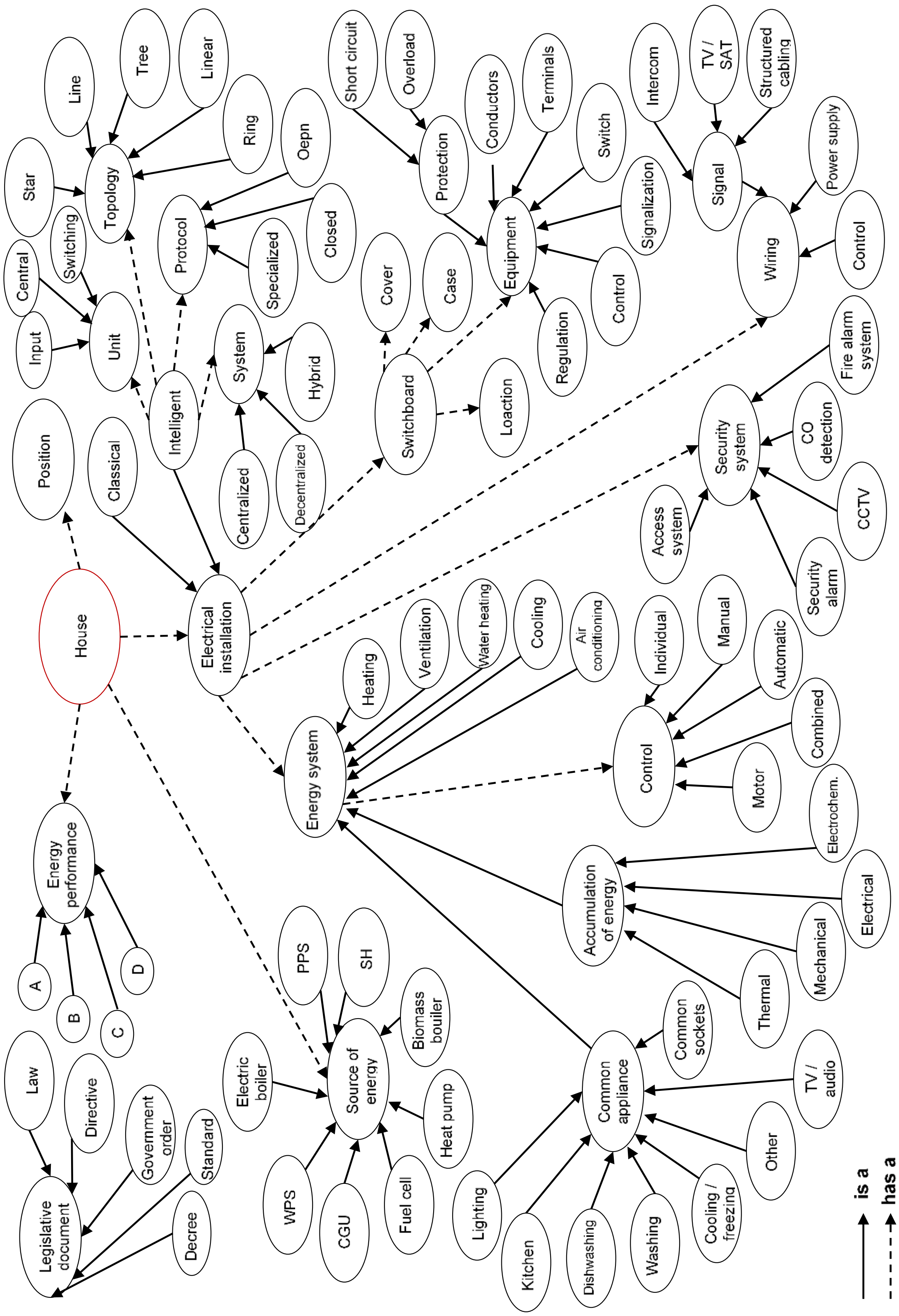


**Figure 14.** Taxonomy of basic classes for the household installation

4.3.3. Definition of individuals and properties assignment

Figure 15 presents a structure that defines the partial parameters of each type of *Batteries*. This structure shows that for the Battery class, properties that specify properties for specific individuals of the Battery class that works on the electromechanical accumulator system are defined. These attributes are assigned to each individual in the Battery class. Not all of the possible parameters of the batteries, which could be considered important in some cases, are certainly not listed in this example. This is part of the whole design process - continuous development, replenishments and sub-adjustments.

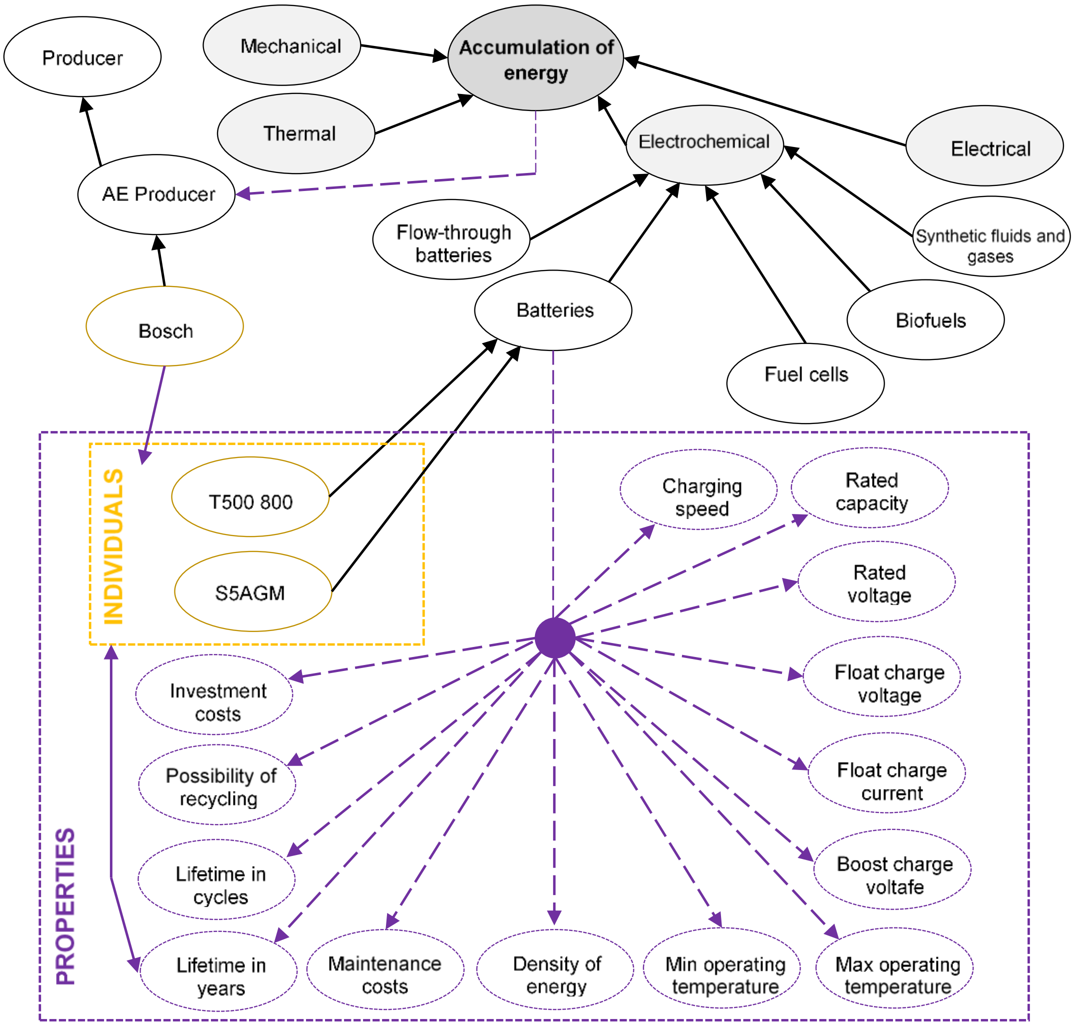


**Figure 15.** Definition of individuals and properties assignment demonstration

These parameters are crucial for the selection and design of the required energy storage or accumulators in the energy system of the house and in the design compared to the energy performance requirements for buildings, costs etc.

Nowadays, there are many information sources and types of representations that can be used as expert knowledge. Of course, the difference is whether the data will be processed for a normal person interested in the matter only in general or for an expert (for example a designer) who will want to get very detailed information from specific parts. Create a uniform and transparent structure, human-readable and machine-processable, it is not quickly and easily feasible task. All information needs to be transformed into a suitable form, some standardization and integration into the right structures must be done.

The most common and most used information sources are technical data sheets (according to the relevant technical specification standards) in which the producer of the equipment gives basic information about its properties. For example, in the battery data sheet, their design will be described and the areas of their use will be specified, specifying the specific types of battery. For each battery, the basic operating parameters will be listed in the catalog - rated voltage, rated capacity, operating temperature range, etc.

As can be seen from the above, acquiring information for the knowledge base is a rather complicated and lengthy process. There are many techniques for obtaining input information, but no uniform and optimal approach can be established. However, there are many empirically verified and heuristic principles that can be beneficial to a knowledge engineer. Knowledge can be obtained from experts either directly in a generalized form or by analyzing specific decision situations. However, it is generally advantageous to combine both ways.

## 5. Conclusions

The current situation in the field of electrical installation and sources of energy is moving towards lowering the cost of energy consumption (or energy in general) and the direction of increasing austerity measures. On the part of the European Union (and not only), it is a constantly visible effort to reduce the energy efficiency of buildings, not only with the use of intelligent electrical installation but also by using alternative energy sources. Thanks to the technical development of intelligent installation, alternative power sources, and the general development of the knowledge of designers and designers involved in designing small units (flats, family houses or apartment buildings), there is a reduction in the price of both electrical installation and more possibility of frequent use of an alternative energy sources.

The possibilities of using knowledge systems have been demonstrated in the description of the household electrical installation. A significant amount of knowledge from the field of knowledge has also been defined. The built-in demonstration base of household installation has shown the possibility of saving knowledge in simple text form. The advantages and disadvantages of this knowledge base have been briefly described.

In the last part of the article, links between ontology and the knowledge base were defined. Simple demonstrations have demonstrated the basic steps to build a knowledge base using simple taxonomic relationships. In order to build a basic sample knowledge base, the problems associated with the use of the Protégé development environment have been described, which enables the creation of basic ontologies and their representation in various formats suitable for machine processing or direct use. Ontologies can greatly assist in the process of converting classification systems, but it is certainly not possible to implement this process through ontology (or other fully automated processes). Ontology, however, can speed up the creation of mapping rules between taxonomies and effectively describe these systems.

Benefits for knowledge engineering:

- Reusability - formal and formal representation of elements and domain relationships makes it easier to share and reuse.
- Search - ontologies are meta data character (meta information) allowing an easy search of large data sources.
- Reliability (authenticity) - Writing formats allow an ontology to automatically check data consistency.

As has been mentioned several times, ontology is a very important tool for describing data, information and knowledge. Application of ontology in data modeling as a tool for describing and cross-transforming data structures is not a miraculous means of eliminating the shortcomings of other similar tools.

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**List of acronyms**

| Acronym | Description |
|---|---|
| BIM | Building information modeling, Building information management |
| AA-CAES | Advanced adiabatic compressed air energy storage |
| AE | Accumulation of energy |
| CAES | Compressed air energy storage |
| CGU | Cogeneration unit |
| CU | Control unit |
| EN | European standard |
| EPBD | Energy Performance of Buildings Directive |
| ES | Expert system |
| EU | European Union |
| FB | Facts base |
| HVAC | Heating, ventilation and air conditioning |
| IEC | International standard |
| IFC | Industry foundation classes |
| IM | Inferential mechanism |
| ISO | International Organization for Standartization |
| KB | Knowledge base |
| KNX | Konnex |
| LON | Local Operating System |
| OWL | Ontology Web Language |
| PPS | Photovoltaic power station |
| PSH | Pumped-storage hydroelectricity |
| RDF | Resource Description Framework |
| RES | Renewable energy sources |
| SH | Small hydro |
| UNMZ | Czech Office for Standards, Metrology and Testing |
| WPS | Wind power station |
| WWW | World Wide Web |
| W3C | World Wide Web Consortium |
| ZVEI | Central Union of Electrical Engineering and Electronics Industry |

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