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### Short Papers

# Table of Contents

## Papers



## Short Papers

# Effect of Mobile Gaming on Mathematical Achievement among 4th Graders

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**Abstract—**This study aimed at identifying the effect of mobile gaming in mathematical achievement among the 4th graders. The study instrument was a math achievement test which consisted of (30) items of the multiple choice type (4 alternatives). The sample consisted of (66) students of the 4th grade in the City of Zarqa (Jordan), which was distributed over two groups: experimental groups (n=34), and control group (n=32). The researcher employed the experimental method on both groups. The experimental group was taught using the educational mobile games, and the control group was taught by the conventional method. The study found the use of mobile games an effective practice for providing educational support to the students in mathematics. In addition, the size of the effect of using mobile games was significant, a fact which supports the effectiveness of the mobile games in math achievement among the 4th graders.

**Keywords—**Achievement, gamification, math teaching, mobile gaming

## 1 Introduction

Many elementary school' students struggle to acquire the basic mathematical skills. Based on Trends in International Mathematics and Science Study TIMSS (2015), the mathematics mean of the 4th graders in Jordan was 388, much lower than, the international mean (508). Actually, several studies highlighted the poor performance of the students in mathematics; one striking example was that less than 10% of the students of classes (1-6) were able to solve the problem (8+4=?+5) correctly (Carpenter et al., 2005).

Educational technology has long been regarded as a valuable approach to improve elementary school children's math achievement (Kebritchi, Hirumi & Bai, 2010). According to the National Council of Teachers of Mathematics (NCTM, 2000), technology is essential in math teaching and learning, and that technology stabilizes math that had been taught and reinforces the students' learning. During the last three decades, different types of computer-aided programs were developed and taught. Results of the studies on this issue showed that technology has a positive effect on the students' achievement in mathematics (Cheing & Slaving, 2013; Ferri et al., 2018; Li & Ma 2010; Slavin & Lake, 2008).

Koutromanos & Lucy (2014) indicated that the applications on the mobile appliances are able to become new methods of providing students with the educational content. While the mobile technologies play an increasingly significant role in the children's life everywhere, the ministries and schools are testing the use of these appliances to achieve learning and teaching objectives. The smart mobiles and tablets are among the new emerging technologies that may have a great effect in teaching-learning and research in the elementary education (Chun Ou, 2015; Sirkemaa & Varpelaide, 2018; Zanchi, Presser & Vahey, 2013), particularly in math subject.

Mobile appliances enjoy many valuable advantages as compared to the traditional gaming platforms. First, they are the more spreading throughout the world; currently, almost everybody has a mobile appliance. Furthermore, the mobile appliance is always with you, which enables you use it anywhere, and an advantage over the desktop computer. The latest mobile systems contain color screens of high resolution, clarity, high memory capacity, and rapid linking with the Internet, as well as many other advantages that make the mobile games more attractive (Robers & Vanska, 2011).

The rapid development of the mobile systems creates new possibilities to learn math, as compared to the office and mobile computers. The mobile systems are light weighing and enjoy a longer battery life, as it could "survive" for an entire day without recharge. In addition, the touch screen is easier to use than the mouse or keyboard, and provides a better sensory experience by direct touch and physical movement (Koutromanos & Lucy, 2014; Nicol, 2017; Zaranis, Kalogiannakis & Papadakis, 2013). Segal (2011) found that the students who used a tablet with a touch screen better performed in the arithmetic and digital estimation as compared with those who used the mouse entries.

Gaming concept witnessed a remarkable change among the children due to the rapid changes taking place worldwide in the information technology age. While the children gaming is tied to their loud voices and collective laughs in an open space such as the house garden, the mobile gaming came as an inevitable result of the information leap, which has occupied our life with all its particulars. The young's interest shifted to the electronic, video and mobile gaming, which succeeded in attracting both the young males and females (Huizenga et al., 2009, Miller & Robertson, 2011).

The mobile game makers succeeded in attracting large numbers of users who are highly fond of the computerized games, particularly the children and adolescents. In this concern, the innovated designs, the renewable ideas of these computerized games, the ease of using the mobile telephones, and possibility to take them wherever they go, all led to the addiction of the vast majority of children and adolescents on the use of the games in their mobile telephone. As such, the mobile gaming industry managed to attract the children due to many factors. Certain factors are connected to the technical aspects, and others are due to mobile spread over and the ease of use. Their success is also ascribed to being an entertainment way that provides children opportunities to discover and experiment, without the risk of responsibility or punishment (Admiraal, et al., 2011; Hursen. & Bas, 2019; Seidg, 2008).

Many studies indicated the significance of educational mobile gaming use among learners. They integrate learning with pleasure and suspense; thereby increase their academic achievements, and develop their creative thinking through innovated meth-

ods. They further contribute to the teaching individualization, allowing the learner to progress in his/her learning the way it fits his/her abilities and speeds learning, without shy or fear (Bicen & Kocakoyun, 2018). The study of Kebritchi, Hirumi & Bai (2017), and Seow Wong (2016) showed that the educational mobile gaming increases the student's achievements in various educational stages, and in different academic subjects, such as mathematics, English, and others.

The study of Christothea (2018) and of Koutomanos and Lucy (2014) emphasized the importance of the mobile gaming in providing scientific concepts. Miller and Robertson (2010) and Wang Huang and Hsu (2017) asserted the importance of the mobile gaming in the development of the student's scientific skills, such as computer use skills, social media skills, reading skills, and self-learning skills. Finally, study of Diah, Ehasn & Ismail (2010), Franklin & Peng (2008) and Wijers, Jonker & Drijvers (2010) indicated the importance of the mobile gaming in increasing the motivation level with the students toward teaching and stimulating their mental abilities.

The above studies show that the mobile gaming provides the learners a chance to see things in ways totally different from what they are. Games can do this without going through details or extensive explanations, which lead to the learner's mental dispersion. Learning through mobile gaming is superior to learning from the books, as it is more successful in communicating the information, because it fills the gap between the student and the academic subject (Fabian, Topping & Barron, 2016; Huizenga, Admiraalm Akkerman & Dam, 2009).

The researcher observed the students' passion in using the games in their mobile telephones. They tirelessly spend their free time playing, and based on this fact, the researcher believes that employing a pool of mobile games that includes the mathematical concepts may lead to provide these concepts to students. Based on the previous studies, the researcher concluded that it is important to design an attractive and innovative mobile way that contributes in providing the student with mathematical concept. This may lead to an increase in the positive effects of the mobile games in the students' math achievements. Accordingly, the study attempts to answer the question: what is the effect of the mobile gaming in math achievement of the 4th graders? Therefore, the study seeks to design mobile gaming that could be used through the mobile telephones, and identify the effect of these games on the math achievements.

This study may benefit the curriculum and the academic subjects designers through focusing the attention to the preparation of mobile games, which contributes in developing the student's acquisition of different concepts. It further benefits the educational supervisors through holding training courses for the math teachers, to provide them with skills for designing mobile games according to specific criteria and controls. Teachers also may benefit from it through understanding the best ways to apply the mobile gaming in math teaching, and provide educational environment that encourages students to interact and participate. Parents also can make use of it through introducing them to the importance of the educational mobile gaming in facilitating their children's learning. Finally, it widely opens new educational mobile gaming-based research horizons and prospective, and provides particulars of their effects in many aspects, such as improving the academic achievement, developing the thinking styles, providing values, and other advantages.

# 2 Method

The quasi-experimental design was used to investigate the effect of mobile games on mathematical achievement among 4th grade students. This design requires the following groups:

- The experimental group: Consisted of design, who studied "mathematics" using mobile games.
- Control group: Consists of design, who studied "mathematics" using the conventional method.

## 2.1 Study sample

The study was applied to a sample of 4th grade students, who studied "mathematics" in Zarqa City (Jordan) during the first semester of the year 2018/2019, due to the importance of the 4th grade. Where the Ministry of Education of Jordan considers this grade a stage through which it can enable students Understand the different math ideas. Furthermore, the TIMSS exams are designed based on this grade, because there is a similarity in the content of the Jordanian, European, and American mathematics textbooks for the $4^{th}$ grade in the fields of numbers, geometry, algebra, statistics and probabilities, as they are all built in the light of the NCTM. (Note: this is the adopted 4th grade math book for all Jordanian schools). The sample was randomly distributed over the study groups: group one (n=34) taught using mobile gaming, and group two (n=32) taught by the conventional method.

## 2.2 Achievement test

The researcher built a test consisting of (30) multiple-choice types, by analyzing the content of the mathematical textbook, and building the specification table, based on the National Assessment of Educational Progress (NAEP) levels of the educational objectives. Namely: conceptual knowledge, procedural knowledge and problem solving, the test was presented to the reviewers to verify its validity, and the test was modified in light of the reviewers' feedback. The researcher applied the test on an exploratory sample, and computed the difficulty coefficients ranging between 0.28 and 0.78, the discrimination coefficients, which ranged between 0.29 and 0.81. The reliability of the test was verified by Cronbach Alpha (0.83), which is an educationally acceptable value, The researcher used the test before the experiment to verify the parity between the experimental and control groups, and then after the experiment to detect the existence of differences statistically significant between the two groups.

## 2.3 The educational mobile games

The Dick and Carey model and the SMSE model associated with mobile learning content were combined and consisted of the following stages: Scenario, Message, Synchronization and Evaluation, In the light of the learning program nature in the

study, which combines these stages in the Dick and Carey model for the production and development of educational materials, the model used in this study appears in Figure 1.

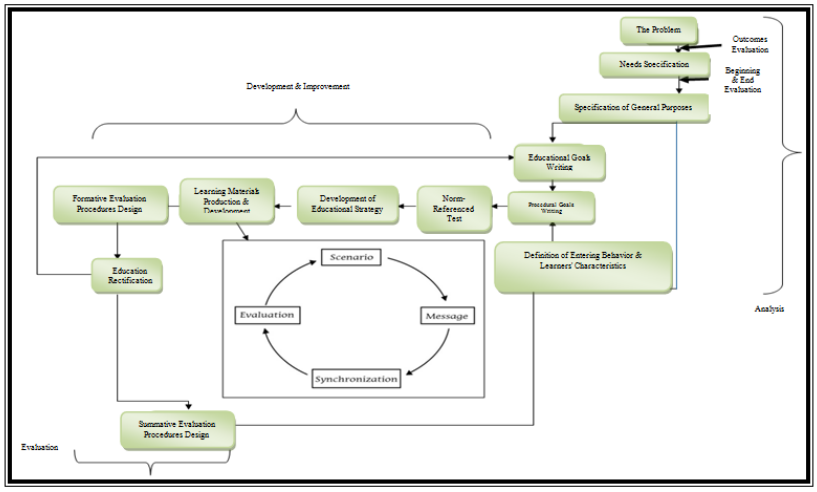


**Fig. 1.** The suggested learning model design

The researcher designed and produced mobile games, in order to use them in the teaching of the experimental group; to detect their impact on mathematical achievement, and so the researcher followed the following Stages:

**Stage one: analysis and writing goals:** The analysis stage is one of the basic stages in designing a suitable educational environment for teaching and for the use of mobile gaming. To achieve this, the researcher carried out the following:

- Specifying the general objectives of the educational content in the mobile games. The general purpose of designing the mobile games is providing the students with the mathematical concepts stated in units four and five (Fractions and Fractional Numbers/Decimal Fractions).
- Determining the educational content in the mobile games. The educational content in the mobile games included the math concepts, which resulted from the academic content of the unit (Fractions and Fractional Numbers/Decimal Fractions). In this concern, the analysis resulted in 10 mathematical concepts.
- Defining the Learners' characteristics and needs. In the current study, 4th graders are the beneficiaries of using the mobile gaming. Therefore, care should be taken regarding their needs, tendencies and abilities when we design and produce these games. We are also required to decide the learners' characteristics of the current study through the following:
- The students possess good experiences in the use of the mobile telephones and their different applications.
- Most of the students want to learn with the mobile telephones applications.

- Students tend to compete at the individual level at first, then at the group level thereafter.
- Students, during the learning process, need what stirs their imagination and launches challenges to their minds. Students generally tend to be curious, seek exploration, experimenting and discovering new things.
- They continuously try to link the knowledge they study with examples of the factual surrounding environment.
- They prefer the instant enhancement after providing correct answer, particularly in the individual contests.

**Stage two: development and improvement:** This stage is related to the preparation of a detailed description of all the processes of the operations and components of the mobile games. Therefore, the researcher reviewed the literature and scientific references concerning designing the mobile games to explore the technical and educational criteria that should be adopted when we design such kind of games. Especially, the games used in the current study are practiced by the smart telephones, which add more criteria and conditions due to the differences of the smart mobile telephones capabilities from other appliances used in gaming, such as the small sized screen, possibility of playing through the touch technology, freedom of moving during the game and so on. During the design stage, in this Stage, the integration of the SMSE model was used in the tutorial design steps where the researcher implemented the SMSE model; the researcher conducted the following procedures:

- **Phrasing the procedural objectives**: The researcher phrased the objectives in a procedural manner, and presented them to a pool of arbitrators to show their views and comments. In the light of their comments, the researcher made the relevant amendments, which led to produce the list of the educational objectives in its final shape.
- **Designing the suitable educational content of the mobile gaming**: The researcher organized the educational content of the subject to be taught using the mobile gaming in the light of the predefined educational objectives. The content elements were coined by two ways:
  - Phrasing the educational material in the form of abbreviated information, so that they are presented to the user before starting the games, to help him/her in achieving the assignments, overcome the obstacles, and realize winning.
  - Phrasing the educational material in the form of various questions, so that they are presented to the game user during practicing the game. Therefore the student should answer correctly to allow him/her proceeds in the game and win.
- **Designing the mobile games:** After defining all the educational and technical specifications of the games, the researcher developed a vision of the mobile games that may be appropriate to the subject matter of the current study. He took into account that they should fit the age group of the 4th graders. To design these games, the researcher carried out setting designs of all the interfaces, graphical objects, and play environments of each game, Selecting the still and moving images and sound effects appropriate to each game, Selecting the type of clear scripts with attention so that the size and color of the script should be suitable for the play environment, De-

signing interactional buttons the player uses to start or exit the game and other functions, Giving the game an interesting and relevant name and designing the number of the levels it includes. Accordingly, a game that included 9 levels was developed.

- **Distributing the educational content over the mobile game:** The researcher distributed the educational content over the different game levels. The math concepts to be provided to the students were determined at every level, to achieve the current study objectives. Table (1) illustrates the math concepts distribution over the game levels.

**Table 1.** Distribution of the mathematical concepts on the levels of the games

| Game Title | Level | Math Concepts |
|---|---|---|
| Math Helicopter | 1 | Equal Fractions |
| | 2 | Fractions Simplification |
| | 3 | Conversion of the fractional number to a fraction and vice versa |
| | 4 | Adding the fractions and the fractional Numbers |
| | 5 | Subtracting the fractions and the fractional Numbers |
| | 6 | The decimal fractions |
| | 7 | Parts of 10 |
| | 8 | Parts of 100 |
| | 9 | Decimal numbers |

Designing the interactional interfaces in the mobile games. User interface is all that the learner sees of elements, and all that interacts with him/her of tools on the screen. It includes all the system components, its different functions, as well as all the icons, buttons and links, which help the learner in the navigation process, and provide access to the different elements of the system. Accordingly, the researcher divided the designs of the interactional interfaces of the educational mobile games into six parts, as follows:

- **Main game interface**: It was designed in an attractive manner with music in the background. It contains the name of the game, an enter button and a button to move to the screen around the game (Fig. 2).
- **Game level interface**: It includes a number of the game levels. The player must achieve winning in a certain level to enable him/her move to a higher level. After achieving the winning in all the game levels, the player can choose the level he/she wishes, and the time he/she wishes.
- **Information interface**: It includes a part of the educational material in the shape of brief information, the interface appears to the user before he/she starts playing, to help him/her achieve the educational assignments, face the graphical objects, and realize winning.
- **Game environment interface**: It is the playground that includes the educational tasks in the form of question that needs an answer. In addition, it includes the graphical objects that require the player make correct answer toward them, to enable him/her accomplish the educational tasks and achieve winning the game level.

- **Winning interface**: This interface appears automatically just when the player completes all the educational tasks in the game level. It also has attractive animation and music in the background that implies winning.
- **Loss interface:** It automatically appears just when the player fails to accomplish an educational task, or offers wrong response about the graphical objects, or else if he/she "consumes" the time allocated to the achieve all the educational tasks in the game level. This interface contains expressive animations and music in the background that signify the loss (Fig. 3).
- **Designing the suitable teaching strategies for the mobile learning environment**: The researcher depended on the students' use of the mobile games, In addition to a set of teaching strategies, namely collaborative learning, PowerPoint strategy, Discussion strategy.
- **Defining programs of the mobile games production**: The researcher determined the computer programs needed to convert all the designs of the educational electronic games into usable software. These programs are Game Marker Studio Program, Adobe Photoshop SC6 Program, Audacity Program, and Microsoft Office Word 2013 Program.
- **Designing the evaluation tools**: The researcher designed the evaluation instruments that fit the nature of the educational environment, which is based on teaching through using the educational electronic games in the smart mobile telephone, which were as Winner lists or lead rankings, Worksheets and mathematical achievement test that is applied directly to the students just when the experiment is over.


**Fig. 2.**

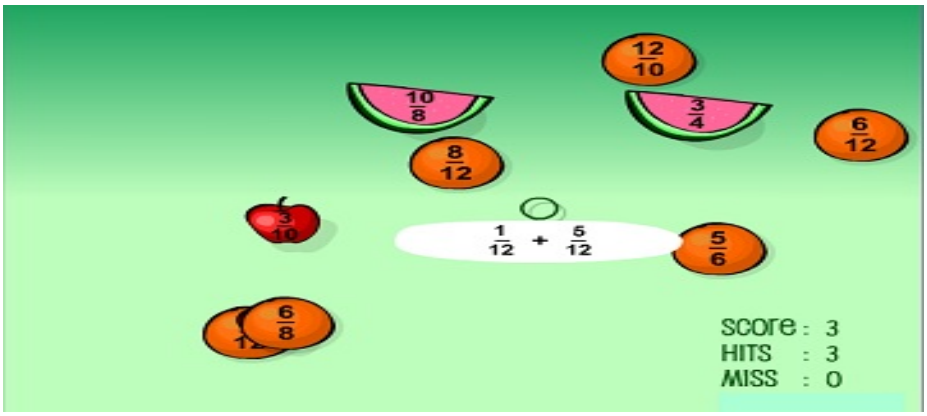


**Fig. 3.**

**Stage three: Evaluation:** This stage is connected with the mobile games following the completion of their production process, to ensure their application validity to the learners and their suitability for the use in their smart telephones. I conducted the evaluation process through presenting the mobile games for arbitration, to carry out the amendments that they may require. I further applied it to an exploratory group of twenty 5th graders to discover the difficulties and challenges that may encounter the students during the game practice using their smart mobile telephones. I discovered their need for a longer time to achieve the required tasks in the second game levels, as well as ambiguity of certain questions in the third game level, and inability of some smart mobile telephones to download the games. The researcher overcame all these problems.

After ensuring the field applicability of the games, the researcher distributed them over the experimental group students to teach them the educational material using these games in the smart mobile telephones. Following the experiment application, the post-application math achievement test was applied to both the control and experimental groups.

## 2.4 Group parity

The researcher determined the achievement by verifying that there were no statistically significant differences in the achievement among the students of the control and experimental groups by applying the achievement test to the students before the experiment was started. Therefore, the researcher conducted a (T) value for two independent samples, the value of T is 0.85 and the statistical significance is 0.40, which indicates that there are no statistically significant differences due to the variable of achievement between the two study groups.

## 3 Results

Results showed there were differences in the achievement between students in two study groups. The group taught using mobile gaming had the following results: conceptual knowledge (9.29), procedural knowledge (8.82), problem solving (8.32) and overall all test (26.44). While the group taught using, conventional method had the following results: conceptual knowledge (6.81), procedural knowledge (6.88), problem solving (6.47) and overall all test (20.16). Table (2) show these results.

**Table 2.** M's and SD's of the three groups

| Variable | Group | No. | M | SD |
|---|---|---|---|---|
| Conceptual Knowledge | mobile gaming | 34 | 9.29 | 0.76 |
| | Control Group | 32 | 6.81 | 0.69 |
| Procedural Knowledge | mobile gaming | 34 | 8.82 | 0.97 |
| | Control Group | 32 | 6.88 | 0.91 |
| Problem Solving | mobile gaming | 34 | 8.32 | 0.81 |
| | Control Group | 32 | 6.47 | 0.88 |
| Overall Test | mobile gaming | 34 | 26.44 | 1.86 |
| | Control Group | 32 | 20.16 | 1.08 |

The (ANOVA) was employed; its results showed differences between the two study groups as follows: In the conceptual knowledge: $F=191.471$ ($p<0.05$); in the procedural knowledge: $F=70.791$ ($p<0.05$); in problem solving: $F=79.928$ ($p<0.05$); and in the overall test: $F=276.718$ ($p<0.05$), as shows in Table (3).

**Table 3.** ANOVA to Identify the significance of the differences among the means of the two groups

| Source | Dependent Variable | Sum of Squares | DF | M. Square | F | Sig | Partial Eta Squared |
|---|---|---|---|---|---|---|---|
| Teaching Method | Conceptual Knowledge | 101.521 | 1 | 101.521 | 191.471 | 0.00 | 0.75 |
| | Procedural Knowledge | 62.589 | 1 | 62.589 | 70.971 | 0.00 | 0.53 |
| | Problem Solving | 56.711 | 1 | 56.711 | 79.928 | 0.00 | 0.66 |
| | Overall Test | 651.156 | 1 | 651.156 | 276.718 | 0.00 | 0.81 |
| Error | Conceptual Knowledge | 33.934 | 64 | 0.53 | | | |
| | Procedural Knowledge | 56.441 | 64 | 0.88 | | | |
| | Problem Solving | 45.410 | 64 | 0.71 | | | |
| | Overall Test | 150.601 | 64 | 2.353 | | | |

The results showed the students of the group taught using mobile gaming outperformed the control group students; this preeminence was in all the dependent variables (conceptual knowledge, procedural knowledge, problem solving and the overall test).

## 4 Discussion and Conclusion

This study found encouraging evidence of the use of the mobile gaming to improve the students' math learning, and fill the achievement gap between the defaulter and normal students. The previous research works showed that learners will benefit the interference of technology in math teaching (Kebritchi, Hirumi & Bai, 2010; Sedig, 2008). Nonetheless, not much is known about the effectiveness of the mobile gaming. This current study found that the use of the mobile gaming is an effective practice in providing educational support to the students inside the classrooms in the public education. In short, there is a possibility of using the well-designed mobile games to assist the students realize high achievement in mathematics.

The effect size of the mobile games use on the grand total of the test levels was high, which emphasizes the mobile games effectiveness. The researcher attributes this result to that the mobile gaming learning method, as a new learning style, raised the students' interest and increased their motivation toward learning. The games displayed the academic material in an interesting and enjoyable way, as the photos, drawings, sound effects, and motion overlap in an attractive manner, which made the student active, effective and willing to learn.

On the other hand, the mobile games allowed the student a chance of gradual and self-progress in the scientific materials, according to his/her ability in achieving the educational tasks and realizing the winning in every level of the game. The mobile games relied on stirring the spirit of the individual competition among the students, in addition to competing at the group level, which increased their interaction and willingness to achieve the educational tasks in the game level, and approach realization of winning. The mobile gaming also provided an opportunity to play without time and place constraints. Students were seen playing in the school courtyard and during the break times. They further provided instant feedback after every response, which initiated a challenge with the self and propelled him/her to continue playing to achieve winning.

The mobile games introduced the concepts to the students gradually. They handled the same concept many times in different ways, and in more than one of the game levels, which resulted in the occurrence of learning based on understanding. This assisted the student integrate the math concepts into his/her knowledge structure in an organized, retrievable manner; this explains the high effect size of conceptual knowledge among students.

The use of mobile games inside the classroom resulted in strong relation between the students and the teacher, which stimulated them to express their emotions and posit their questions free of shame or fear. This made them participate in the teaching-learning process in a positive, active and effective manner. This result is in line with many previous results, such as Rava'a and Daher (2009); Kiger, Herro and Prunty (2012).

Pursuant to the test the researcher made on the use of the mobile telephones in math learning, he strongly believes that many chances and possibilities are not yet realized. We are still at the beginning stage of the discovery of such a promising use in the educational environment. In spite of the disturbance that these systems may cause in

the classrooms, yet the researcher believes that preventing their use in schools is not the solution. We have to continue studying pedagogy, side by side with the use of mobile telephones in the actual educational environment, and develop suitable activities that are efficiently used in these systems in the learning process.

In the light of the findings of this study, the researcher recommends employing the mobile game in teaching the math concepts, for all the educational stages, for both males and females. The Ministry of Education is required to adopt principles of gamification in education and provide relevant software's to it. It is also required to train the teachers on their use and designing and producing new mobile games that fit the objectives and content of the math curricula, which also correspond to the learners' age and psychological characteristics.

The researcher suggests conducting more studies to unfold the effect of employing the mobile gaming in developing other learning aspects, such as the different thinking styles, creative problem-solving, decision taking skills, and development of learning processes. Furthermore, the researcher suggests conducting studies to uncover the effect of the mobile games in teaching academic courses to students of different levels, such as gifted students, students with learning disabilities, and special needs students.

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# Enhancing Reflection and Empathy Skills via Using a Virtual Reality Based Learning Framework

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**Abstract**—The last few years Virtual Reality (VR) based approaches have emerged as a new education paradigm. This paper addresses the possibility to cultivate reflection and empathy skills using a VR based framework targeting to maximize the professional development of teachers. Reflection and empathy are skills of paramount importance for teachers and an integral part of their professional development. The current research aims to investigate possible differences in cultivating reflection and empathy skills between participants who used a VR system and the control group who were trained in a real classroom environment. Experimental results indicate that the participants using the virtual classroom environment were able to better reflect and empathize with the students whereas participants from the control group tended to be more undecided. Moreover, the VR system gave the participants the opportunity to enter the students' virtual body and understand the different perspectives affecting at a higher level the reflection process than the control group.

**Keywords**—Teachers, reflection, empathy, virtual reality

## 1 Introduction

Today's societies are plagued by constant changes brought about by the rapid technological evolution of recent years. The new technological trends led to the transformation of the educational systems globally and to the digitalization of today's classroom, making teaching an even more complex and dynamic process that requires highly skilled teachers able to deal with unforeseen challenges that arise within the school context. Thus, teacher's professional development and high-quality expertise is of paramount importance and the key that will eventually maximize the quality of education.

Teachers are the heart of every school or educational institution in all levels. Hence, the quality of their training, starting from Initial Teacher Education (ITE) to

career-long professional development, plays a crucial role for the quality of teaching and student management that shapes the future generations [1]. ITE is a teacher's first step of a long journey in teacher training and development. However, research reveals that ITE programs do not adequately prepare pre-service teachers towards today's challenges, while most teacher education programs are still very theoretical and disconnected from the school environment [2][3][4][5][6]. As a result, the knowledge gained at University courses is not sufficient for confronting the classroom, while the lack of classroom practice and of strong communication channels between universities and schools does not provide new teachers with experiences related to realistic in-school situations [4]. Furthermore, nowadays classrooms are characterized by heterogeneity and an increasing number of pupils who whose first language is not the official language of the school. Consequently, teachers need to respond to this multicultural challenge, understand student's different cultural backgrounds and needs, while they must treat all students equally and individualize learning.

This paper presents a proposal for the improvement of teacher education via using a VR based approach as part of teacher education framework that will allow teachers to experience an entirely new side of training. The article analyzes one of the first attempts, at least to the best of our knowledge, to use a VR based framework to educate teachers. Moreover, the VR system and scenarios were designed based on an extensive literature review research, surveys and interviews with teachers and experts to address real needs of teachers maximizing the effectiveness of the VR system. Furthermore, the VR system targets the cultivation of specific competencies and specifically reflection and empathy, derived from an extensive documentation of existing Teachers' Competence Models and significant guidance by experts who pointed specific competencies of primary importance to teachers. VR can provide teachers an absorbing, realistic and interactive virtual classroom space, allowing them to virtually experience real life classroom scenarios. Within the virtual world teachers can experience real-life situations, test their knowledge and decide the appropriate course of action, but within a safe environment that minimizes the risk of harming real students. The paper presents an experiment that aimed to investigate the possibility of using a VR-based approach aiming to enhance teacher's reflection and empathy skills. Additionally, the experiment aimed to identify possible differences between the groups that used the VR system and those who were trained in a real classroom without using the VR system.

## 2 Literature Review

### 2.1 VR-based approach in teacher education to enhance reflection skills

The past few years, there is a growing interest of the scientific community to take advantage of VR technology in the field of education [7]. Nevertheless, research regarding the use of virtual reality environment (VRE) - based educational interventions in teacher training is still at its infancy and there is limited yet growing body of research indicating the potential of using such an approach [8].

The first attempts of using VR based learning for teacher education regarding issues such as bullying, and recognition of student's vision disorders yield promising findings [9][10]. Moreover, the use of VR environments is very useful in domains complex and difficult to master, and as such it is well suited for teacher professional development. VR has the potential to become an innovative and essential tool in teacher training offering teachers the room for experimentation but without the risk of harming real students [11]. Equally important is the fact that the knowledge gained using VR can be applied to real life and thus teachers will be able to apply the knowledge gained in their real classroom [12][13][14]. Moreover, such a VR system can offer users the opportunity to record their performance, reflect on it and experiment again supporting in that way the enhancement of teaching performance [13][15].

Taking all the above into consideration, this paper proposes the use of a VR tool for the development of effective future teachers that will be successful in the classroom, while constant training within the virtual environment will ensure their survival in todays' digital and multicultural classrooms. This research aims to give an innovative VR-based approach to teacher education and the related training methodology that will allow in-service and pre-service teachers to experience an entirely new side of training. Moreover, the use of VR in teacher training responds to a real need from the European Union [1] for improving the development of teaching practices and attracting more high-quality candidates to the teaching profession. The aim of this research is to offer a new paradigm in teacher training, an alternative safe and low-cost environment that allow users to learn from their mistakes without consequence for the students. The proposed virtual reality tool aims to provide strong support for teachers' professional development through high-quality scenarios that address real needs of teachers. Moreover, the VR tool addresses specific teachers' competences as outcome, after an extensive documentation of existing Teachers' Competence Models and significant guidance by experts who pointed specific competencies of primary importance to teachers.

The implementation of the VR based approach followed a full designed cycle, a five-phase process influenced by the ADDIE model (Analysis, Design, Development, Implementation, Evaluation). The development of the VR system is linked to both strong theoretical foundations in education derived from the literature, and real teachers' problems based on extensive literature analysis and survey. The VR based approach allows users to construct knowledge from facts and improve their teaching practice via recalling their own experiences and reflecting on them [16][17]. Furthermore, VR offers the possibility to experience a range of professional situations while it also includes the element of repetition. A professional practitioner, experiences various situations repeatedly and through reflection he/she can criticize and think back the situations he/she experienced maximining his/her knowledge and understanding and be prepared for future situations [18]. Thus, a teacher within a VR environment can encounter a certain situation repeatedly and through experimentation and constant practice to be able to respond in a similar situation in the real class-room context.

### 2.2 The five-stages for the development of the VR system

The development of the VR system progressed through the five stages of Analysis, Design, Development, Implementation and Evaluation of instructional design that is being used widely for the development of training programs [19][20]. The five stages constitute a set of activities that target specific outcomes [21]. More specifically, the five stages are:

**Phase 1:** Analysis and investigation of teacher's real training needs through literature review research, survey and interviews with teachers and experts.

**Phase 2:** Designing the competency framework for the proposed Virtual Reality-based investigation. Addressing all teacher's competencies included in the various models is unmanageable at this stage, thus, a selection of competencies had to be made based on the indications by teachers and experts. Hence, the proposed VR system aims to enhance reflection and empathy skills.

**Phase 3:** Design of the scenarios

**Phase 4:** Development of the VR system

**Phase 5:** Implementation and evaluation of the effectiveness of the VR system

### 2.3 Reflection in teacher education: significance and challenges

Reflection comes from the Latin word 'reflectere' that means to turn back [22] and it is not a new concept, but it can be traced back to ancient times as Socrates and Plato were the first to use the process of reflection. Even though the concept of reflection has been around for a long time, the educational systems became capable of integrating reflection skills in the 18th century when education was treated as part of the total social system [23]. For this reason, the social context and its influence on the school environment cannot be omitted during the process of reflection and should be taken into consideration by teachers when reflecting on their work [24] [25]. Neglecting the social conditions that influence today's classrooms, especially nowadays that the societies have become multicultural posing enormous challenges, will lead to teachers who are incapable to confront the transformation and modernization of the educational system and ineffective to achieve the educational goals and prepare today's students for tomorrow.

There is no single definition of the concept of reflection but a variety of classifications representing the different viewpoints of the theorists that used the term. Dewey [26] defines As stated in Ref. [26] reflection is an 'active, persistent, and careful consideration of any belief or supposed form of knowledge in the light of grounds that support it, and the further conclusions to which it tends'. Reflection is an everyday process, 'an important human activity in which people recapture their experience, think about it, mull it over and evaluate it' [27]. Additionally, reflection is a learning mechanism that includes the process of stepping back from an experience and through extensive consideration get a better and deeper understanding of a phenomenon [28].

Reflection has been considered as a skill of paramount importance for teachers and an integral part of their professional development [29]. As stated in Ref. [30] teacher education programs should emphasize on the promotion of reflection skills that will

help teachers understand the connection between theory and practice maximizing their effectiveness. Reflection can promote the development of new knowledge regarding good teaching practices that goes beyond the role of the university and needs the active participation of the teacher [31].

Reflection on teaching practice concerns all teachers, educators or tutors of all educational levels, who are led by their need to understand and evaluate their teaching practice, identifying mistakes or problems in order to act as efficient as possible [32]. Through reflection teachers can explore more critically their teaching practice allowing them to enhance their professional knowledge. Hence, pre-service teachers could start reflecting on their practice aiming to improve their teaching skills, newly appointed teachers could use reflective practice to increase their knowledge and understanding maximizing their professional development, while experienced teachers through reflection could understand in depth various educational issues that arose during their career because of the enormous educational changes [24]. Reflective practice is a promising method to be used in education allowing people to recapture their experience and use it as an opportunity to learn [27] [33]. Additionally, the process of learning through experience, experiential learning, promotes the development and maintenance of professional expertise [24] [32] [34].

Even though the process of reflection is quite promising in the field of education, several challenges have been encountered that need to be addressed. One significant issue is that reflection is not characterized by conceptual clarity and as a result it has been used differently by different scientists and practitioners [33] [34]. Furthermore, there is high possibility that in many cases reflective activities promote predetermined outcomes turning the reflective process to a memorization process preventing learners self-reflect and brainstorming [35]. Moreover, in many cases reflective activities do not target learning. It is important to design reflective activities within the context of specific aims and consequences, otherwise the expected outcomes might not be accomplished [24]. In many cases, reflection is not being encouraged by the learning context the trainer has set and as a result, the trainees do not focus on their personal experience and do reveal their misunderstanding and uncertainties, undermining their learning [34]. Equally important is the fact that the aims and boundaries of reflection following an activity must be set; otherwise, it is possible to observe ethical dilemmas affecting negatively the relationship between the teacher and a student [34].

Reflection must become a top priority of teacher education programs, as through the reflective process teachers will be able to evaluate their experiences and throughs, especially those coming from their classroom practice and analyze different viewpoints increasing their awareness and understanding [16] [33] [35]. As a result, reflection has been set as a goal of many teacher education programs as there are indications that the integration of reflection within the curriculum resulted in more empowered beginning teachers [16]. Moreover, reflection is included in most teacher competence models and frameworks these days [36] [37].

Nevertheless, despite the fact, the reflection is a key component in most competence models; it is also one of the most difficult challenges for teachers [38]. There are indications that teacher education programs promote superficial cultivation of teacher's reflective skills [39] [40]. Moreover, teacher education focuses on the pro-

motion of reflection regarding teaching practice and the ways to improve the teaching strategies to respond to the standardized curriculum, ignoring the importance of reflection to the promotion of teacher's professional development [25]. Furthermore, results indicate that beginning teachers do not possess the ability to self-reflect even after receiving relevant education and as a result they face enormous difficulties in critically reflect on their teaching practices [41]. This lack of teacher's reflective skills indicates a failure of teacher education programs [42]. Thus, there is a need to enhance teachers' self-reflection through experiential learning, so as to maximize their expertise [24].

Taking all the above into consideration, reflection is a key point in the professional development of teachers. Reflective practices will allow teachers to detect their strengths and weaknesses and learn through the experiences of their everyday classroom lives. Self-reflection will also enable them to invent new strategies of action and make decisions based on prior experiences. Moreover, by recognizing their own errors and weaknesses teachers can have an explicit picture of their progress and see what needs to be improved. Reflection is the means that will enable them to increase their self-awareness, develop critical thinking and evaluation skills. In addition, reflection encourages metacognition and self-empowerment, enhances creativity and contributes in the improvement of communication, which will help them respond to the new social challenges of the 21st century.

### 2.4 Empathy and Education: Enhancing empathy skills using VR

Empathy is the ability to place oneself in another's position, participate in what one suffers until complete empathetic identification without the lost of the personal identity [43]. There is no consensus on the meaning of empathy, as it is used by several disciplines and thus the different definitions reflect the differences of the fields [44]. Empathy refers to the ability to enter the position of another person and see the world with his/her own eyes. As stated in Ref. [45] empathy as "a quality shown by individuals which enables them to accept others for who they are, to feel and perceive situations from their perspective and to take a constructive and long-term attitude towards the advancement of their situation by searching for solutions to meet their needs". Empathy is the ability to understand or appreciate how someone else feels [46]. As stated in Ref. [47] empathy is the 'capacity to (a) be affected by and share the emotional state of another, (b) assess the reasons for the other's state, and (c) identify with the other, adopting his or her perspective'. Despite the variation in the terminology of the term, all the definitions converge that empathy is the ability of 'predicting, of appreciating the psychological dispositions of a person, his/her perceptions, thoughts, feelings and attitudes as own traits perceiving the other's mentality, his feelings, desires, opinions, and more concretely to predict his behaviours put yourself in another's place, to see the world as he sees it' [48].

Empathy is a very strong communication technique as it promotes the establishment of social interactions and cooperation [46]. The development of empathy skills allows us to enter the position of the other, understand his/her behavior and motives and thus see the world through his/her eyes that is a very strong communication tool.

The role of empathy is decisive in all sciences today. Hence, empathy is considered an integral part of education and must be an integral part of the pedagogical process to assist with the social and emotional development of students. As stated in Ref. [49], 'understanding of the self in relationship to others is a fundamental element in teaching'. In the context of education, empathy 'refers to the teacher's participation to the pupils' emotions and feelings, to their sharing, to their common experience. It consists in a togetherness with pupils, to the grasp of their inner universe' [48].

Empathic teachers can take on the perspective of their students and respond from that perspective. This allows them to transpose themselves to the position of the student and to decide the best course of action within the limits of a permissible error [48]. The establishment of balanced and strong relationships between students and teachers and teacher's ability to meet their students' needs can increase their student's elf-esteem and self-worth. Additionally, the establishment of strong communication channels between teachers and students affects positively student's cognitive, social and emotional development, while it also increases their sense of belonging to the school [48][50][51][52]. Moreover, empathic teachers who become emotionally involved with their students receive similar responses in return that affect positively student's personal and academic development and their relationships with the others [45].

Empathic teachers can be moral models setting a good example for the students and impart their values to their students expecting them to learn to value other people [45]. However, it seems that the educational system itself undermine teacher's efforts and even though they begin their career with a great deal of concern for others, their lack of empathy training and their everyday school life changes their caring role giving priority to the classroom management and curriculum implementation [45]. Teachers as most people have not been trained and do not poses empathy skills. In the past when societies were smaller, people could more easily understand their neighbors. However, the new living conditions and the modern social and economic problems have led to people who find it hard to express themselves and thus, their problems cannot be understood easily just by observing them. As the school is a microcosm of the society teachers deal everyday with students who are not able to express themselves. It is therefore a necessity for teachers to be trained and enhance their empathy skills in order to be able to help their students but also other people around them.

VR is an 'empathy-inducing medium' [53], which makes it a suitable tool in enhancing empathy skills as it can help people in general to relate to each other and help teachers in particular to relate to their students. The current research explored the possibility to cultivate empathy skills using a VR based approach. This need arose also from the fact that although empathy is considered a key skill for teachers it is not include as a key competence in the various competence models (add references). Another factor that contributed to that was that only in a model proposed outside Europe and specifically by the National Institute of Education-NIE [54] in Singapore empathy is included as a top priority skill.

# 3 Experimental Set-up

## 3.1 The groups

The experimental investigation included three different classroom scene settings:

- Physical (Real) Classroom space setting (see Figure 1 top)
- Virtual Environment with Realistic Appearance (see Figure 1 middle) that was designed based on real classrooms
- Virtual Environment with Imaginary Appearance (see Figure 1 bottom) that is an imaginary virtual classroom space

The imaginary environment was designed based on suggestions by active and experienced teachers who would prefer to be trained within a virtual world that does not simulate the real classroom that is part of their daily routine.

**Fig. 1.** Physical (Real) Classroom space (top), Virtual Environment with Realistic Appearance (middle) and Virtual Environment with Imaginary Appearance (bottom)

Three groups, each consisting of 11 participants, took part in the experiment and each group experienced the same scenario but in a different classroom setting among the ones described above [55]. However, the present paper does not aim to analyze the differences between the two virtual worlds and for the presentation of the results the participants are divided into two groups:

- The control group, the Physical Space group (PS.group) experienced the scenario in a physical classroom with real students
- The second group, the Virtual Reality group (VR.group) experienced the scenario in the two virtual classroom environments

### 3.2 The scenario

The scenario dealt with multiculturalism and verbal bullying and its selection was the result of an extensive literature review research, survey and interview conducted with experienced in-service teachers and academic experts regarding the most important problems that teachers face within today's classrooms. The scenario begins with the teacher introducing a new foreign student called Lynn to the classroom. Following her introduction to the class, Lynn receives verbal bulling from her classmates. The user-teacher was given the opportunity to experience the problem from two different perspectives (see Figure 2):

- **Perspective I** Through the eyes of the student Lynn
- **Perspective II** Through the eyes of the teacher

The scenario and the dialogues were the same at both perspectives, changing only the camera position allowing the user to experience the two different viewpoints.

**Fig. 2.** Experiencing the virtual worlds through the eyes of the student Lynn (right) and through the eyes of the teacher (left)

### 3.3 The virtual classroom environment

The VR system was developed with the Unity© game engine. The 3D avatars (teachers and students) were created using the online software Autodesk® Character Generator and the 3D models (school and objects including desks, chairs etc.) were develop using Maya Autodesk student version. Moreover, the Head Mounted Display

(HMD) HTC VIVE was used as a means of viewing the application. It is worth mentioning that there are several researches arguing the use of VR in education including the use of a three-dimensional environment displayed on computer screens. However, those researches do not include the use of the special electronic equipment such as HMD glasses such as VIVE. It must be clear that for the needs of the current research VR specific equipment was used.

# 4 Methodology

## 4.1 The research questions

The aim of the experiment was to identify the potential of using a VR based approach to enhance the cultivation of reflection and empathy skills. Moreover, the research aimed to identify possible differences regarding reflection skills between the groups that used the VR system and the control group that was trained within a real classroom setting without the use of VR. To achieve the above aims two re-search questions were posed:

- Does the use of VR promote the cultivation of reflection and empathy skills?
- Is there a difference in the cultivation of reflection and empathy skills between participants who used a VR system and those who were trained in a real classroom setting?

## 4.2 The sample

A total of 33 participants (22 male and 11 female), took part in the experiment all from higher education sector. Regarding the profile of the respondents in terms of their age 63.6% are in the age range of 25 to 29 years old 27.3% in the range of 30- 39 years old, 18.2% in the range of 50-59 years old and 9.1% in the range of 18-24 years old. In the first group, 54.6% of the respondents had between 1 to 2 years of teaching experience, while 36.4% of the respondents indicated no teaching experience at all. On the contrary, in the second group 72.8% of the respondents had between 1 to 5 years of teaching experience, while in the third group 45.5% of the respondents had between 1 to 5 years of teaching experience and 36.4% has between 6 to 10 years of teaching experience. What is significant is the fact that data revealed that most of the participants were unfamiliar with the use of virtual reality.

## 4.3 The research tool and the process

For the measurement of reflection and empathy, a questionnaire was developed based on several instruments concerning reflection and empathy, as none of the already existing instruments responded to the needs of the current research. The questionnaire was pre-tested along with the virtual classroom space by academic experts, and their comments and support lead to several modifications to achieve a clear out-

come for the participants. The experiment took place in December 2017. Before taking part in the experiment, all participants were informed about the experiment and its purpose, assurances of confidentiality and non-traceability regarding their participation were given along with explanations regarding their right to withdraw at any time and for no reason. After voluntary informed consent was obtained, the scenario was explained to the participants with more details and the experiment began. After the end of the experiment, the participants were asked to complete the questionnaire.

## 5 Results

After the data has been collected and analyzed with the use of SPSS software (Statistical Package for Social Sciences). Before the presentation of the results, there is a need to clarify the names of the two groups participated in the experiment and explained in the framework section above: VR.group (Virtual Reality group) and PS.group (Physical Space group).

Cronbach's Alpha coefficient of internal consistency was quite good for the items of the reflection scale (Cronbach s Alpha =0.88). For the empathy items Cronbach's Alpha coefficient was 0.71>0.7 indicating an acceptable reliability.

### 5.1 Reflection scale results

The results indicate that reflection is considered an important process for all respondents as the vast majority tend to score from agree to strongly agree in both groups (VR.group M=5.18 SD=.54, PS.group M=5.27 SD=.47). From the data it can be concluded that participants' experience within the virtual classroom can contribute to the change of their beliefs and ideas regarding multiculturalism and bullying as the majority tended to score from agree to strongly agree (VR.group M=5.00 SD=.41). On the contrary, participants of the control group tend to be more neutral and undecided (PS.group M=4.36 SD=.51). The output states that participants of both groups disagree with teachers disinterest in analyzing student's needs as they tended to score from disagree to strongly disagree (VR.group M=4.68 SD=.48, PS.group M=4.36 SD=.51). The results suggest that the group that used the VR system argued that such an experience can change the way teachers attend the needs of their students, as the participants tended to score from agree to strongly agree (VR.group M=5.23 SD=.43). The majority of the participants in the control group tended to be more undecided and neutral indicating their training experience in the real classroom setting did not have the same impact as the VR experience to the other two groups (PS.group M=4.36 SD=.51). From the data it can be also concluded that both the VR and the real-time classroom training experience can help teachers change the way they will react on disruptive behavior among my students, nevertheless many of the participants tended to be neutral especially those of the control group (VR.group M=4.82 SD=.73, PS.group M=4.36 SD=.51). Moreover, the results indicate that training both via VR and real-time can help teachers discover faults in their interaction with students that they previously believed to be right as the participants tended to score from agree to

strongly agree, however, many of the participants tended to be neutral and undecided in both groups (VR.group M=4.82 SD=.79, PS.group M=4.55 SD=.52). Based on the questionnaire responses it can be concluded that the participants who used the VR system indicated that they agree / strongly agree that a VR experience can offer them the ability to enter their student's position, while the participants of the control group tended to be more neutral regarding entering their student's position (VR.group M=5.55 SD=.51, PS.group M=4.36 SD=.51). Furthermore, the results suggest that VR can promote teacher's ability to provide improved support to students of other racial and ethnic groups. The majority of the participants that used the VR system tended to score from agree to strongly agree (VR.group M=5.00 SD=.62), while the participants of the control group scored lower tended from disagree to agree, indicating that their training in the real classroom did not seem to promote at high level their ability to support more students belonging to racial and ethnic minority groups (PS.group M=4.09 SD=.70).

The results from the tests of normality (namely the Kolmogorov-Smirnov Test and the Shapiro-Wilk Test), revealed that most of the items are below 0.05, therefore, the data significantly deviate from a normal distribution and non-parametric tests were used. Mann-Whitney U test indicated statistically significant differences between the two groups in some of the reflection scale items. There was a statistically significant difference between VR and PS group regarding the impact of the VR experience and the real-time classroom training on challenging teachers' firmly held ideas about the issues of multiculturalism and bullying ($U = 54.5$, $p = .003$) (Figure 3 top left). Moreover, Mann-Whitney U test revealed that there was a statistically significant difference between the two groups regarding changing the way that teachers attend the needs of the students ($U = 34$, $p = .000$) (Figure 3 top right). Another statistically significant difference between the two groups was found regarding teacher's ability to enter the student's position ($U = 20$, $p = .000$) (Figure 3 bottom left). Furthermore, Mann-Whitney U test revealed a statistically significant difference between the VR and the control group regarding teacher's ability to support more efficiently students belonging to racial and ethnic minority groups ($U = 45$, $p = .001$) (Figure 3 bottom right).

### 5.2 Empathy scale results

The mean scores do not indicate significant differences between the two groups regarding empathy. Respondents of both groups tended to agree that teachers should be able to predict the feelings of their students (VR.group M=4.78, SD=1.11, PS.group M=5.09, SD=.83). Respondents of both groups tended from agree to strongly agree that teachers should be able to spot when students are feeling awkward or uncomfortable (VR.group M=5.5 SD=.51, PS.group M=5.18 SD=.41). According to the results the participants tend from agree to strongly disagree that teachers should try to look at every student's side of a disagreement before making a decision (VR.group M=5.18 SD=.67, PS.group M=5.18 SD=.61). Additionally, respondents of both groups tend to agree that as teachers they should try to understand the students better, by imagining

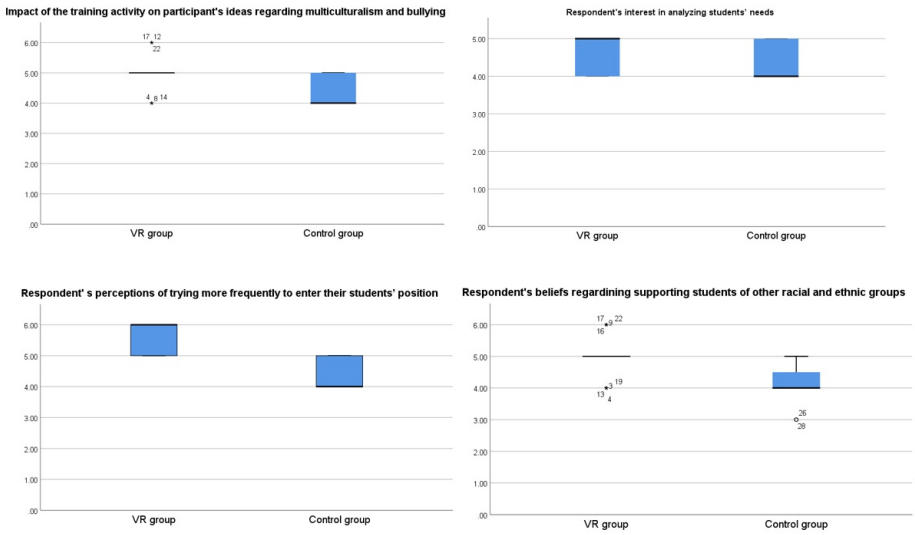


**Fig. 3.** Plot box presenting the differences between the VR and PS groups in the reflection scale items

how things look from their perspective (VR.group M=5.46 SD=.51, PS.group M=5.27 SD=.65). regarding teacher's ability to see things from the student's point of view the results indicate that participants of the VR.group tend to be from expressing no opinion to strongly agree (M=4.73, SD=1.39), while the participants of the PS.group tend to agree (M=5.09, SD=.83). Moreover, the results indicate that regarding teacher's emotional involvement with student's problems the VR.group tend to be from expressing no opinion to strongly agree (M=4.00, SD=1.42), while the PS.group (M=4.09, SD=1.30) tend from disagree to strongly agree. Both groups tend to agree that teachers they should try to imagine how they would feel in the students' situation, (VR.group M=5.18 SD=.80, PS.group M=5.18 SD=.41). Regarding teacher's support of students of other racial and ethnic groups, the participants of all groups tend from agree to strongly agree, (VR.group M=5.23, SD=.76, PS.group M=4.91 SD=.70). Finally, the results indicate that regarding teachers' ability to put himself/herself in the position of someone who is racially and/or ethnically different, the VR.group tend from no opinion to strongly agree (M= 3.60, SD=1.26), while the participants of the PS.group tend from disagree to agree (M=4.73, SD=.91).

The results from the tests of normality (namely the Kolmogorov-Smirnov Test and the Shapiro-Wilk Test), revealed that most of the items are below 0.05, therefore, the data significantly deviate from a normal distribution and non-parametric tests were used. Mann-Whitney U test did not indicate statistically significant differences between the two groups in the majority of the items of the empathy scale. Nevertheless, the test provided very strong evidence (p= 0.008) of a statistically significant difference between the VR and PS group related to teachers' ability to put himself/herself in the position of someone who is racially and/or ethnically different (see Figure 4)

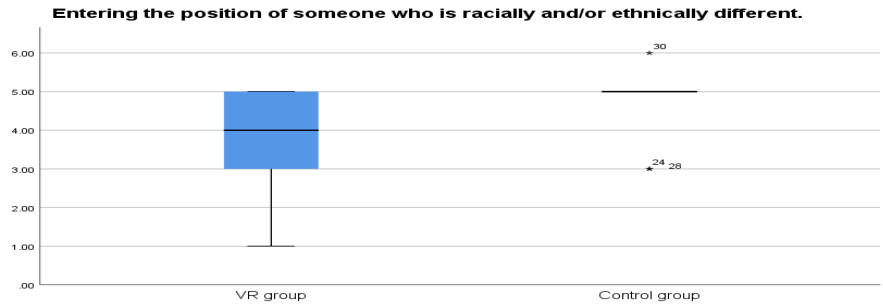


**Fig. 4.** VR and PS group response regarding respondents' ability to put themselves in the position of someone who is racially and/or ethnically different

## 6 Discussion

The last few years the technological evolution reshaped teaching and learning providing new and innovative strategies to be implemented in the classroom environment including VR [56][57]. VR can have positive effects on students enhancing their cognitive development and motivation as the lesson is becoming more interesting [56]. The question lies in whether the use of VR can have a positive effect in teacher education providing teachers a new way of learning.

The current research aimed to explore the possibility of promoting and cultivating teacher's reflection and empathy skills via the use of a VR based approach. Moreover, another objective was to identify possible differences between the participants who used the VR system and those who were trained without real classroom without using the VR system. The results of the research are promising regarding the potential of using VR based methodology as part of teacher training regarding the cultivation of reflection and empathy skills.

The results indicate that participants from both groups consider the process of reflection significant. Nevertheless, experimental results indicate that the control group that did not use the VR system scored lowered in all items of the reflection scale and tended to be more undecided regarding the effectiveness of their training within the real classroom setting. On the contrary, experimental results indicate that the VR experience can contribute to a higher level to the change of beliefs and ideas regarding multiculturalism and bullying, change the way teachers attend the needs of their students and react on disruptive behavior among the students. Moreover, the VR experience offered the participants the opportunity to enter the student's position and experience bullying through the student's viewpoint, challenging some firmly held ideas and promoting more support to students of racial and ethnic minority groups. Within the VR environment, the camera was placed in a way allowing the participants to see themselves as being in the body of the student, offering a more immersive experience and deeper understanding of the problem. This could not be achieved in the real classroom setting where the participants felt more like themselves, resulting in more neutral scores. It seems that although there are indications that reflection skills

were cultivated at all groups, the VR based approach was more effective encouraging reflection and understanding of different views at a higher level. The key point consists in the ability of VR to offer the user the opportunity to view a scenario from the eyes of a different person, making their experience a unique learning opportunity. The great variation of different point of views does not seem possible to be achieved in a real classroom setting, and as a result, multiple perspectives reflection cannot be achieved.

From the data, it can also be concluded that empathy was cultivated to both groups. Both groups identified the importance of entering the students' position in order to understand his/her perspective to take the proper course of action that will meet the student's needs. The results did not reveal significant differences between the two groups except from one item of the empathy scale related to teachers' ability to put himself/herself in the position of a student who is racially and/or ethnically different. The results revealed a significant difference between the participants that used the VR system and those who were trained in the real classroom, as those experienced the virtual classroom space claimed that teachers can put himself/herself in the position of someone who is racially and/or ethnically different, while the physical group tend to disagree. The results indicate that the use of the VR system and the opportunity to view a scenario from the eyes of a different person affected more the cultivation of empathy skills towards foreign students to the group that used the virtual classroom as they scored higher to the scale, while the control group tended to be undecided.

Overall, there are several indications regarding the effective use of VR for the cultivation of reflection and empathy skills. However, further research is required to investigate the impact of the VR system on the cultivation of those competencies. A new scenario is already under development with several modifications based on the input provided from the experiment that was conducted and after close collaboration with psychologists and experts from the educational field. Future experiments will add more light on the impact of VR to the cultivation of reflection and empathy skills.

## 7 Acknowledgement

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# Conception of a Conversational Interface to Provide a Guided Search of Study Related Data

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**Abstract**—Since the beginning of software development, solution approaches and technologies have changed massively, including the requirements for a user interface. At the very beginning, it was the desktop application, with a classic Graphical User Interface (GUI), which fulfilled the needs of a user. Nowadays, many applications moved to web respectively mobile and the user behavior changed. A very modern concept to handle the communication between a computer and a user is a chatbot. The range of functions of a chatbot can be very simple up to complex artificial intelligence based solutions. This publication focuses on a chatbot solution for Graz University of Technology (TU Graz), which should support the student by finding study related information via a conversational interface.

**Keywords**—Chatbot; conversational interface; natural language understanding

## 1 Introduction

### 1.1 Applying the styles to an existing paper

This publication is about researching, designing, implementing and evaluating a chatbot for the TU Graz, which provides a search concept for students to simplify finding study related information. The bot should be a standalone client messenger and not integrated in one of the major messenger platforms like Facebook Messenger[1] or Slack. Although, it is a standalone messenger, it should be similar to existing ones, so that there is no confusion how to use it. The web client should also be responsive to provide a good mobile user experience. The design should adhere to the corporate identity of TU Graz. To be able to implement a standalone chatbot, a front-end and back-end solution has to be developed. Therefore, several frameworks were evaluated. To increase future maintainability, JavaScript was used on client and server side. An essential point of the bot is the communication with the TU Graz search proxy, which provides all study related data in the form of an Extensible Markup Language (XML) result. This has to be parsed and the desired data has to be extracted. It should also provide some kind of artificial intelligence to improve the user experience. To

https://de-de.messenger.com/, accessed 19 April 2018

integrate a suitable artificial intelligence platform an evaluation was done. The most used and best known tools were analyzed and based on the given requirements the most appropriate one was chosen. The TU Graz Searchchatbot is personal, domain specific and follows the information based approach. It covers information about employees of the TU Graz, rooms, subjects, books and organizations. It also provides a site search of the website. For that reason a crawler was implemented, to extract the necessary data to answer the question of the user. After the implementation, a test period started, to evaluate the acceptance and satisfaction of the chatbot in comparison to the already existing search solutions.

The following three Research Questions were addressed in this study:

- How big is the general interest of a chatbot in the university area?
- Is a chatbot able to replace a conventional graphical user interface?
- Does the help in searching through a chatbot lead to more satisfactory search results than via a search form?

## 2 Introduction to Searchbots

### 2.1 Implementation of the prototype

In the last years, there is undoubtedly some kind of revolution in the software industry. In the past web and mobile applications changed the requirements of a software dramatically. The chatbot or a conversational interface is a further development to the conventional user interaction. The reason why chatbots became so popular is, that messenger applications are heavily used by people, especially in terms of mobile. Table 1 shows the usage of messenger applications in 2016, which indicates the importance of a conversational interface to expose services via a chatbot.

**Table 1.** Chat statistics in 2016 [1]

| Network | Origin | Monthly active users |
|---|---|---|
| WhatsApp | US | 1 billion |
| Facebook Messenger | US | 900 millions |
| Viber | Israel | 784 millions |
| Viber | China | 762 millions |
| Line | Japan | 560 millions |
| Instagram | US | 500 millions |
| Kik | Canada | 275 millions |
| Snapchat | US | 220 millions (est.) |
| Hike | India | 100 millions |
| Palringo | UK | 40 millions |

A chatbot has many advantages over a classic user interface. The user is able to directly communicate with the information system and ask for the desired information. It is no longer needed to go through multiple steps to find the information the user is

looking for. Communicating with a chatbot is also more natural then using a traditional GUI.

Back then, the first developed chatbot was ELIZA [2] by Joseph Weizenbaum. It was possible to communicate with the bot in natural language and ELIZA was able to emulate several different dialogue partners. The most successful one was a psychotherapist, which used a thesaurus to make it possible to have an ongoing conversation with the user. ELIZA was programmed to recognize keywords and to apply appropriate transformation based on context. Each keyword has special transformation rules [3]. Nowadays, chatbots are much more complex and several types are existing, as figure 1 shows. A chatbot is a combination of three subtypes. They can be personal or impersonal, domain or non domain specific and have a task, information or conversation based goal.

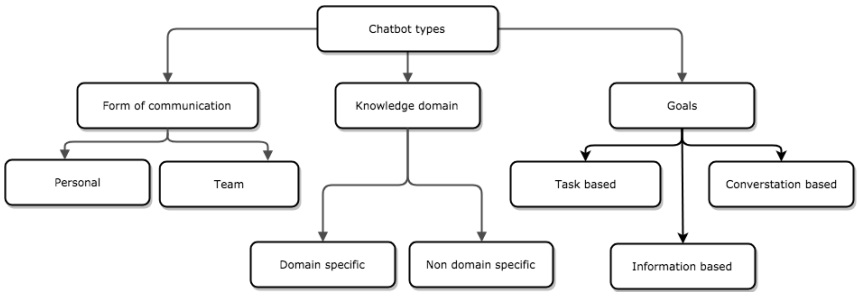


**Fig. 1.** Chatbot types

The difference between a personal and a team bot is the user basis. A personal bot satisfies the needs of a single user within a single context, while the team bot has to switch between multiple user inputs and is used in a shared channel. A typical example for a personal bot is a personal assistant. Team bots can be used for team organization in messenger applications. [4]

In terms of the knowledge domain categorization, there are domain and non domain specific bots. Domain specific ones are typically implemented for a single service or a specific product. It more or less represents a product or a brand. The team bot on the other hand exposes multiple services, it is a so called super bot. A very well known bot of this category is Amazon's Alexa [5]

As already mentioned there are three types of goals which can be followed. The task based bot is implemented to execute a certain task. The conversation flow is predefined and the main goal is to finish a job. However, the conversation based bot tries to communicate with the user as long as possible without executing a specific job. The main goal for this approach is an ongoing conversation with the user. Last but not least, the information based bot provides information to specific topics. The conversation should be short and purposeful. A typical example for this category is a Frequently Asked Questions (FAQ) bot. [5]

Those types can be applied for business to business as well as for business to consumer bots, although they have different objectives. A business bot is goal-driven, the conversation flow should be short and jobs should be executed very easily. The con-

sumer bot has a different approach how to communicate; it is more personal can be also off topic or just entertaining. Often the main goal of a consumer bot is to stay in touch with a brand.

Two major platforms have emerged to offer chatbots. The best platform for the consumer to business approach is the Facebook Messenger. This messenger provides an easy to use Application Programming Interface (API) for bot interaction. It is available for mobile and web and it is very easy to get in touch with potential customers. The most known business messenger is Slack It is widely used for business bot integration such as bots for time tracking or project management support.

As already mentioned, the work developed had the goal to implement a search chatbot for the TU Graz website. It should cover all the features of the already existing TU Graz search mobile application, but should expose the service via a conversational interface.

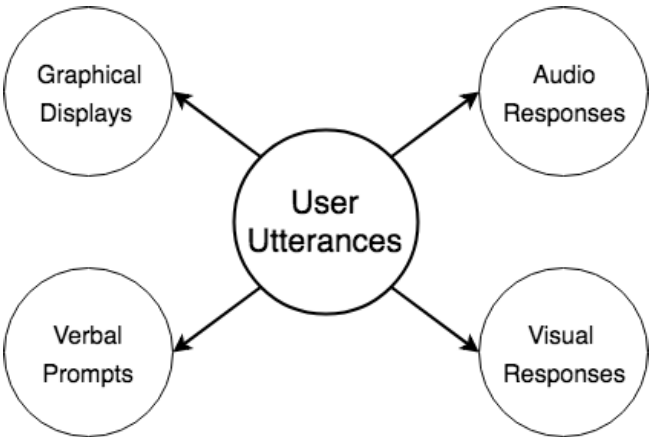


**Fig. 2.** Types of user utterances, based on [6]

A conversational interface should be as natural as possible, so that the user does not have to adapt his/her behavior when using the TU Graz Searchchatbot. To guarantee that, the onboarding phase should be very clear to the user. A bot is able to contribute to a conversation with for different types of interactions as figure 2 shows. The TU Graz Searchchatbot follows the graphical display approach to interact with the user. [6]

For providing artificial intelligence, dialogflow is used. Dialogflow, former api.ai, was launched in 2010 and acquired by Google in 2016. It parses the query and returns a JavaScript Object Notation (JSON) object with the most suitable intent based on the information stored in the intent. In addition, several other artificial intelligence platforms were evaluated, especially wit.ai. In general, there are consumer and business platform tools. Dialogflow and wit.ai are belonging to consumer tools; an example for business tools is Watson. Dialogflow was chosen because of its rich feature set, it is tested over eight years now and it delivers good intent matching results. Furthermore,

the pricing model of Dialogflow fits for this project, because it offers free usage of text queries.

Dialogflow consists of five main parts namely agents, intents, entities, context and fulfillment. Agents are the natural language understanding (NLU) modules, which is the starting point of your application. To recognize what the user wants, the intent matching comes into play. To match an intent Dialogflow needs data to train a machine-learning model. The more data you provide the better is the intent matching, although Dialogflow not just understands the phrases you have entered it also matches phrases which means the same thing. To identify and extract information a user mentioned the entity matching is needed. Dialogflow provides build-in entities, such as date, time and geo-state. This is a good starting point but with high probability, you need to define your own entities when developing a chatbot application. Same as for the intent matching, also for the entity matching training data has to be added.

Context plays vital role in the success of a chatbot conversation. It helps the chatbot to talk more like human by answering within a context in a linear and non linear dialog. In general, as long as there is no fulfilment of the user's needs, the context stays the same.

### 2.2 Architecture

The TU Graz Searchchatbot application is a full stack standalone web solution. Therefore, it consists of four parts which are:

- Single Page Application Client
- Back-end/Middleware
- TU Graz search proxy
- Third party NLU platform for artificial intelligence support

To outline how the bot works, figure 3 illustrates the final architecture of the application. Dialogflow does not support a PHP SDK as several other platforms. Due to that fact, Node.js[2] was used for the back-end. Therefore, the same programming language could be used on front-end and back-end, which is also a benefit for maintainability.

The basic flow works as follows. The user starts the bot by visiting the website and receives a valid session token. After that, the user sends a message and the session token to the Node.js back-end. For evaluating the correct intent, the Node.js back-end passes the message to the Natural Language Understanding (NLU) platform, which is Dialog flow. It will respond with a JSON object to the Node.js back-end with all the necessary information to perform the search, which are the matched intent, the extracted entities, the context and the fulfillment state. For example if a user enters a phrase like "Do you have contact information about Martin Ebner?", the Dialog flow agent respectively the NLU agent will match the intent Contact Information, with the extracted entity @sys.name Martin Ebner. That information will be passed to the

https://nodejs.org/en/, accessed 24 April 2018

Back-end/Middleware if the fulfilment of the dialog is achieved. Otherwise a linear or non-linear dialog will be performed.

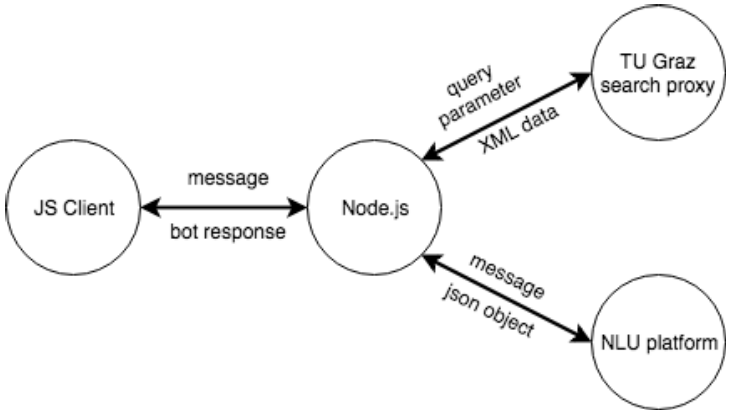


**Fig. 3.** Final architecture

The search itself is done by the TU Graz search proxy. It responds with a list of found items in a XML data format. After receiving the data, the Node.js back-end parses the items, extracts the desired information and returns it to the front-end. The client handles the response data and displays the message to the user. Figure 4 shows an example communication with the chatbot.

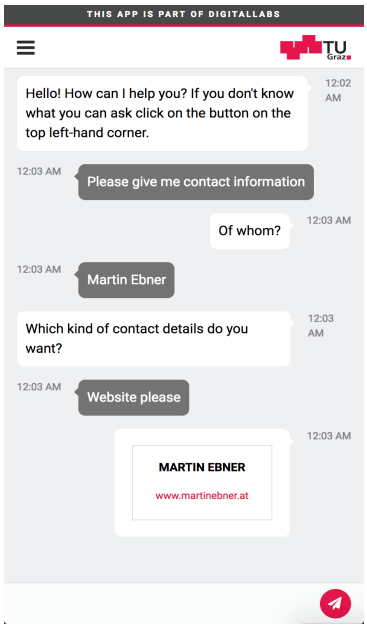


**Fig. 4.** TU Graz Searchchatbot

### 2.3 Evaluation of client

To ensure a pleasant user experience a Single Page Application (SPA) was developed. To accomplish that, JavaScript front-end frameworks were evaluated. Table 2 gives an overview of the analyzed candidates.

**Table 2.** Comparison of front-end frameworks

| | Angular | React | Vue |
|---|---|---|---|
| Publisher | Google | Facebook | Vue Technology |
| Programming Language | Typescript | Javascript | Javascript |
| Componend based | Yes | Yes | Yes |
| State management | ngrx | Redux | Vuex |
| CLI | angular-cli | - | vue-cli |
| Integrated router | angular/router | Only external | Vue-router |
| CSS modules | Yes | Has to be configured manually | Yes |
| Separate HTML/JS | Yes | No | Yes |
| Official style guide | Yes | No | Yes |

Angular, React and Vue are the most popular Javascript frameworks nowadays. Every framework has its benefits. In terms of rendering performance, React is the framework to choose. It is blazing fast and optimized, but the biggest disadvantage is, that many third party dependencies are needed to have a full framework tool set. Vue is a lightweight framework, which supports many features out of the box, like a router, state management and a Command Line Interface (CLI). It is a well designed framework for small to medium sized projects. In comparison to React, Vue is more a framework, however React has library characteristics. The third candidate in this comparison is Angular. It is the most stable and maintainable framework in relation to Vue and React. It has an official style guide, which explains exactly how a project should be structured and implemented. Due to that, the entry into an Angular project is straight forward. The framework is based on Typescript, hence a type safe implementation increases the code quality. Angular has also a clear separation of logic. This framework provides modules which are wrappers for components and services. Services are containing business logic, however components are responsible for the representational logic. React and Vue has also some kind of separation of logic, but Angular handles it in a more structured way than the other two. All three frameworks have a state management system. Initially the state management was developed by Dan Abramov in the form of Redux. Angular supports a fork of this implementation, namely ngrx. Vue provides also a state management system with Vuex, which is a fork of redux as well. Summarizing all aspects, Angular was chosen for the client implementation. [7], [8], [9], [10]

### 2.4 Evaluation of back-end

With an increase in importance of JavaScript, Node.js frameworks are very common nowadays. Before comparing frameworks let's take a quick look what Node.js is. Node.js is a server-side JavaScript platform, based on the Google Chrome V8 engine.

It is a big advantage for JavaScript developers to implement a full stack solution, without switching the programming language. They are serious alternatives to Symfony or Laravel, which are based on PHP. There is one Node.js framework, which stands out in terms of acceptance by the community. It is called Express.js[3] and it was published in 2010. For this publication also another Node.js framework was evaluated, namely Hapi.js. Hapi.js was built by Walmart to alleviate issues occurred while using Express. [11]

Hapi.js, which stands for HTTP API, provides a lot of features out of the box like authentication, caching, validation and more. It is also stress tested under a realistic production atmosphere, and it exists a test coverage of hundred percent. Hapi.js is in comparison to Express more configuration centric and the learning curve is steep. Express has a lightweight minimalistic approach, based on the core Node.js http module and connect components which are called middleware. The philosophy of Express is configuration over convention. Due to the huge community support, there are many additional features available. [12], [13]

Summarizing it can be said that Hapi.js is the better framework for enterprise application. For the TU Graz Searchbot, where the back-end acts more or less as a middleware the minimalistic approach of Express is the better option.

### 2.5 Feedback

The TU Graz Searchchatbot was available from 01.09.2017 to 28.02.2018 on DigitalLabs. DigitalLabs is a platform of the TU Graz for evaluating applications and tools. The chatbot was deployed on a separate route and was ready to use after a user hits the Uniform Resource Locator (URL). No user related data were stored.

After the go-live of TU Graz Searchchatbot, the evaluation phase started. A feedback form was integrated to be able to make a statement about the bot. Only student users participated. Among others, following questions were asked:

- How satisfied where you with the Searchchatbot?
- Which search concept would you generally prefer in the future?
- Do you think that the application / the Searchchatbot persist in the long term?

**How satisfied where you with the Searchchatbot?** The result to this question indicates a positive signal for the TU Graz Searchbot. More than a half of the participants are in some way satisfied. Considering that a conversational interface is a new approach to communicate with the user, it is a promising result. Table 3 shows the result in detail.

**Which search concept would you generally prefer in the future?:** As table 4 shows, that almost half of the users are interested in the bot concept. As already mentioned, people are not used to chatbots and therefore it may need further testing phases to optimize the user experience to convince other users.

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http://expressjs.com/de/, accessed 23 May 2018

**Do you think that the application / the Searchchatbot persist in the long term?:** As table 5 shows, 58.33% of the users appreciates the bot concept and are of the opinion that the TU Graz Searchchatbot should be an additional solution to the current search solution.

**Table 3.** Result of "How satisfied where you with the Searchchatbot?"

| Answer | Percentage |
|---|---|
| Very satisfied | 0 |
| Satisfied | 25 |
| Rather dissatisfied | 33.33 |
| Dissatisfied | 41.67 |

**Table 4.** Result of "Which search concept would you generally prefer in the future?"

| Answer | Percentage |
|---|---|
| Chatbot | 8.33 |
| Searchfield | 50 |
| Chatbot and Searchfield | 33.33 |
| Nothing | 8.33 |

**Table 5.** Do you think that the application / the Searchchatbot persist in the long term?

| Answer | Percentage |
|---|---|
| Chatbot | 8.33 |
| Searchfield | 50 |
| Chatbot and Searchfield | 33.33 |
| Nothing | 8.33 |

## 3 Discussion

The feedback of the Searchchatbot indicates positive signals. Due to the fact that the Searchchatbot is in the prototype phase, there are many things to improve. Basically we analyzed which improvements can be done by the implementation of the Searchchatbot, and which improvements are related to the API of the search proxy.

In terms of natural language processing there will be some improvements as well towards dialogflow. At the moment dialogflow is based on a decision tree. Machine learning is supported in terms of given examples, but if a user asks a question which the chatbot cannot handle, there will be no intent recognition improvement if the user asks exactly the same question again. The simple reason for that is, that there is no artificial intelligence providing that kind of learnings. Due to that, there have to be more feedback iteration phases to analyze the given user input. After every iteration, patterns for intent recognition can be adapted and more training data could be added, to improve the usefulness of the bot. Already the first iteration will offer a big improvement as a lot of new questions could be added to the trainings dataset. Another

evaluation of a separate classifier like Watson Classifier[4] could be done, to recheck if there would be an improvement in terms of intent matching and entity extracting.

The biggest advantages in terms of user experience would be additional information about study related data. The TU Graz search proxy should continue to be used, but there have to be other possibilities to retrieve data. Providing an API which is dedicated to that purpose would be required.

## 4 Conclusion

The aim was to build a chatbot, which supports the student by finding study related information. A standalone solution has to be developed, which was done with Angular on the front-end and Express on the back-end side.

To support natural language understanding, several platforms was compared and evaluated. Finally, dialogflow was chosen, because of the good results of its intent recognition.

Chatbots will become more popular in the future, therefore the Searchchatbot is an interesting first step to provide such an application for TU Graz. NLU tools are becoming smarter blazing fast, so there will be improvements expected very soon. This means that also the user experience of the Searchchatbot will increase in terms of intent recognition.

This prototype showed a possibility of a searching solution via a chatbot. The feedback of this implementation indicates positive signals to continue with this concept. Summarizing it can be said that, there is an acceptance and an interest of it but since this is only a prototype there is room for improvement. The bot has also an experimental feature on board, namely voice recognition, which should be activated in the next implementation iteration.

The current search implementation with a search form can not be replaced with a chatbot at the moment, therefore more data API's have to be provided to increase the user experience and the meaningfulness of the bot. For search results about personal data, the bot provides good results. People were satisfied with the guided search and got their desired data with less effort than with a conventional search behavior. In other search areas the satisfaction of the search result varies. To improve that, more test phases must be carried out and based on that adoptions must be made.

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# Implementing Multiple AR Markers in Learning Science Content with Junior High School Students in Thailand

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**Abstract**—This study demonstrates a supplementary classroom technology using an Augmented Reality (AR) application to enhance students in learning Genetics at Junior High School in Thailand. The tool provides visual cards of concepts about Genetics with multiple AR markers (cards). An interactive experience provides students a multiple-choice format to respond to different cases (questions). Using a purposive sampling technique, sixty students from the 9th grade compared and selected AR markers to generate an animated two-dimensional graphic with sound feedback. In addition, the students' learning scores were compared among the groups of different analytical thinking abilities who used single and multiple AR markers. The results found the potential of using Augmented Reality (AR) in supporting students' learning especially in improving analytical thinking ability.

**Keywords**—Augmented reality, genetics, multiple-choice format, Thailand

## 1 Introduction

Thailand moves forwards to knowledge economy society. National policies and plans are targeted to bring the country to be one of the preferred investment destinations in Asia. By the declaration of the National Economic and Social Development plan of 2017-2021, the preparation of the future human resources is aimed at Thai youth and students to bring the country to the new industrial S-curve. Young Thai, especially in tertiary education, is trained oriented towards critical and creative technological atmosphere [1][2]. In addition, critical and creative thinking, a core element of an intellectual complex problem solving, found in a common core as analytical thinking. An ability which an individual is able to analyze and evaluate a choice of solutions to suit a specific problem [3][4]. In accordance to the national policy, Office of Basic Education states learning outcomes of an individual student to be capable of self-directed, highly motivated, and having critical and creative thinking that will contribute to a perpetuate such industry. A step-by-step breaking down a complex problem into a manageable mini component becomes a good practice of an instructional for analytical thinking process. However, the Thai government remarks the issue of the disparity between students from schools in the city and rural caused by a lack of teacher in a specific content of Math and Science in a rural, either an

experienced teacher with a skill in teaching students' such analytical/higher order thinking skills [5][6][7][8]. To fill the gap of the teaching in this specific content area and the analytical thinking ability, the Ministry of Education invited a research and development of a supplementary classroom with technology for quality of teaching and learning.

Among teaching and learning materials, a paper-based is still an effective learning material despite a widespread an e-book. A textbook allows students to elaborate and extend their thought repeatedly through their touch of fingers, flip, and write for a note taking, incorporated with images, drill and practices, along with sets of exercises which at most accompanied by key answers for those questions in the exercises. With Augmented Reality (AR) technology, a printed material could be augmented with meaningful media for students to play with the contents and their thought, while manipulating the media at their own paces. Manipulative learning materials are typically physical tools of teaching and learning that engage students visually and physically with objects [9]. A use of manipulative learning material helps students construct thinking while discovery during the learning process. Typically, the materials are provided along with a direction, and students explore the materials and ask questions before and during the lesson. With technology augmented to the materials, students could interact with instructional events pre-instructed by teachers. This methodological approach allows a deep learning because students engaged their learning with touchable learning manipulative materials (meaningful single/multiple cards) in a textbook with augmented multimedia activity for mastery skills in analytical thinking. Therefore, this research is aimed to explore the use of single/multiple markers in augmenting media that could help students learning to analyze the concept of Genetics.

### 1.1 Research questions

- What implementation strategy of using some AR markers (single or multiple markers) influences learner performance?
- What implementation strategy of using AR markers (single or multiple markers) influences groups of learners with differing thinking ability skills?

## 2 Literature Review

Analytical thinking is an essential ability that enhances a person's diagnostic, evaluation, decision-making, and planning. Analytical thinking performs distinguishing, categorizing elements, its cause and effect which underlying reason. It is actually an analysis of relationship that affects each other by finding what is related, what degree, corresponding or opposing, linking causes and consequences. Analytical or logical thinking is accounted to be a component of critical thinking and problem-solving. Individuals analyze complex problems by finding all possible solutions, then evaluating those solutions and selecting the best one as an answer. It is a process of selecting the best alternative by ordering, comparing, contrasting, evaluating and

selecting. Analytical thinking is also categorized as part of a "learning transfer" that meaningful learning occurs when students focus on information, its relationships, and apply to other contexts [10][11].

Augmented reality (AR), a technology that simulates 3D, animate, VDO objects for students visually and auditory perceive and virtually interact with objects using computing device with a camera such as mobile phone [12]. Simple display process, an input of a card "marker" processes and locates a preset media to augment on to an object via a real-time video output of a computing device/smartphone.

The affordable AR reality system on desktop and mobile provides opportunities to research the application of the system on educational topics or settings. Examples of the implementation of an AR reality system included an interactive book that applied a traditional book enhanced with AR markers embedded in a particular page or figure. With the use of a smartphone's camera, the markers display 3D animation or additional videos on a specific page. Also, some learning toolkits are designed as cardboard games. The AR application provides virtual renditions of the 3D animation or meaningful information to the cards that help learners gain a realistic experience while playing, compared to using flat cardboard [13][14].

Technical aspect of AR on learning: Two types of AR application are primary consideration for a learning design: dependent VS independent location. Place-dependent AR is aligned with a specific environment, not applied to other locations. The key point of AR place-dependent is the location where situated learning took place. On the other hands, a place-independent experience is highly portable and has less or no amount of authentic interaction with physical environment [15]. An AR place-independent experience could embed a contextualized learning within a problem-based narrative along with a layer of content for learners to observe, manipulate, and analyze [16].

AR Technology is aligned with constructivist theory and claimed to be a cognitive tool that learners construct new knowledge based on connecting the previous knowledge in a situated learning environment. Besides, the connectionist expands the constructivist that individual constructs knowledge from a connection of memories. Memories are from an encoding process that information converted into memory, and later construct into knowledge. Four primary types of encoding are visual, acoustic, elaborative, and semantic. Visual encoding gives mental pictures and temporarily stored in iconic memory in Amygdala in human brain. Acoustic encoding is the use of auditory stimuli or hearing to implant memories, in a phonological loop. Elaborative encoding uses known information and relates to the new information being experienced. Semantic encoding involves the use of sensory input that has a specific meaning is applied to a context [17][18][19]. The AR technology could set a learning environment for learners to connect with, of which information in a touchable item and augmented displayed in a visual and acoustic format that can be further elaborated.

Related AR technology and research in teaching and learning found several interesting effects. Researchers claim the affordance of AR to students' affective in associated with cognitive learning outcomes, for the sense of presence, immersion, and contextualization. Researchers state that AR is an effective combination of a

constructivist and visualization learning activities and that AR in replace to simulation gains learners' involvement, beliefs in augmented media they see, values of a real context encountered with. AR serve as effective resources for immersive contextualization [20][21]. The stronger perception of the learners on the augmented media to be real along with their presences in the environment, resulting a more beneficial to the learning outcomes [21].

AR Technology is strong supported by constructivist theory and claimed to be a cognitive tool that learners construct new knowledge based on connecting the previous knowledge in a situated learning environment. For an example, AR technology has been implemented to build capacity in working, simulated practice allowing anatomical structure prior to surgeries. When perform, observe, or practice a real surgery, medical students can connect their previous knowledge from the virtual practice [16][17].

AR technology, when claimed as a cognitive visualization tool in Chemistry subject [22], demonstrates spatial relationships by overlay a displayed three-dimensional object and animation to facilitate students to learn an abstract concept or a subject that require students visual-spatial thinking. Students with visual-spatial ability were reported to spend less cognitive load, but no relation found on less cognitive load and learning performance, either learning in-group. However, research found higher learning performance outcome of students with visual-spatial ability, and also scaffolding technique contribute greatly to the learning achievement.

Besides, the connectionist expands the constructivist that individual constructs knowledge from a connection of memories. Memories are from an encoding process that information converted into memory, and later construct into knowledge. Four primary types of encoding are visual, acoustic, elaborative, and semantic. Visual encoding gives mental pictures and temporarily stored in iconic memory in Amygdala in human brain. Acoustic encoding is the use of auditory stimuli or hearing to implant memories, in a phonological loop. Elaborative encoding uses known information and relates to the new information being experienced. Semantic encoding involves the use of sensory input that has a specific meaning is applied to a context [18]. The AR technology could set a learning environment for learners to connect with, of which information in a touchable item and augmented displayed in a visual and acoustic format that can be further elaborated.

Learners eventually transfer knowledge and procedural rules to other cases. In a mixture of real and virtual objects or actors, participants in an immersive simulation use location-based handheld device to physically walk throughout a real-world location while collecting place-dependent simulated data, interacting with virtual characters, while collaboratively investigating simulated scenario with others [23].

In this study, the focus is on the AR marker with independent-place context; students build knowledge based on analytical thinking when comparing, contrast, and select choices from manipulative and touchable printed markers with augmented media over the choices they make.

# 3 Research Methodology

A quasi-experimental research design was employed in this study. The activity involved a step-by-step scenario or questions on the screen that allows learners to manipulate the AR marker in a cartoon graphic drawing by exposing the marker to the webcam's focus as an input device. Two types of AR markers, single and multiple, were manipulative materials supporting students with high and low analytical thinking to compare and contrast among AR markers with cartoon graphic design and genetic questions/scenarios on the screen. Students expose an AR marker or two AR markers on to the webcam's focus as an input in order to respond to question or scenario on the screen.

The analytical thinking measurement test was developed based on diagnostic, evaluation, and decision-making, to assess students in analyzing complex problems by finding all possible solutions, then evaluating those solutions and selecting the best one as an answer. Researchers gave the test instrument to five experts who are the lecturers in the areas of thinking skills and psychology. These five experts were required to validate the content IOC (Item Objective Congruence) at .82. In addition, the test instrument was given to a group of high school students to rate according to the content validity and its clarity, found clearly understandable. A pilot study was carried out to obtain the reliability with Cronbach's alpha = 0.90.

AR technology can engage students with an augmented information in a form of graphic or video representing an actual object or place. The Augmented Reality (AR) program used for this research project, relating to Genetics subject for a Thai junior high school. An AR instructional and media design, the AR marker design: single vs multiple markers, Instructional process and Learning system flowchart, and the AR platform are described as following:

## 3.1 An instructional AR design

Augmented Reality (AR), a technology that simulates 3D, animate, VDO objects for students visually and auditory perceive and virtually interact with objects using computing device with camera such as mobile phone. Simple display process, an input of a card "marker" processes and locates a preset media to augment on to an object via a real-time video output of a computing device/smartphone.

Among several types of AR technology, for this media design, based on a manipulative material concept, genetic cartoon image cards are used as a marker-based AR. In this setup, the input hardware recognizes the images on a card; the AR application program recognizes and locates the markers and then projects a media-based image such as a video on to the card. Students also register a simple 2D cartoon image representing characteristics of persons into their memory. The character of person is obviously shown in the drawing.

An instructional and media design:

- Define learning outcomes
- Create a display information that is relevant to the intended learning outcome

- Construct a series of items that require students to reasoning their knowledge of the content subject specifically through analyzing and inferring the display information
- Compile with effective test item construction principles
- Design the page layout to display a relationship between the display and each item
- Guiding tasks that are expected students to perform
- Define the criteria to evaluate students' responses
- Review and validate the items [24]

### 3.2 The AR marker design: Single vs multiple markers

Among several types of AR technology, for this media design, based on a manipulative material concept, Genetic cartoon image cards are used as a marker-based AR.

**The AR function**: The functions designed framework of the AR markers are an answer choice to compare, contrast, and find a rule from a logical circumstance. Instead of answering the question via clicking on the choices appearing on the screen, the proposed program applies AR technology using an AR marker in a printed-paper with a meaningful graphic design as a choice. The markers are designed to be reused across questions on the same topic. Using AR markers as manipulative materials to learn a logical explanation of Genetic. The learners perceive a concrete cartoon images on the AR marker, compare, and categorize the relationship between images on the markers and the augmented information.

**Color-coding**: The designed AR card as a marker, at each corner of a marker contains a small filled-color square. The AR system used the small square filled with colors on the card as a feature to serve as a marker. The filled colors are yellow, blue, red, and black. The non-ordered combination of these colors produces 36 distinct markers, which provides the maximum number of choices for the learners during the activity.

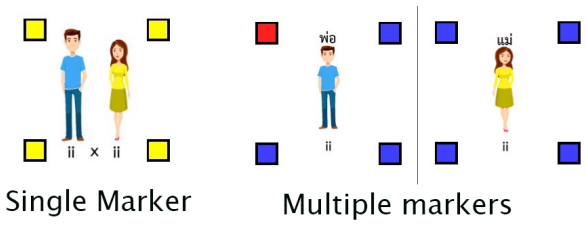


**Fig. 1.** The AR marker design: single vs multiple markers

**A single marker AR design**: A single marker allows instructors to post scenarios with certain number of choices that are equal to the number of markers. The design implies problem-based learning narratives presenting students with a scenario, specific information, and a fact pattern. The students' task is to recognize and identify problems that each example represents. Students are required to complete this

essential step. Problem recognition is a technique for students to develop a valuable diagnostic skill. Five scenarios are presented to students to answer, and with a supported hint. If students fail to answer within a limitation of 12 possible markers (answers) for the first time, and -1 (minus one) for each time of the marker they choose. This means students have 12 times (markers) to answer for the five scenarios.

**A multiple-marker design**: Using a probability technique on multiple markers, the AR program supports an instructor to post scenarios and increase students' makers to compare, contrast, and choose. With the same five scenarios, students choose two markers at the same time for an answer. This multiple marker provides a possible answer of 12 * 11 which is 132 possible answers. If the student answers a wrong solution, then the instructor provides a hint in a form of an augmented video or an image overlay the two markers. The instructor can align appropriate hints based on two markers student selected. This design allows an instructor to elicit students' errors and remedial by a hint for students to further their comparison, contrasting, other choices of the markers.

### 3.3 Instructional process and learning system flowchart

Students are step-by-step provided an instruction and problems to be solved, students will respond the one choice of responding is brought to the next questions. Eventually, students will learn from hints and feedbacks that helping them compare and contrast the rest of the choices. The instructional design employs a formative feedback, known as an "assessment for learning", while students learn from the feedback [25][26]. The feedback process is to decide an appropriate direction for students based on evidence received from their responses. One of several formative assessment techniques that selected in this design is "a context-dependent item set" that help instructors in designing scenarios that require students to generate, analyze, compare, and contrast. The item set consists of series of questions that make use of the context. Students use a display information to answer the questions.

The AR system shows and instructs the learner how to use the system and markers in the flowchart. To skip this process, the learner takes the "start" marker to the defined area on the screen. Second, the system shows a question or a command in text, image, or video. Third, the process shows an answer screen containing an answer section. The image captured via webcam overlays the answer section and displays thumbnail images at the top right corner. When students choose a marker in the answer section, the program recognizes the marker and shows a response in an image or a video format in the answer section, as shown in Fig. 2.

When the learner submits the marker to answer the section, the program checks the submitted answer. If the answer is correct, then the program proceeds to the next question. If not, then the program proceeds to show a hint section. For this part of the process, the program may show a hint of an image or a video corresponding to the learner's answer. Once the program provides a hint, then it navigates back to the question and answer process.

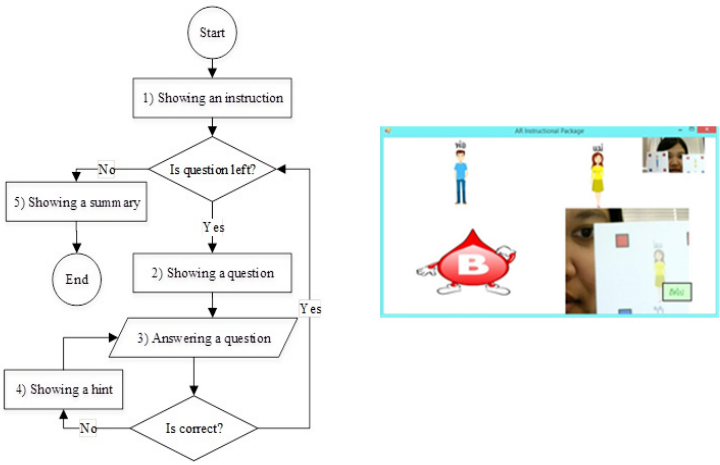


**Fig. 2.** An instructional process and the AR system

### 3.4 System platform

The program is designed as a window-based application. The C# language is used to implement the main graphical user interface and control the process flow. The OpenCvSharp, a wrapper of OpenCV for .NET Framework in C# language, is used to implement image processing and webcam controlling. The software requirements are Microsoft Window 7 or newer versions, the Microsoft.Net Framework 4.0, and the webcam driver. The minimum hardware requirements are the third generation Intel Core I series, 4 gigabytes system memory, and the HD webcam.

The researchers designed the AR card as a marker. Each corner of a marker contains a small filled-color square. The AR system used the small square filled with colors on the card as a feature to serve as a marker. The filled colors are yellow, blue, red, and black. The non-ordered combination of these colors produces 36 distinct markers, which provides the maximum number of choices for the learners during the assessment.

### 3.5 Research procedure

A paper test on analytical thinking ability was administered to a hundred sampling group. The sampling group was assigned to the low-level analytical thinking skills group based on percentile scores: high-level of analytical thinking ability ($100^{th}$ – $61^{st}$ percentile) and low-level of analytical thinking ability ($33^{rd}$-$1^{st}$ percentile). Each group of high and low thinking ability was thirty students.

Fifteen pairs of students with similar low-level analytical thinking scores were assigned to a group using a single AR marker and the other using multiple AR markers. The same procedure was repeated to the group of high-level analytical thinking skill (see Table 1).

With four groups identified, all students completed a pretest before the activity. Students were provided a brief instruction about Genetics, specifically a genetic transformation. The AR instruction package was ranged for 100 minutes. Students could repeat the activity as much as they preferred, then the posttest was administered.

**Table 1.** Distribution of students with different thinking ability skills and the use of AR markers

| Analytical thinking | Single AR Marker | Multiple AR Marker | Total |
|---|---|---|---|
| Low-level | Group 1: 15 | Group 3: 15 | 30 |
| High-level | Group 2: 15 | Group 4: 15 | 30 |
| Total | 30 | 30 | 60 |

## 4 Findings

Table 2 shows the results of the comparison between pretest and posttest data collected from the learners in the same category but different groups. The statistics used include mean score (Mean), standard deviation (SD), t-value, and p-value. In addition, Table 3 illustrates the posttest comparison between users of a single AR marker and those using multiple AR markers.

**Table 2.** Comparison of pretest and posttest results between categories of thinking ability skills and AR marker user groups

| Implementation | | Thinking ability skills category | | Measurement | | | |
|---|---|---|---|---|---|---|---|
| | | | | ***Mean*** | ***SD*** | ***t*** | ***p*** |
| | 1 | Low | Pretest | 4.33 | 0.90 | | |
| | | Low | Posttest | 9.40 | 1.84 | | |
| | 2 | High | Pretest | 9.87 | 1.25 | | |
| | | High | Posttest | 12.80 | 2.08 | | |
| | | | | | | | |
| | 3 | Low | Pretest | 4.07 | 0.96 | | |
| | | Low | Posttest | 11.33 | 1.63 | | |
| | 4 | High | Pretest | 10.07 | 1.28 | | |
| | | High | Posttest | 15.40 | 1.50 | | |

The results from the comparison between pretest and posttest data indicate that the posttest data from all groups significantly reported higher numbers (see Table 3). The posttest comparison between user groups (single AR and multiple AR markers) reported significantly higher numbers for those who used multiple AR markers on both low and high-level analytical thinking ability categories (see Table 4). The result seems to imply that using AR for instructional feedback positively influence learners' performance in recall, retention, and analytical thinking.

**Table 3.** Comparison of pretest-posttest data from users of single and multiple AR markers across all thinking levels (low vs high)

| Implementation | | N | | SD | df | t | p | |
|---|---|---|---|---|---|---|---|---|
| Single AR Marker | Pretest | 30 | 7.10 | 3.01 | 29 | 11.148 | .000* | p<.01 |
| | Posttest | 30 | 11.10 | 2.59 | | | | |
| Multiple AR Marker | Pretest | 30 | 7.07 | 3.25 | 29 | 20.239 | .000* | |
| | Posttest | 30 | 13.37 | 2.58 | | | | |

**Table 4.** Comparison of posttest data from users of single AR and multiple AR markers across all thinking categories (low vs high)

| Implementation | N | | SD | df | t | p | |
|---|---|---|---|---|---|---|---|
| Single AR Marker | 30 | 11.10 | 2.59 | 58 | 3.40 | .001* | *p<.01 |
| Multiple AR Marker | 30 | 13.37 | 2.58 | | | | |

## 5 Discussion and Conclusion

**First,** the results of the study demonstrated the potential of using Augmented Reality (AR) to support student learning especially in developing analytical thinking ability. Students all group levels of analytical thinking had better learning performance after study from the package. Students had a chance to manipulate learning materials by performing specific cognitive task step-by-step information and hints providing through the instructional system, look through its components, its relationships, and apply to other contexts. Eventually, students could deduct the patterns to be a rule [10]. Independent location type of card marker need not a geographical variable, to display the overlay media on the object and highly portable; in this research embedded contextualized learning within a problem-based narrative along with a layer of content for the learner to observe, manipulate, and analyze. This design in accordance with the previous assumption of Klopfer and Sheldon [14] and Perry et al. [15].

In addition, the meaningful images on the markers associated with the video or image media overlay on to the screen could help reducing cognitive load that improves students' performance. The AR technology provides a learning atmosphere that is curious, motivated, and challenged by fantasy when students interact with information embedded on physical object [19][27]. Psychological learning of constructivist and connectionist could well explain the phenomena of students building a layer of knowledge when interacting with two repetitive media arousements, manipulative cards and augmented media in a virtual format right on to the context of learning. Students construct knowledge from a connection of memories by encoding information on the marker to the memory, then another layer of information is placed in connecting to the previous one.

**Second**, the finding found that the use of multiple AR markers provides students' performance better than the single card. In this study, students have more choices to compare and logically compare from the probability of 12 markers in double in which the choices of selection become a hundred thirty-two, while the single marker is only twelve choices. The latter one, single could help to scaffold students to go through a

limited step and come to a conclusion easier. However, the multiple marker gives students more logical choices to compare and contrast than a single one, that could help students gain better score in analytical thinking.

**Finally**, research should aim to further the study for learners' complex critical and problem-solving in the expansion of this finding; to explore and design with a flexibility of geographical location based Augmented Reality, that could help students to investigate in-depth, connecting possible choices of probability in a situated learning environment, as well as its effect on a contribution of cohort learning.

Although AR still limited to the availability and accessibility in some schools setting, the instructional package with AR markers and downloadable system for offline use could be integrated into the classroom for effective teaching and learning for students' analytical thinking ability

## 6 Compliance with Ethical Standards

Funding: This study was funded for the Innovative Educational Technology Research Unit, Chulalongkorn University in Bangkok, Thailand.

Conflict of Interest: Each author declares that he/she has no conflict of interest.

Ethical approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent: Informed consent was obtained from all individual participants included in the study.

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# Measuring Learner Satisfaction with Formative e-Assessment Strategies

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**Abstract**—The Student experience with different aspects of online instructional settings has been the focus of educational practitioners and researchers in many studies. However, concerning technology-enabled formative assessment, little is known about student satisfaction regarding different possible formative e-assessment strategies students are involved in. Using a 5-point Likert scale questionnaire, a web-based survey was developed to examine students' satisfaction with the formative e-assessment strategies within an enriched virtual blended course. The results show that, in general, the students were satisfied with the quality of their engagement and the quality of feedback across all the formative e-assessment learning activities. The results also show that the student satisfaction varied between and within the formative e-assessment strategies. However, the gap between the student satisfaction mean ratings across all formative e-assessment strategies was marginal and could not help researchers decide upon which formative e-assessment strategy that stood out as the most preferred one. Learner satisfaction with different formative e-assessment strategies was positively correlated to each other at various levels but no relationship was found between students' scores and learner satisfaction with formative e-assessment strategies. In the end, the study recommends a sustained and integrated use of all three formative e-assessment strategies (online knowledge survey, online student-generated questions and peer-responses, and electronic reflective journals) in the context of blended courses. The study suggests also further studies that would widen, diversify both the scope and research instruments to investigate learner satisfaction with formative e-assessment strategies.

**Keywords**—Formative e-assessment, student engagement, feedback, learner satisfaction.

## 1 Introduction

Recent developments in technology have changed in many ways how people work and live. In teaching and learning, technology is changing pedagogical practices, and with the advent of e-learning solutions, the Internet is revolutionizing instructional delivery methods. Higher education institutions seem to be under pressure [1] to partially or wholly move the teaching, learning and assessment activities online. [2] assert that that one of the important pedagogical factors to consider when designing online courses in higher education is to create a learning environment where the content and assessment are embedded and integrated into the learning experience and knowledge building.

Despite the fact that both formative assessment (assessment to support learning) and summative assessment (assessment for accreditation and validation) are important in online courses [3], there has been a tension between them [4]. Summative assessment has been dominating instructional processes in online higher education at the expense of formative assessment [5], [6], [3], [7]. For this reason, some authors (for example [8]) advocate for a shift from focusing heavily on summative assessment practices in order to develop instructional assessment tasks that not only assess the end-product or the performance but also provide ongoing feedback.

Some studies have demonstrated that the effective use of technology can improve and support formative assessment practices [9], [10]. Technology allows students to monitor their understanding whenever and wherever they want [11]. Technology can also support immediate feedback and allow a rapid change of students' misconceptions [5]. Technology helps in speeding up tracking, tracing, storing, processing and visualising students' results as well as actions [11]. In addition, technology can be a "resource-efficient way" to give timely feedback to students [12].

It is important to notice that, amid the progressive increase of using new technologies to support Formative Assessment (FA), the consideration of students' perceptions has a paramount importance. Students' acceptance and attitude towards these technologies seem to be part of the determining factors [13]. Research studies on students' attitude towards online FA [14], [15], [16], [17], [18]) have mainly focused on students' views and attitudes towards online FA with little emphasis on students' satisfaction. Therefore, the present study aims at exploring the student satisfaction with formative e-assessment strategies. This is a retrospective study that looks back at three previous studies about the implementation of formative e-assessment strategies in real classroom settings. We examined how the students perceived formative e-assessment strategies (online knowledge survey; online student-generated questions and peer responses; and structured electronic reflective journals) they were involved in.

## 2 Literature Review

Studies on student perceptions of formative e-assessment have been contextualised within a growing need to respond to universities' concerns about the effectiveness and

quality of online courses. Research on student satisfaction with online courses in higher education has involved both graduate and undergraduate students and across diverse populations of students [19]. In the following paragraphs, some of the theoretical approaches and models that have been used to define, understand, and assess the student satisfaction with online courses are reviewed.

The study by [20] that investigated the relationship between the constructs of a web-based learning and student satisfaction, identified five key constructs that predicted the student's perception with online courses: learner relevance, active learning, authentic learning, learner autonomy, and computer technology competence. According to [21], many studies have established that both quantity and quality of student interactions are highly correlated with student satisfaction in most learning environments. Student interaction plays an important role and constitutes one of the major factors that determine the student satisfaction in online course [22].

In their study that examined the satisfaction of students and instructors toward online learning tools and resources, [23] used the Expectancy Confirmation Theory (ECT) and Technology Acceptance Model (TAM). Their study's findings indicated that student expectation was a very important factor that helped the teachers design and develop effective technology-based instructional activities that enhance student learning. By extending the research on the community of inquiry framework [24] to understand online learning, [25] examined the effects of technology on the community of inquiry (social, content and teaching presence issues) and satisfaction with online courses. They specifically examined how the Learning Management System (LMS) provided people with the ability to take actions in an online course and one the major findings was that satisfaction with the LMS predicted course satisfaction.

Previous research studies also focused on some formative e-assessment-related areas such as student perceptions or views, effect, student satisfaction, evaluation, and student attitudes. A university student survey by [26] indicated the students' positive perceptions of an anonymous online peer feedback in formative e-assessment. The students' positive perceptions were also observed in the studies by [27] and [17]. They respectively found out that the students valued the utilization of formative feedback in an online learning environment and perceived the online homework use for formative assessment as useful.

Students' perceptions of the effect of formative e-assessment on their learning have also been investigated. [28] conducted interviews and a student survey to study students' perceptions of a "novel formative assessment" that consisted of involving students solving circuit problems online individually. Compared to a traditional online discussion, the majority of students reported more engagement, more learning, and more interaction with the instructor. In addition, [29] and [30] found out that the students thought their learning was improved as a result of taking part in online formative assessment instructional activities.

Some few research studies that have focused on student satisfaction with formative e-assessment practices suggested that students' high satisfaction with e-assessment [31] and with a web-based formative assessment [32], and a positive and collaborative learning resulting from online peer assessment led students to report strong satisfaction [33]. Research in this area has also focused on the students' evaluation of the

effectiveness of formative e-assessment [34], [35] and students' attitudes towards different aspects and strategies of online formative assessment [36].

A close look at the research studies highlighted above may lead to two main observations. Firstly, in most cases, these previous studies were not based on the principles of good formative assessment and feedback practice proposed for example by [37] that may result into increased learning benefits when they are applied using technology in teaching and learning process. The second observation that can be drawn from the reviewed research studies is that the focus was put on the formative e-assessment strategies other than the ones the present study is concerned with which are: online knowledge survey, online student-generated questions and peer-responses, and the online reflective electronic journals. These strategies are briefly described in the following paragraphs.

Online knowledge surveys consist of sets of questions that cover the entire content of an [online or blended] course [38]. The students are expected to address these questions, not by providing actual and correct answers, but instead by responding to a rating scale of one's own confidence to respond with competence to each question [39]. Knowledge surveys are used as instructional tools students and teachers can use to analyse the student understanding of the course contents, and organise and review the curricula [40]. Knowledge survey practices can serve formative assessment purposes by providing students with an opportunity to monitor their understanding of the learning material, to know where and when they have deficiencies [39] and provide them with a sense of control over their own learning by making the learning more visible [41].

The use of student-generated questions can promote student learning. Student-generated questions can be an effective approach to assessment in online courses [42]. Questioning process is fundamental to intelligent understanding [43] and "a hallmark of self-directed, reflective learners in their ability to ask questions that help direct their learning" [44], p. 522). Students' questions can serve formative assessment purposes by providing instructors with "incidental" opportunities for gathering information about the students' understanding [4]. They can also help students with self-reflection and checking of their understanding throughout the teaching and learning process [45]

Reflective learning journals are the written records that are created by the students as they reflect on their learning, on the critical events or incidents that were involved, or on the student-teacher interactions over a given period of time [46]. According to [47] learning journals can take various forms: they can be highly structured or free, on paper or in electronic forms. As far as formative assessment is concerned, reflective journals help understand the progress of students by providing good opportunities for teachers to gain better insights into how the students think and feel about the course, and the learning progress of the students throughout the courses [48].

The present study aims at expanding and taking to further step the investigation of student experience with formative e-assessment practices. Specific to this study is the measurement of learner satisfaction with formative e-assessment strategies which is driven by "the quality of student engagement" and "the quality of feedback" that seems to be important characteristics of a successful assessment that supports stu-

dents' learning [49]. According to these authors, the analysis of the quality of student engagement in any successful assessment task should focus on a number of criteria. Those criteria include the sufficiency of assessment tasks, the variation and distribution of assessment tasks across all the course sections, whether assessment tasks are quite engaging: communicating clear and high standards criteria, whether assessment tasks are engaging students in meaningful learning activities (whether they are worth the time and efforts the students spend on them). They argue also that the analysis of the quality of feedback in any successful assessment task should focus on the sufficiency of feedback, the details of feedback, the timeliness of feedback, the appropriateness of feedback to the purpose of assessment task, and the clarity of feedback (whether the feedback clearly describes what the learner is supposed to do). The following research questions guided this study:

- To what extent are students satisfied with the quality of their engagement with formative e-assessment learning activities?
- To what extent are students satisfied with the quality of feedback received in formative e-assessment learning activities?
- Does the student satisfaction differ between and within formative e-assessment strategies?
- Does a relationship exist between the learner satisfaction ratings on formative e-assessment strategies and the students' scores?
- How are the learner satisfaction ratings on different formative e-assessment strategies related to each other?

The common denominator for all these research questions is the "learner satisfaction." However, each research question addresses a different aspect of the study as it is illustrated in Figure 1 below:

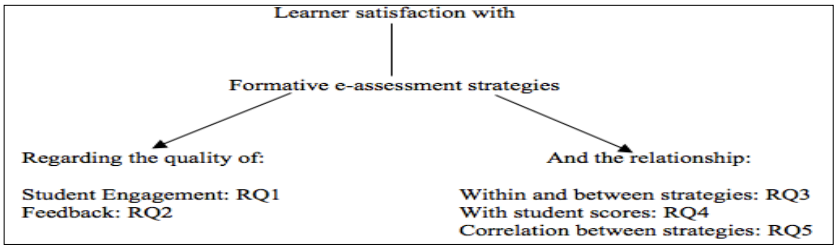


**Fig. 1.** Relationship between the research questions

# 3 Methodology

## 3.1 Context of the study

The present study aims at measuring learner satisfaction with formative e-assessment strategies. It is a retrospective account of three studies about the implementation of formative e-assessment strategies in real classroom settings at the Uni-

versity of Rwanda-College of Education. We examined how the student perceived three formative e-assessment strategies: online knowledge survey, online student-generated questions and peer responses, and structured electronic reflective journals.

**Online knowledge survey:** That was used in [50] study, was used as a formative e-assessment strategy to help students monitor their understanding and progress throughout an enhanced virtual course. Online knowledge surveys (KS) were developed basing on three key elements: learning objectives, module content, and the revised Bloom's Taxonomy of learning objectives [51]. The KS question items were developed using Moodle Feedback module and were sequenced along the four sections of the blended course.

**Online student-generated questions and peer responses:** Were used as a formative e-assessment strategy in the study by [52]. The student-generated questions and peer-responses were used in the context of the student-based formative e-assessment through peer scaffolding. Students were invited to generate learning material-related questions and to seek responses and support from peers. After each section of the blended course, the student-generated questions and answers were retrieved from Moodle learning management system for analysis by means of an assessment rubric that was structured on three levels of thinking: basic, medium, and high.

**Structured electronic reflective journals:** Were used as a formative e-assessment strategy in the study by [53] in a blended course. At the end of each course section, the participants were invited to reflect on their learning experience by completing a reflective e-journal. The students' reflective e-journals were analysed by means of a reflection framework and students were categorized into three groups: critical reflectors, reflectors, non-reflectors, and beginners.

### 3.2 Participants

The measurement of student satisfaction with formative e-assessment strategies covered three studies ([50], [52], and [53] that had addressed year three student-teachers (n = 109). These students were accessing and engaged with formative e-assessment learning tasks that were inbuilt in the blended course (EDC 301: Integration of ICT in Education) that was delivered through the University of Rwanda online learning platform (Moodle).

### 3.3 Instruments

This study used a self-completion questionnaire which facilitates the collection of large amounts of information in a relatively short time from the respondents who have a greater feeling of anonymity and more comfortable in expressing their real feelings [54].

A twenty-seven-item questionnaire was used to measure student satisfaction with formative e-assessment strategies. The respondents were invited to indicate their level of satisfaction with the question items' statements on a range of five-point Likert-type satisfaction scale

- 5 : Very satisfied,
- 4 : Satisfied,
- 3 : Neither satisfied nor dissatisfied,
- 2 : Dissatisfied,
- 1: Very dissatisfied.

These items were constructed based on "the quality of student engagement" and "the quality of feedback" that [49] consider being the two important characteristics of any successful assessment that supports students' learning.

As this study used a multiple item Likert-scale based questionnaire, we deemed it necessary to determine if the scale was reliable. To determine the level of internal consistency among the questionnaire items, Cronbach's alpha test was run in SPSS for 12 items that measured student satisfaction with e-assessment strategies in terms of *the quality of student engagement* and for 15 items that measured student satisfaction with e-assessment strategies in terms of *the quality of feedback.* The Cronbach's alpha was respectively 0.878 and 0.951 for the quality of student engagement items and the quality of feedback items. Since the commonly recommended acceptable level of internal consistency is $\geq 0.70$ [55], the test results indicated a high level of internal consistency for the Likert scale that was used.

### 3.4 Data collection procedure

The questionnaire that was used in this study was made of self-rating questions where a respondent was asked to rate how s/he was satisfied with a statement. A 5-point Likert- type scale questionnaire was created using Google Forms and the link was sent to the respondents via email. The questionnaire was pre-tested by asking some of the potential respondents to complete it before it was sent out to the actual research respondents. The pre-test of the questionnaire allowed the researchers to identify some of the eventual flaws within the questionnaire and address them. In this study, 109 electronic questionnaires were sent out. Of these, 108 satisfaction questionnaires were returned and represented an overall response rate of 99%.

### 3.5 Data analysis

Through Google Forms, the respondents' answers were automatically saved onto a computer file at the time of collection. These data were subsequently exported into excel sheets that are compatible with SPSS analysis software using the predefined codes. Descriptive statistics were used first and included the measurement of means and standard deviations. In addition, a Cronbach's alpha reliability test was done to measure the level of internal consistency for the Likert scale that was used. A One-Way ANOVA test was run in SPSS to determine whether there was a significant difference in learner satisfaction between and within the formative e-assessment strategies. Finally, a Pearson's *r* data analysis was calculated to determine whether there was any relationship between learner satisfaction and students' scores, and between the learner satisfaction ratings on different formative e-assessment strategies.

# 4 Results

## 4.1 To what extent are the students satisfied with the quality of their engagement with the formative e-assessment learning activities?

To answer this question, data collected from 12 items (item number one through item number twelve) of the questionnaire were used. The students were asked to report how they perceived the engagement level of formative e-assessment activities within EDC 301 course. The students were asked to indicate their level of satisfaction with the formative e-assessment tasks in terms of *sufficiency of formative e-assessment tasks*, the *variation and coverage*, *engaging standards and criteria*, *whether completing assessment tasks was worth the time and efforts the students spent*.

In general, the students were satisfied with the quality of every engagement criteria across all the formative e-assessment strategies (see Table 1). The highest level of the Likert satisfaction scale that was used was 5 (very satisfied) and the students' satisfaction mean rating (see Table 1) was ≥ 4.28 (SD = 0.70).

**Table 1.** Descriptive Statistics of students' Ratings of satisfaction with formative e-assessment tasks regarding the quality of student engagement

| N=108 | Mean | Std. Deviation |
|---|---|---|
| Assessment tasks were varied in online Knowledge survey | 4.64 | 0.60 |
| Completing the assessment tasks was worth the time and efforts I spent in online knowledge survey | 4.56 | 0.63 |
| Sufficient assessment tasks were provided in online knowledge survey | 4.55 | 0.54 |
| Assessment tasks were engaging enough in online knowledge survey | 4.45 | 0.69 |
| Completing the assessment tasks was worth the time and efforts I spent in online student-generated questions | 4.38 | 0.67 |
| Assessment tasks were engaging enough in online student-generated questions | 4.38 | 0.69 |
| Assessment tasks were varied in electronic reflective journals | 4.37 | 0.68 |
| Sufficient assessment tasks were provided in electronic reflective journals | 4.37 | 0.73 |
| Completing the assessment tasks was worth the time and efforts I spent in electronic reflective journals | 4.32 | 0.71 |
| Assessment tasks were varied in online student-generated questions | 4.31 | 0.69 |
| Assessment tasks were engaging enough in electronic reflective journals | 4.31 | 0.72 |
| Sufficient assessment tasks were provided in online student-generated questions | 4.28 | 0.70 |

If taken separately, there are variations in students' satisfaction with formative e-assessment strategies regarding the quality of student engagement. The results show that the respondents were, in most cases, dominantly satisfied with the quality of student engagement in formative e-assessment tasks they completed in knowledge survey. In fact, within knowledge survey, the students' satisfaction mean rating was 4.64 (SD = 060) for the variation of assessment tasks, 4.56 (SD = 0.63) for the completion of assessment tasks that was worth the time and efforts the students spent,

4.55 (SD = 0.54) for the sufficiency of assessment tasks, and 4.45 (SD = 0.69) for the fact that assessment tasks were engaging enough.

The students' satisfaction mean rating was the same for some engagement criteria of formative e-assessment strategies. The mean rating was 4.38 for the completion of assessment tasks that was worth the time and efforts the students spent in online student-generated questions (SD = 0.67) and the fact that assessment tasks were engaging enough (SD = 0.69) in online student-generated questions. The mean rating was also the same (4.37) for both the variation (SD = 0.68) and sufficiency (SD = 0.73) of assessment tasks in electronic reflective journals. This was also observed in the variation of assessment tasks (M: 4.31, SD = 0.69) in online student-generated questions and in the fact that assessment tasks were engaging enough (M: 4.31, SD = 072). The results show that, based on the extent to which the students were satisfied with the quality of their engagement, knowledge survey was an e-assessment strategy the students were mostly satisfied with; followed by electronic reflective journals and online student-generated questions.

Two clusters emerged from the analysis of the student satisfaction mean ratings of the quality of student engagement with formative e-assessment tasks. Three formative e-assessment engagement criteria within knowledge survey were included in the first cluster and had the student satisfaction mean rating that was greater than 4.50. The nine remaining engagement criteria were included in the second cluster with the student satisfaction mean rating of $4.45 \leq M \geq 4.28$.

### 4.2 To what extent are the students satisfied with the quality of feedback received in formative e-assessment learning activities?

To answer this question, the data collected from 15 items (item number 13 through item number 27) of the questionnaire were used. The students were asked to report how they perceived the quality of feedback within formative e-assessment activities they were involved in. Using a 5-point scale (very satisfied: 5, satisfied: 4, neither satisfied nor dissatisfied (neutral): 3, dissatisfied: 2, and very dissatisfied: 1), students were asked to indicate their level of satisfaction with the formative e-assessment tasks in terms of the *sufficiency of feedback,* the *details of feedback*, the *timeliness of feedback*, the *appropriateness of feedback*, and the *clarity of feedback*.

In general, the students were satisfied with the quality of every feedback criteria across all the formative e-assessment strategies. The highest level of the Likert satisfaction scale that was used was 5 (very satisfied) and the students' satisfaction mean rating (see Table 2) was ≥ 4.03 (SD = 0.93).

If taken separately, there are variations in students' satisfaction with formative e-assessment strategies regarding feedback. The results show that the respondents were, in most cases, predominantly satisfied with the quality of feedback of formative e-assessment activities they completed in knowledge survey. In fact, knowledge survey takes the first three highest mean ratings for student satisfaction with the quality of feedback. The students' satisfaction mean rating was 4.41 (SD = 0.74) for the appropriateness of feedback, 4.25 (SD = 0.80) for the clarity of feedback, and 4.23 (SD = 0.73) for the timeliness of feedback.

**Table 2.** Descriptive statistics of students' ratings of satisfaction with formative e-assessment tasks regarding the quality of feedback received

| N: 108 | Mean | Std. Deviation |
|---|---|---|
| The feedback was appropriate to the purpose of the assignment in online knowledge survey | 4.41 | 0.74 |
| The Feedback was describing to me what I was supposed to be doing in online knowledge survey | 4.25 | 0.80 |
| The feedback was timely in online knowledge survey | 4.23 | 0.73 |
| The Feedback was describing to me what I was supposed to be doing in electronic reflective journals | 4.22 | 0.84 |
| The feedback was appropriate to the purpose of the assignment in electronic reflective journals | 4.21 | 0.90 |
| Sufficient feedback was provided often enough in online knowledge survey | 4.20 | 0.90 |
| The feedback was provided in enough details in online knowledge survey | 4.19 | 0.89 |
| The feedback was appropriate to the purpose of the assignment in online student-generated questions | 4.18 | 0.82 |
| The feedback was timely in online student-generated questions | 4.14 | 0.79 |
| The feedback was provided in enough details in online student-generated questions | 4.13 | 0.86 |
| Sufficient feedback was provided often enough in electronic reflective journals | 4.13 | 0.81 |
| The feedback was timely in electronic reflective journals | 4.13 | 0.83 |
| The feedback was provided in enough details in electronic reflective journals | 4.07 | 0.84 |
| The Feedback was describing to me what I was supposed to be doing in student-generated questions | 4.06 | 0.78 |
| Sufficient feedback was provided often enough in online student-generated questions | 4.03 | 0.93 |

The students' satisfaction mean rating was the same for three feedback criteria of formative e-assessment strategies: enough details of feedback and the sufficiency of feedback in electronic reflective journals with the respective mean ratings of 4.13 (SD = 0.86) and 4.13 (SD = 0.81). The results show that, based on the extent to which the students were satisfied with the quality of feedback, knowledge survey was ane-assessment strategy the students were mostly satisfied with; followed by electronic reflective journals and online student-generated questions.

### 4.3 Does the student satisfaction differ between and within formative e-assessment strategies?

The results illustrated in Table 1 and 2 show that there is variation in the extent to which students were satisfied with formative e-assessment strategies. However, to determine whether the differences were statistically significant, the analysis of the results was taken to another level. A One-Way ANOVA test (see Table 3) was run in SPSS assuming the equality of the means for learner total satisfaction scores of the three-formative e-assessment strategies ($H_0$: $\mu_{\text{Knowledge survey}} = \mu_{\text{Online student-generated questions}} = \mu_{\text{Electronic reflective journals}}$)

**Table 3.** Tests of between-Subjects Effects from one-way repeated measures ANOVA

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 213.75 | 2 | 106.87 | 3.61 | 0.03 |
| Within Groups | 9502.50 | 321 | 29.60 | | |
| Total | 9716.25 | 323 | | | |

The one-way between-subjects analysis of variance revealed a reliable effect of learner satisfaction with individual formative e-assessment strategy on the overall learner satisfaction with three formative e-assessment strategies, $F$ (2, 321) = 3.61, $p = 0.03$, $MS_{error} = 29.60$, $\alpha = 0.05$. Since the $p$ value associated with the F ratio is less than the α level, then we could reject the null hypothesis that the means for learner total satisfaction scores of the three-formative e-assessment strategies are equal. Thus, student satisfaction was different between and within the formative e-assessment strategies, they were involved in. Since the F ratio was statistically significant, we looked at the multiple comparisons output (see Table 4) to analyse the results of a Least Significant Difference (LCD) Post-Hoc tests.

**Table 4.** Pairwise Comparisons from one-way repeated measures

| (I) Strategies | (J) Strategies | Mean Difference (I-J) | Std. Error | Sig. |
|---|---|---|---|---|
| Online knowledge survey | Online student-generated questions | 1.80* | 0.74 | 0.02 |
| | Electronic reflective journals | 1.64* | 0.74 | 0.03 |
| Online student-generated questions | Online knowledge survey | -1.80* | 0.74 | 0.02 |
| | Electronic reflective journals | - 0.16 | 0.74 | 0.83 |
| Electronic reflective journals | Online knowledge survey | -1.64* | 0.74 | 0.03 |
| | Online student-generated questions | 0.16 | 0.74 | 0.83 |

* The mean difference is significant at the 0.05 level.

The results illustrated in Table 4 show that there was a significant difference in learner satisfaction total score when paired comparisons were conducted between online knowledge survey and online student-generated questions (p = 0.02), online knowledge survey and electronic reflective journals (p = 0.03). However, the paired comparisons did not show a significant difference (p = 0.83) in learner satisfaction total score between online student-generated questions and electronic reflective journals.

### 4.4 Does a relationship exist between learner satisfaction ratings on formative e-assessment strategies and the students' scores?

To measure the relationship between the students' scores on the blended course and the learner satisfaction with formative e-assessment strategies, A Pearson's $r$ correlation coefficient (see Table 5) was run in SPSS.

**Table 5.** Correlation between variables

| N = 103 | Variable | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| | 1. Students' scores | 1.00 | | | | | | |
| Online Knowledge Survey | 2. Learner satisfaction with the quality of student engagement | .09 | 1.00 | | | | | |
| | 3. Learner satisfaction with the quality of feedback | .09 | .32** | 1.00 | | | | |
| Online student-generated questions | 4. Learner satisfaction with the quality of student engagement | .04 | .30** | .19** | 1.00 | | | |
| | 5. Learner satisfaction with the quality of feedback | .12 | .24** | .59** | .31** | 1.00 | | |
| Electronic reflective journals | 6. Learner satisfaction with the quality of student engagement | .09 | .41** | .24** | .41** | .26** | 1.00 | |
| | 7. Learner satisfaction with the quality of feedback | .05 | .34** | .54** | .26** | .58** | .43** | 1.00 |

**Correlation is significant at the 0.01 level (2-tailed)

The students' scores (M = 69.2, SD = 12.36) were correlated with the learner satisfaction ratings on the quality of the student engagement and the quality of feedback within formative e-assessment learning activities. A Pearson's *r* data analysis showed that there was no correlation between these variables. No relationship was found between the students' scores and the learner satisfaction ratings on the quality of the student engagement and the quality of feedback across all formative e-assessment strategies.

### 4.5 How are the student satisfaction ratings on different formative e-assessment strategies related to each other?

A Pearson's *r* data analysis (see Table 5) was run in SPSS to measure the relationship between different learner satisfaction ratings on the quality of student engagement and the quality of feedback within formative e-assessment strategies. In general, a Pearson's *r* data analysis revealed low, moderate, and high positive correlations.

Firstly, the *high positive correlation* ($.59 \leq r \leq .54$) was found where the students who reported high satisfaction ratings in one assessment strategy were *highly* likely to report higher satisfaction ratings in another formative e-assessment strategy. This was observed between the learner satisfaction with the quality of feedback in online knowledge survey and in online student-generated questions, in online student-generated questions and electronic reflective journals, and in online knowledge survey and electronic reflective journals.

Secondary, the *moderate positive correlation* ($.43 \leq r \leq .30$) was also found where the students who reported high satisfaction ratings in one assessment strategy were *moderately* likely to report higher satisfaction ratings in another formative e-assessment strategy. This was observed for example between the learner satisfaction with quality of student engagement and the quality of feedback in electronic reflective journals, between learner satisfaction with the quality of student engagement in online

knowledge survey and electronic reflective journals, in online student-generated questions and electronic reflective journals.

Thirdly, there was a *low positive correlation* ($.26 \leq r \leq .19$) where the students who reported high satisfaction ratings in one assessment strategy were *less* likely to report higher satisfaction ratings in another formative e-assessment strategy. This low positive correlation was observed for instance between the learner satisfaction with the quality of student engagement in online student-generated questions and the learner satisfaction with the quality of feedback in electronic reflective journals. In addition, a low positive correlation was revealed between the learner satisfaction with the quality of feedback in online knowledge survey and the learner satisfaction with the quality of student engagement in online-student generated-questions.

## 5 Discussion and Conclusion

In this study, a satisfaction questionnaire was used to measure the learner satisfaction with the formative e-assessment strategies the students were involved in. The construction of the learner satisfaction questionnaire was guided by the 'the quality of student engagement' and 'the quality of feedback' as the two important characteristics of any successful assessment that supports students' learning [49]. The present study's aim was to measure the extent to which the students were satisfied with the quality of the student engagement and the quality of feedback in formative e-assessment learning activities and determining any differences in student satisfaction between and within formative e-assessment strategies. In addition, the study aimed to determine whether there was a relationship between the learner satisfaction ratings on formative e-assessment strategies and the students' scores and to examine the relationship between the student satisfaction ratings on different formative e-assessment strategies.

In general, the students were satisfied with the quality of their engagement and the quality of feedback across all the formative e-assessment strategies. These findings concur with some previous studies that concluded that students reported positive perception towards online formative assessment [27], [17] and were highly satisfied [31], [32] with different e-assessment criteria. The present study showed that the students were satisfied with the quality of their engagement with formative e-assessment tasks. These findings are in accordance with [28]' s study where the students reported more engagement, more learning, and more interaction in online formative assessment. Concerning the quality of feedback, the present study indicated that the students were satisfied with the quality of every feedback criterion across all the formative e-assessment strategies. This extends [26]'s findings about the students' positive perceptions of online feedback in formative e-assessment.

A Pearson's r data analysis revealed low, moderate, and high positive correlations between student satisfaction ratings on different formative e-assessment strategies. In most cases, it was found out that the students who reported high satisfaction ratings in one assessment strategy were *moderately* likely to report higher satisfaction ratings in another formative e-assessment strategy. However, unlike some previous research

studies [56], [57] that established a link between learner satisfaction with various aspects of online or blended learning and performance, this study found no relationship between the students' scores and the learner satisfaction (see also [58]) with formative e-assessment strategies.

A one-way between-subjects analysis of variance revealed that the student satisfaction was different between and within the formative e-assessment strategies. In addition, for both the quality of student engagement and the quality of feedback, the results showed that knowledge survey was an e-assessment strategy that the students were mostly satisfied with; followed by electronic reflective journals and online student-generated questions. In line with [59] who claimed that the use of the Likert-scale questionnaire does not allow the researcher to distinguish between spontaneous and constructed responses, the present study's results also showed that the gap between the student satisfaction mean ratings across all formative e-assessment tasks was marginal and could not help researchers clearly discriminate between these formative e-assessment strategies in terms of learner satisfaction.

Thus, as a conclusion, the study recommended a sustained and integrated use of all the three formative e-assessment strategies in the context of blended courses. Further studies were also recommended: there is a need to widen and diversify the scope of the study of the learner satisfaction with formative e-assessment strategies by extending it to more than one course and one classroom and using much more open-ended research instruments that would allow the respondents to freely express their views.

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# College Students' Usage of and Preferences for Print and Electronic Textbooks

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**Abstract**—Although print textbooks have been central for schooling for more than two centuries, electronic textbooks (e-textbooks) are steadily growing in popularity among students at all levels of education. This sharp growth has escalated the need for further research to enable a better understanding of the changing patterns of students' usage of print and electronic media. The study explores college students' usage of and preference for print and electronic textbooks in Bahrain Teachers' College, in Bahrain. The sample of the study consisted of 271 undergraduate students selected from courses that utilized both formats of textbook as clearly indicated in their syllabi. Descriptive analyses were used to analyze data collected. Results indicate that regardless of textbook format, the highest percentage of students use their textbooks only when their instructors require them to do so. For print textbooks, results show that the highest percentage of students spend between 1 to 3 hours a week on reading. However, for e-textbooks, the highest percentage of students spend only less than 1 hour per week on reading. An interesting finding for this study is that compared to print textbooks, e-textbooks gain a higher percentage of students' usage when it comes to spending higher numbers of hours of reading per week. The study affirms that students are in general positive to the use of electronic format but still show a preference for print format as the best medium for academic study. Lastly, the study uncovers reasonable findings as to why students prefer one textbook format over the other.

**Keywords**—Electronic textbooks, print textbooks, college students, textbook preference, Bahrain Teachers' College

## 1 Introduction

A textbook is a book used as a standard work for formal study of a specific subject [41]. By collecting huge amounts of facts from a wide spectrum of sources, textbooks are the standard platform of knowledge for students [6]. They are also integral learning tools that help in explaining various concepts and terms [24]. In fact, textbooks can be used to guide students when analyzing and solving problems in different areas of study [23]. And by aiding teaching and learning, textbooks can also help students make connections across the disciplines. Therefore, textbooks largely affect what is taught and what students learn [48; 52].

According to Simon & Garcia-Belmar [47], the dramatic advancement in technology has undeniably brought innovations that can play a significant role in reshaping teaching and learning practices. These innovations have provided students access to much more information than has been previously available. They have also affected the manner in which students interact with materials. As an innovation, electronic books (or simply e-books) have been a viable format since late 1990s.

Wang [55] defines the e-book as a book published in a digital format, transferable via the Internet, and can be accessed and read on a portable device, such as a laptop, a smartphone, an eBook reader, a tablet or on a desktop computer. This digital format initially started as PDF files or a set of HyperText Markup Language (HTML) pages. New features, such as built-in dictionaries and pronunciations guides, audio, video, animations, interactive simulations, and live experiments were then added to facilitate the content understanding of e-books [18; 28; 35; 39]. Nowadays, other e-book digital formats, such as EPUB, AZW, RFT, IBA, LIT, ODF and MOBI, are gaining popularity among readers.

Electronic textbooks (or e-textbooks) are e-books that contain educational materials and functions, and are used for educational purposes [29]. Some of these educational purposes, however, require that the design of electronic textbooks be interactive, collaborative, and differ for students of different learning abilities. Therefore, electronic textbooks support authentic learning by incorporating collaborative tools such as peer review, sharing functionality, and content creation [10; 17; 20; 34]. According to Rockinson-Szapkiw et al. [43], digital course materials included in electronic textbooks have more interactive tools that support student learning inside and outside the classroom.

Johnston et al. [26] stated that while print is at present the dominant format of textbooks, the rising condition is supporting a move toward electronic textbooks. They also went on to say that electronic textbooks are a strong competitor for print textbooks despite the convenience and familiarity of the latter to learners. In a recent study, Kouis and Konstantinou [28] revealed that more than 62.5 percent of the participating students believed that electronic textbooks would be the primary format for textbooks in the near future. Similarly, Hendricks [22] affirmed that with the significant increase in the quality and availability of electronic textbooks, future generations of students are expected to use them in all levels of education. According to Lee, Messom, and Yau [30], electronic textbooks "will potentially replace existing paper-based textbooks in the school curriculum" (p. 32).

Baker-Eveleth and Stone [5] asserted that the use of digital book format in education is a trend that will not disappear in the short term. Since this trend is heavily and constantly supported by the technological and publishing industries [33], e-books or e-textbooks are continuously being updated to improve their features and functionality for a pleasant student experience [37]. Unfortunately, in spite of this, the adoption of electronic textbooks by students has been surprisingly slow [8; 19; 38; 57] and has not yet reached an acceptable level [49]. Therefore, more time and more research are needed to better understand and evaluate this trend and its implications in education.

The purpose of this study is to assess the experience of college students regarding their usage of and preference for two textbook formats, electronic and print. The study

also looked at the reasons for which students expressed their preference for one textbook format over the other. The understanding obtained from this study can provide some important guidelines on how to enhance the successful adoption of electronic textbooks in university education. The study was guided by the following research questions:

- How frequently do students use their print and electronic textbooks?
- How many hours a week do students usually spend on reading their print and electronic textbooks?
- What is students' preference for textbook format?
- What are the reasons for students' preference of textbook format?

### 1.1 Print vs electronic: Usage and preference

Literature has been robust in showing that the usage of electronic textbooks and other electronic resources in education is growing in popularity [13; 27; 40; 53; 57; 45; 51]. According to Walton [53], many academic libraries reported that the rates of use of electronic books are equal to or in some cases great than those of print books.

In a comprehensive study, Nicholas et al. [40] investigated the electronic book usage and perceptions in more than 120 universities in the UK. Based on the analysis of 22,437 survey responses, the study showed that the electronic book penetration is very strong. Around 62% of students were found to be using electronic books. The researchers concluded that "the e-book revolution has already happened but clearly it has someway to go" (p. 333).

Levine-Clark [31] carried out a study on the usage of electronic books by all students, faculty and staff at the University of Denver. The results demonstrated that electronic books were used by about half of the campus community. About 68% of faculty, 57% of undergraduates and 64% of postgraduates used them occasionally. Generally, of the 1,116 people responded to the survey, 28% used electronic books one time only, 62% thought that they used them occasionally, and 10% believed that they used them frequently. Similar results were obtained by Rowlands et al. [42] who showed that about half of the 2,067 participants did use electronic books. Along the same lines, the results of the study conducted by Anuadha and Usha [4] indicated that 59.4% of the participated students from the Indian Institute of Science had used electronic books at some time.

In a national study, Cumaoglu et al. [11] examined the electronic book versus print material usage preferences of 222 students from 36 different universities in Turkey. Regarding print materials, the study revealed that around 50% of students read course books (i.e. textbooks). Results related to the frequency of reading print books, the study found that 68.3% of students read at least one book in a week, 19.9% read at least one book in a month, 7.7% read at least one book in 6 months, and 2.7% read at least one book in a year. Concerning electronic books, the findings revealed that while 62.4% of students are e-book readers, 37.6% never read e-books. The study also manifested that the top-rated advantages of e-books over print materials were as fol-

lows: ease of access (68.1% rating), ease of archive (58%), and ease of use (31.2% rating).

Foasberg [16] conducted a qualitative study on university students' reading habits with regard to print and electronic formats. The results asserted that while all students utilized both formats, students used the print resources more frequently for lengthy reading.

Khalid's [27] study analyzed college students' preference for electronic and print textbooks. The study focused on the reasons behind students' preference. A total of 443 responses were received and analyzed. Results showed that the majority of students preferred the print version of textbooks because of readability, ease of use, and portability. However, students who preferred electronic textbooks were inclined by their low cost, portability, and ease of access. In the same line of thought, Millar and Schrier [36] reported that the primary reason students preferred print to electronic textbooks was that "printed textbooks were more convenient than electronic textbooks" (p. 182). In other words, reading from print textbooks does not require any devices or equipment. Another interesting reason for preferring print textbooks was brought up by Dobler's [15] study, in which participants' responses indicated that the ability to physically touch the pages when making notes and highlighting text is extremely important for kinesthetic learners. One last exciting reason for preferring print to electronic textbooks was emphasized by a number of researchers [2; 25; 32], who declared that people retain more of what they read in print. This is likely because of the multi-sensory experience explained in the texture and smell of the paper. Regarding the preference for electronic over print textbooks, research studies reported a number of reasons, such as ease of transport, accessibility, ease of navigation, educational support, searching, availability, currency of information, and cost savings [1; 14; 44; 50].

Another study [21] explored the usage and preference of print and electronic resources among students and faculties of a university college. The results revealed that 30% of students preferred print materials only, 5% preferred e-resources only, and 65% preferred both. Regarding the frequency of use, the results showed that 5% of students used print material rarely, 40% used print material daily, 37.5% used print material weekly, and 22.5% used print material monthly. For e-resources, the results showed that 22.5% of students used e-resources rarely, 37.5% used e-resources daily, 30% used e-resources weekly, and 10% used e-resources monthly. A similar result regarding the frequency of use of e-resources has been achieved by Chiu (2017), who stated that electronic textbooks (one kind of e-resources) are used more on a daily basis when available in schools.

Recently, Adeyinka et al. [3] conducted a study to examine perception and usage pattern of electronic books among students of five universities in Nigeria. The study findings indicated that the entire sample (175 students, 100%) used electronic books. The study also showed that while 52% of students preferred print to electronic books, 48% preferred electronic to print books.

In summary, our review of literature shows that although e-books are believed to replace print books, students at present continue to indicate a preference for the hardcover book. Our review also revealed a comparable preference for e-books in most

studies. Furthermore, it has been evident that as e-books continue to evolve, they become more widely accepted among students. Therefore, students' preference for textbook formats may change.

# 2 Methodology

## 2.1 Participants

The sample of this study consisted of 271 undergraduate students (36 males 13.3%, and 235 females 86.7%). In order to have enough representation for all year level and specialization, participants were chosen based on purposive sampling, non-random sampling of the target population. Table 1 describes the student sample as related to different variables.

**Table 1.** Sample distribution based on gender, year of study, CGPA and specialization

| | Frequency | Percentage |
|---|---|---|
| ***Gender*** | | |
| Male | 36 | 13.3 |
| Female | 235 | 86.7 |
| ***Year of Study*** | | |
| Year One | 57 | 21.0 |
| Year Two | 65 | 24.0 |
| Year Three | 95 | 35.1 |
| Year Four | 54 | 19.9 |
| ***CGPA*** | | |
| Less than 2.00 | 1 | 0.4 |
| 2.00 – 2.49 | 49 | 18.0 |
| 2.50 – 2.99 | 92 | 33.9 |
| 3.00 – 3.49 | 88 | 32.6 |
| 3.50 – 4.00 | 41 | 15.1 |
| ***Specialization*** | | |
| Cycle One | 67 | 24.7 |
| Arabic and Islamic Studies | 66 | 24.3 |
| Math and Science | 53 | 19.6 |
| English | 85 | 31.4 |

## 2.2 Data collection instrument

A self-administered survey questionnaire was used to collect the data for the study. The research survey questionnaire was specially designed for the purpose of this study. The questionnaire consisted of two sections. While the first section contained items related to the demographics of students participating in the study, the second one consisted of items evaluated on a 5-point Likert scale and several multiple-choice questions. The second section was meant to answer the research questions by investigating students' usage of and preference for print and electronic textbooks.

To maintain the internal validity of a questionnaire, the first draft of the questionnaire was piloted. Twenty-five students from different specialization and year level took part in this pilot testing. Students were asked to check for any difficulty in answering the questions and to suggest alternative paraphrases to simplify complicated statements. Comments and suggestions were noted from the participants at this phase, and the draft questionnaire was revised. Pilot participants were excluded from the main study.

The internal consistency reliability estimate for the questionnaire was assessed with Cronbach Alpha. The alpha value was found to be (0.83), suggesting a reliable instrument for the purpose of the study. In addition, test-retest reliability over a two-week period ranged from (0.80) to (0.84) for the questionnaire.

### 2.3 Data analysis

Out of 300 questionnaires distributed, 280 were retrieved. Nine (9) questionnaires were not counted due to missing data. Therefore, the total valid questionnaires that were included in the statistical analysis were 271. Data was analyzed using SPSS software. Means, standard deviations, and frequencies were calculated to help in providing answers for the research questions.

## 3 Findings

As mentioned earlier, this study was conducted to explore college students' experience with print and electronic textbooks in support of courses. Four research questions were formulated to guide the study. Findings are next presented according to these research questions.

### 3.1 How frequently do students use their print and electronic textbooks?

Regarding the first research question, Table 2 displays a summary of students' responses to the question "How frequently do you use your print textbooks?" The same responses were bar graphed in Figure 1.

**Table 2.** Students' Responses to "How frequently do you use your print textbooks?"

| | Frequency | Percent |
|---|---|---|
| Regularly | 59 | 21.8 |
| When Required by instructor | 154 | 56.8 |
| Rarely | 37 | 13.7 |
| Never Used | 21 | 7.7 |
| Total | 271 | 100 |

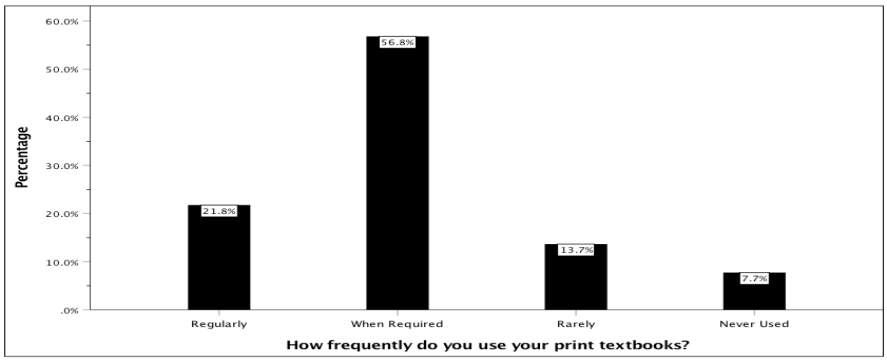


**Fig. 1.** Bar graph displaying Students' Responses to "How frequently do you use your print textbooks?"

Based on the above results, around 57% of the participating students were using print textbooks only when they were required by their instructors. It is worth to notice that around 22% (59 students) were using their print textbooks regularly.

Regarding electronic textbooks, students were asked to respond to the question "How frequently do you use your electronic textbooks?" A summary of the results is displayed in Table 3 and bar graphed in Figure 2.

**Table 3.** Students' Responses to "How frequently do you use your electronic textbooks?"

| | **Frequency** | **Percent** |
|---|---|---|
| Regularly | 55 | 20.3 |
| When Required by instructor | 137 | 50.5 |
| Rarely | 43 | 15.9 |
| Never Used | 36 | 13.3 |
| Total | 271 | 100 |

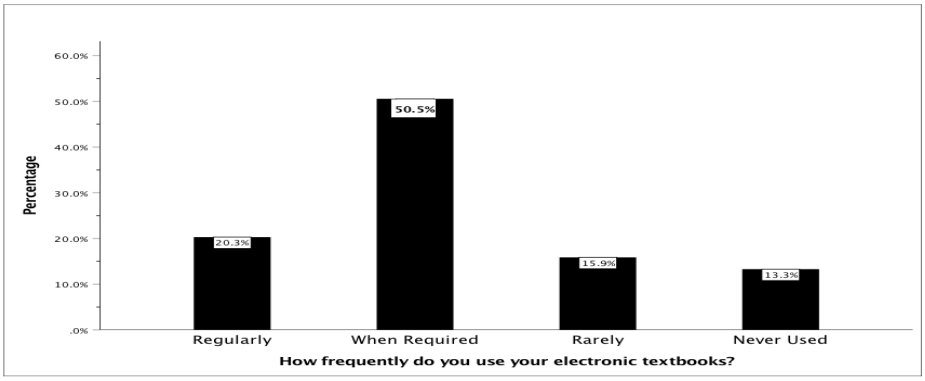


**Fig. 2.** Bar graph displaying students' responses to "How frequently do you use your electronic textbooks?"

As shown above, the results indicated that around half of the sample (50.5%, 137 students) were using electronic textbooks only when they were required by their instructors. The results also showed that around 20% of the students were using their electronic textbooks regularly.

### 3.2 How many hours a week do students usually spend on reading their print and electronic textbooks?

The second research question was concerned with the number of hours students usually spend on reading their print and electronic textbooks. Regarding print textbooks, students reported the results shown in Table 4. These results were used to create the bar graph displayed in Figure 3.

**Table 4.** Students' Responses to "How many hours a week do you usually spend reading your print textbooks?"

| | Frequency | Percent |
|---|---|---|
| More than 3 hours a Week | 30 | 11.1 |
| Between 1 to 3 hours a Week | 109 | 40.2 |
| Less than 1 hour a Week | 69 | 25.5 |
| I do not read textbooks | 63 | 23.2 |
| Total | 271 | 100 |

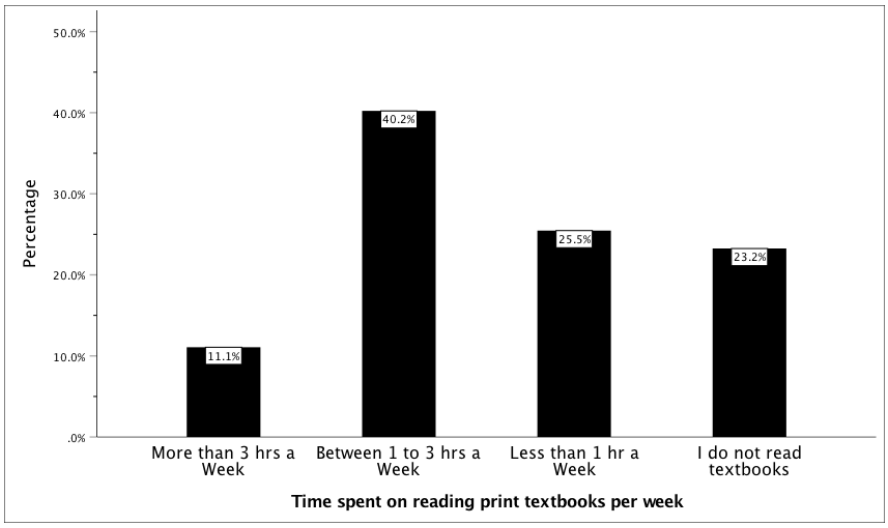


**Fig. 3.** Bar graph displaying Students' Responses to "How many hours a week do you usually spend reading your print textbooks?"

The results indicated that around 40% of the participating students were spending 1-3 hours per week reading their print textbooks. However, only 11% of these stu-

dents were spending more than 3 hours per week reading print textbooks. The results also indicated that around 23% of the students were not reading their print textbooks at all.

Regarding electronic textbooks, the results obtained from the analysis of students' responses are displayed in Table 5. A bar graph depicting these results is shown in Figure 4.

**Table 5.** Students' Responses to "How many hours a week do you usually spend reading your electronic textbooks?"

| | Frequency | Percent |
|---|---|---|
| More than 3 hours a Week | 33 | 12.2 |
| Between 1 to 3 hours a Week | 66 | 24.4 |
| Less than 1 hour a Week | 89 | 32.8 |
| I do not read e-books | 83 | 30.6 |
| Total | 271 | 100 |

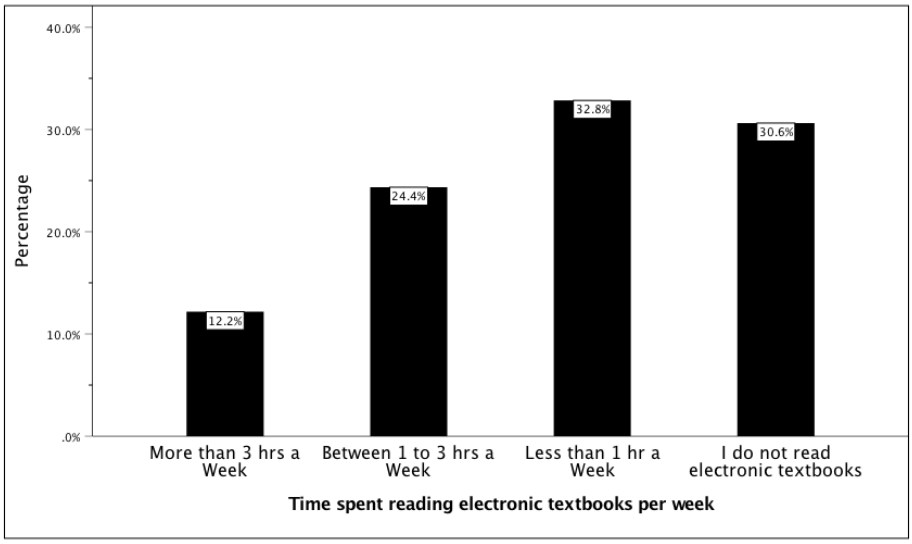


**Fig. 4.** Bar graph depicting Students' Responses to "How many hours a week do you usually spend reading your electronic textbooks?"

As shown, the results indicated that 66 students (around 24%) were spending 1 to 3 hours a week reading their electronic textbooks. The results also showed that only 33 students (around 12%) were spending more than 3 hours a week reading their electronic textbooks. However, it is worth to mention that 83 students (around 31%) were not reading their electronic textbooks at all.

### 3.3 What is students' preference for textbook format?

The third research question measured students' preference for textbook format in support of their studies. Results related to this question as obtained from the sample are presented in Table 6. The data from the table are displayed in a bar graph in Figure 5.

**Table 6.** Students' preference for textbook format

| | Frequency | Percent |
|---|---|---|
| I prefer print textbooks over e-textbooks | 167 | 61.6 |
| I prefer e-textbooks over print textbooks | 95 | 35.1 |
| Undecided | 9 | 3.3 |
| **Total** | **271** | **100.0** |

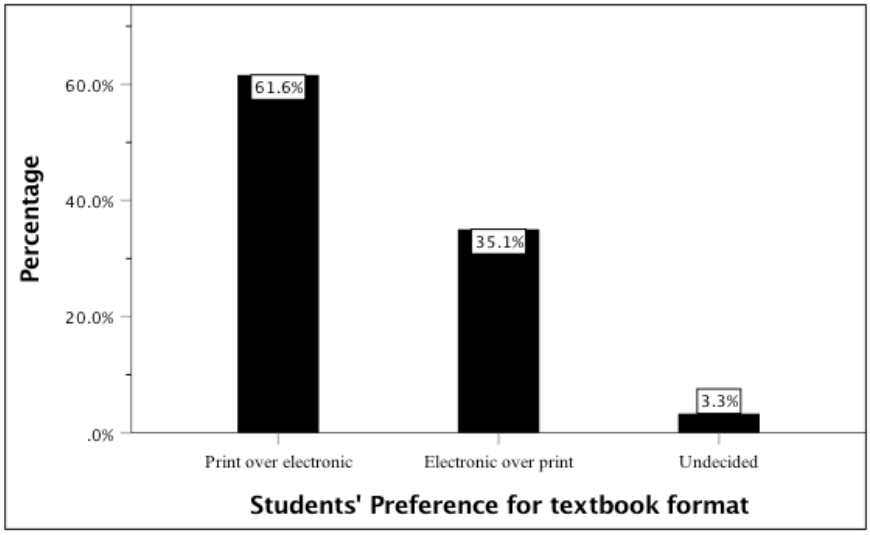


**Fig. 5.** Students' preference for textbook format

The above results showed that 167 students (around 62%) preferred print textbooks over electronic textbooks. Around 31% (95 students) preferred electronic textbooks over print textbooks. Interestingly, a 3.3% of the 271 students who participated in the study were undecided about their preference for textbook formats

### 3.4 What are the reasons for students' preference of textbook format?

The forth research question investigated the reasons for students' preference of textbook format. Students were asked to rate a list of potential reasons on a scale from 1 to 5, with 1 as a "very weak reason", 2 as a "weak reason", 3 as a "moderate reason", 4 as a "strong reason", and 5 as "very strong reason". Table 7 presents, in a descending order, the reasons students rated for preferring print textbooks over e-

textbooks. Students who responded to this list were those who clearly indicated their preference for print textbooks over e-textbooks as previously shown in Table 6. The top "strong" reasons, according to Table 7, for preferring print textbooks over e-textbooks are: (1) Ease of use, (2) Readability, (3) Portability, and (4) Ease of highlighting and taking notes.

**Table 7.** Students' Reasons for Preferring Print Textbooks over e-Textbooks in a Descending Order (n= 167)

| Rank | Reason | Min | Max | Mean | Std. Dev. |
|---|---|---|---|---|---|
| 1 | Ease of use | 1 | 5 | 4.48 | 1.352 |
| 2 | Readability | 1 | 5 | 4.45 | 1.35 |
| 3 | Portability | 1 | 5 | 4.35 | 1.467 |
| 4 | Ease of highlighting and taking notes | 1 | 5 | 4.15 | 1.481 |
| 5 | Effectiveness in memorizing information | 1 | 5 | 3.71 | 1.387 |
| 6 | Ease of searching | 1 | 5 | 3.68 | 1.439 |

On the other hand, Table 8 presents, in a descending order, the reasons students rated for their preference of e-textbooks over print textbooks. According to the table, the top "strong" reasons for preferring e-textbooks over print textbooks are:

- Ease of access
- Ease of searching
- Ease of navigation

**Table 8.** Students' Reasons for Preferring e-Textbooks over Print Textbooks in a Descending Order (n= 95)

| Rank | Reason | Min | Max | Mean | Std. Dev. |
|---|---|---|---|---|---|
| 1 | Ease of access | 1 | 5 | 4.34 | 1.551 |
| 2 | Ease of searching | 1 | 5 | 4.19 | 1.613 |
| 3 | Ease of navigation | 1 | 5 | 4.15 | 1.657 |
| 4 | Ease of archive | 1 | 5 | 3.62 | 1.53 |
| 5 | Currency of information | 1 | 5 | 3.46 | 1.534 |
| 6 | Cost saving (compared to print textbooks) | 1 | 5 | 3.10 | 1.629 |

## 4 Discussion and Conclusion

This study came to explore college students' usage of and preference for print and electronic textbooks in a University college, Bahrain Teachers' College, in the Kingdom of Bahrain. The study surveyed 271 undergraduate students from courses that utilized both print and electronic textbooks. Students were selected based on gender, year of study, Cumulative Grade Point Average (CGPA), and specialization. Four research questions were formulated to help in conducting the study. These questions covered the frequency of using electronic and print textbook, the number of hours spent per week on reading these two formats of textbooks, students' preference for

textbook format, and the reasons why students prefer one textbook format over the other.

On the frequency of using electronic and print textbooks, the results, shown in Figure 6, revealed that almost half of the students (56.8%) use their print textbooks only when required by the instructor. Interestingly enough, a closer percentage of students (50.5%) reported the same frequency of use for their electronic textbooks. This concludes that regardless of textbook formats, the highest percentage of students use their textbooks only when their instructors require them to do so. Based on this finding, the researchers of this study emphasize the vital role of instructors in enhancing the use of textbooks (both electronic and print) among their students.

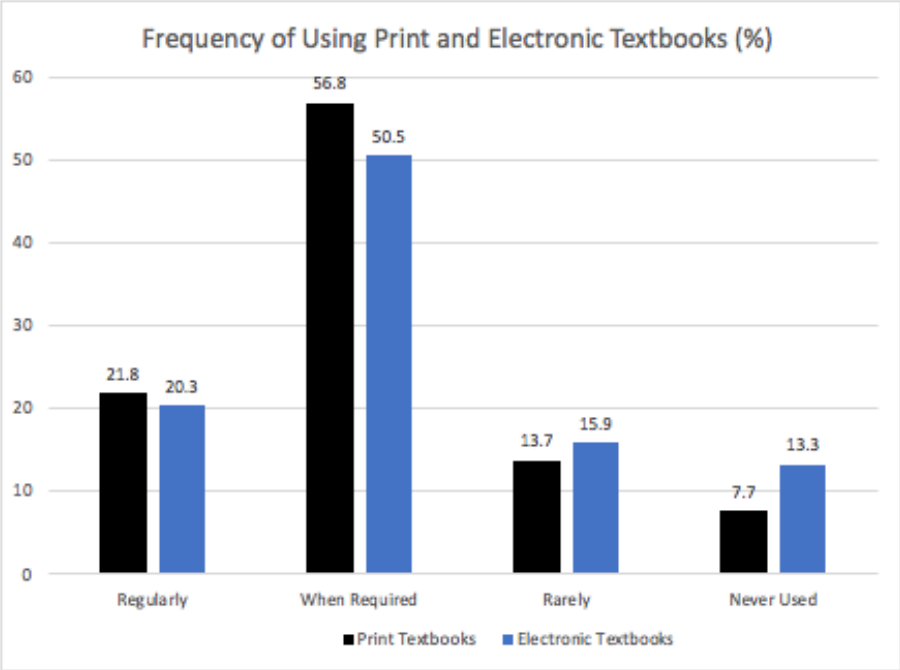


**Fig. 6.** Frequency of Using Print and Electronic Textbooks

Still on the frequency of use, the study manifested that print textbooks and electronic textbooks are "regularly" used by percentages of students of 21.8% and 20.3%, respectively. Inspired by this result, the researchers strongly believe that being used regularly by almost one fifth of the study sample, electronic textbooks are making a tangible progress compared with print textbooks. The percentage of 20.3% is, in fact, double that obtained by Levine-Clark [31], who reported a percentage of 10% only. However, this result underlines the conclusion made by numerous research studies [13; 27; 40; 53; 57; 45; 51], that electronic resources are gaining popularity in education. Taking this to a higher level, the researchers of this study recommend that more research be conducted on the issues related to the popularity of textbooks in educa-

tion. For instance, a recent study conducted by Bouck et al. [7] indicated that the popularity of electronic textbook format will likely continue to grow as students get more exposure to the knowledge of its benefits in education. This, of course, emphasizes the importance of raising awareness of electronic study materials among students at all levels of education.

On the number of hours spent per week on reading textbooks, Figure 7 displays a comparison between print and electronic textbooks as reported by students. While 40.2% of students spend between 1 to 3 hours per week on reading their print textbooks, only 24.4% spend the same number of hours per week on reading their electronic textbooks. Conversely, while 25.5% spend less than 1 hour per week on reading their print textbooks, 32.8% spend the same number of hours per week on reading their electronic textbooks. Based on these results, it can be concluded that for print textbooks, the highest percentage of students (40.2%) spend between 1 to 3 hours per week on reading. Whereas, for electronic textbooks, the highest percentage of students (32.8%) spend less than 1 hour per week on reading.

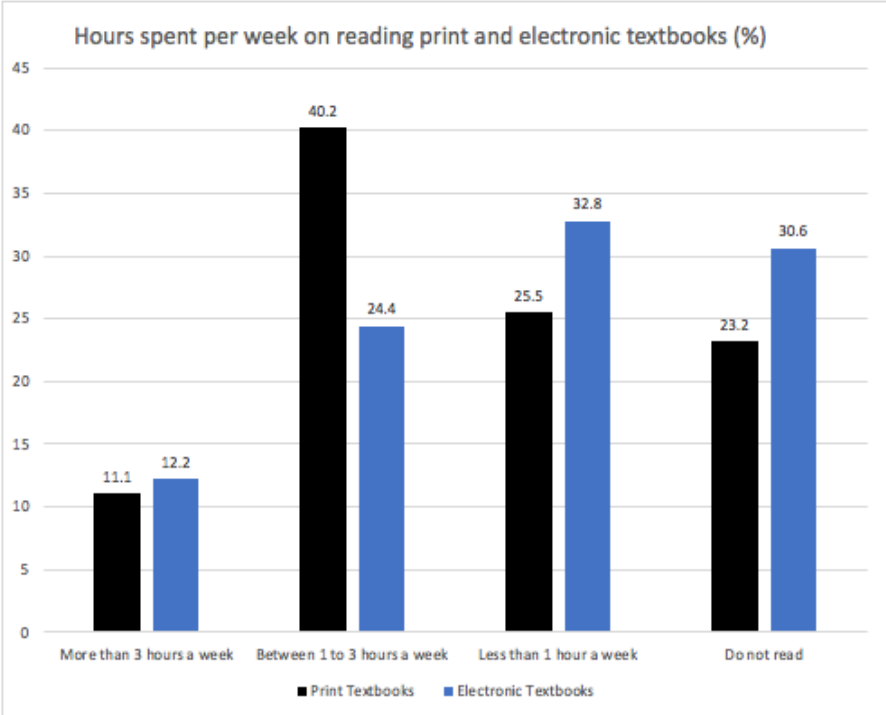


**Fig. 7.** Hours spent per week on Reading Print and Electronic Textbooks

A surprising finding to the researchers of the current study was the comparable percentage of students (i.e. 12.2%) who spend more than 3 hours per week on reading electronic textbooks compared to that of students (11.1%) who spend the same number of hours on reading print textbooks. This concludes that electronic textbooks win

when it comes to spending higher numbers of hours of reading. In the researchers' opinion, although this percentage is relatively small, it can be considered fairly promising and is, therefore, worth obtaining more insight into its nature. For instance, Woody et al. [57] reported that students scan electronic text more than print text. They also noticed that students read electronic text, "searching for key terms rather than reading line by line" (p. 945). Therefore, it could be the "searching" capabilities of electronic text that encouraged students to spend more hours on reading their textbooks.

On students' preference for textbook format, the findings of the study revealed a clear preference for print over electronic. More specifically, while 61.1% of students prefer print textbooks over electronic, only 35.1% have the opposite preference. Based on this result and those of other studies [3; 7; 27; 36; 46; 56], the researchers conclude that in spite of the growing popularity of electronic format in education, over half of college students still prefer print over electronic for their studies. In justifying this conclusion, the researchers believe that students' preferences between the two may not necessarily reflect their actual experiences but rather their familiarities with these formats. Therefore, this study conveys a message to policymakers, practitioners, and teachers to enhance and promote students' experiences with electronic textbooks.

Lastly, the study uncovered reasonable findings as to why students prefer one textbook format over the other. According to the findings, the top "strong" reasons for preferring print over electronic textbooks are ease of use, readability, portability, and ease of highlighting and taking notes. These reasons are similar to those found by Khalid [27] and Millar and Schrier [36]. It's worth to mention that these reasons came as no surprise to the researchers since they are the most cited advantages of the print format in literature. In other words, since print textbooks have been central for education for more than two centuries, their advantages and features are well-known for almost all learners.

Regarding why students prefer electronic over print textbooks, the findings of the study revealed the following "strong" reasons: ease of access, ease of searching, and ease of navigation. These reasons have been cited by a number of research studies, such as Abram [1], Cumaoglu et al. [11], Dillon [14], Khalid [27], Shelburne [44], and Sun et al. [50]. In the current study, it is interesting to notice that the top-rated reason for preferring electronic over print textbooks is ease of access. To the researchers, it seems that students were mostly inclined by the simplicity of accessing electronic textbooks. At the end of the day, an electronic textbook is just at the click of a button!

In conclusion, the study came to provide more insight on college students' usage and preference for print and electronic textbooks. The researchers believe that the findings of the study greatly helped in answering the main research questions. However, further investigations are needed to enable us to better understand the changing patterns of students' usage of print and electronic media in today's information-intensive environment.

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# Edmodo-Based Blended Learning Model as an Alternative of Science Learning to Motivate and Improve Junior High School Students' Scientific Critical Thinking Skills

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**Abstract—**This study aims to analyze students' scientific critical thinking skills through learning with edmodo-based blended learning models. This study is Pre-Experimental using one group pre-test post-test design involving 35 class VIII students at Public Junior High School 10 Jember, Indonesia. The instruments used were teacher activity observation sheets, student activity observation sheets, scientific critical thinking skills assessment sheets, and student motivation sheets. Before and after learning activity, students are given the same initial test (pre-test) and final test (post-test). The collected data was analyzed by quantitative descriptive analysis. The results of the study show that: (1) students are motivated in classical learning by 78.13% with motivated criteria. The highest value is on the likes and active indicators using Edmodo, which is equal to 88.47% and the lowest value on the indicator of activity asks questions and opinions at edmodo, which is equal to 70.93%; and (2) there is an increase in scientific critical thinking skills of students with a mean n-gain of .32, with the criteria being moderate. The highest value is achieved on the indicator of fact analysis, which is equal to .55 and the lowest value on the indicators of delivery of argumentation, which is equal to .19. The conclusion of this study is that science learning with an edmodo-based blended learning model can motivate learning and improve scientific critical thinking skills of junior high school students.

**Keywords—**Blended Learning, edmodo, motivation, scientific critical thinking skills

## 1 Introduction

Education in Indonesia today is faced with a challenge to produce human resources that have superior competencies and are able to compete in the global era. This is in

accordance with the 21st century education development paradigm, where learning outcomes are directed at:

- Critical thinking and problem solving skills, creativity and innovation, and collaboration and communication,
- Skilled at using media, information, technology and communication

(ICT) [1]. Therefore, science learning in the curriculum in Indonesia, namely the 2013 curriculum is designed and directed so that students can fulfill the skills and abilities needed in the 21st century.

Technology has a major role in building 21st century skills, so that students 'skills in using students' technology and scientific critical thinking skills are very important to ensure the success of learning [2].

According to Dwyer et al. [3], students who have higher scientific critical thinking skills will get higher learning outcomes compared to students who have lower scientific critical thinking skills. This is because scientific critical thinking is a combination of abilities, knowledge, values, attitudes, skills, and processes. Scientific critical thinking is reasonable and reflective thinking that focuses on deciding what must be trusted or done through observation, analyzing, synthesizing, and concluding. So, someone who already has scientific critical thinking skills, can be said to have been able to use his mind to think abstract levels, be open to everything, and be able to communicate effectively with others [4]. Therefore, scientific critical thinking skills must be used as part of science learning so that the scientific critical thinking process is increasingly honed.

Based on the results of the 2015 Program for International Student Assessment (PISA), Indonesian students are still at level 3 of the 6 levels in PISA, which can only explain a simple context based on scientific knowledge, whereas scientific critical thinking can be used to think complexly. On level 5, which can make explanations based on evidence and arguments based on scientific critical analysis [5]. This, allegedly causing the results of the achievement of science evaluations of Indonesian students in the measurement of scientific critical thinking in the TIMSS (The Trends of the International Mathematics and Science Study) held by the IEA (International Association for the Evaluation of Educational Achievement) was low. 2011 TIMSS results for science and cognitive domains (understanding, application, and reasoning), Indonesian students obtain a 397 grade below the International average grade of 500, meaning that Indonesian students' science knowledge is still in the limited scientific category if given explicit evidence and clear, and not yet have the ability to reason scientifically in compiling explanations based on evidence and argumentation using critical analysis [6]. This happens because the learning process tends to be done using the teacher center model, where lecture activities become the dominance of learning activities so students tend to be passive and do not show a good thought process [7].

The results of the initial study relating to scientific critical thinking skills in the temperature and heat material in 35 class VIII students of MTs Bustanul Ulum Panti, Jember district were in the score range of 53.25 - 68.42 on a scale of 0-100. The average score of the test results of students' scientific critical thinking skills is included in the less category [8]. In the initial study, students were less able to

formulate problems that were the focus of complex problems. This is in line with the results of the Ulandari et al. [9] in the Public Junior High School 3 of Balung, Jember district, which stated that junior high school students' critical thinking skills, such as; interpretation ability (40.47%); analysis (31.28%); synthesis (30.25%); evaluation (34.45%); concluded (29.53%); inference (37.21%); and explanation (39.53%). According to Martin [10], the problem of scientific critical thinking skills also occurs in other countries, such as Australia in 2011 which reported that the first two years of learning on campus had 45% of students not experiencing a significant increase in scientific critical thinking skills and reasoning.

A suitable learning model to help students achieve 21st century skills is the blended learning model [11]. The blended learning model, also called hybrid learning, is learning that combines face-to-face learning in class with online learning [12]. In the blended learning model, students are required to be able to collaborate, ask questions, and think critically well planned [13]. The application of blended learning is supported by ICT facilities that already exist in schools, such as students who mostly have laptops to access the internet at home through wifi and mobile phones, teachers also have laptops to access the internet, then schools also provide wifi, The use of edmodo as a medium in the blended learning model is an alternative learning that is felt to be very good for improving students' scientific critical thinking skills [16]. This was supported by Fatimah [17] who stated that Edmodo offered a unique opportunity to collaborate among students where they could build collaborative teams so that they could develop students' critical thinking skills. According to Khalel [18] that most students have high motivation for learning because they think that learning to use Edmodo facilitates and increases effective communication of learning and can save time.

Based on the background and problem identification, the objective to be achieved in this study is to increase motivation and scientific critical thinking skills through the application of edmodo-based blended learning models as an alternative to science learning in junior high school.

computer, and projector in learning.Thus, the blended learning model is expected to be able to help students overcome their learning difficulties, and giving them the opportunity to achieve higher scientific critical thinking skills [14,15].

## 2 Overview

### 2.1 Blended learning

Etymologically the term blended learning consists of two words, namely blended and learning. Blended word means mixture or fusion while learning is formed from learned basics that have the meaning of learning [19]. Blended learning as a combination of learning from two historically separate teaching and learning models, namely face-to-face learning systems with online learning systems. Face-to-face learning systems have evolved centuries ago, while online learning began to grow and develop [20]. The application of a learning model must be based on learning theory

that is suitable for the learning process in accordance with predetermined goals [21]. According to Bonk [22] the characteristics of the blended learning model include, namely:

- Blended learning is a way of delivering information and communication, training, education, both the substance of learning material and the science of education that is carried out online.
- Blended learning does not replace traditional learning models in the classroom, but strengthens the learning model through material enrichment and the development of educational technology.
- Use material that is independent because it can be accessed by teachers and students anywhere and anytime.

### 2.2 Edmodo

Edmodo was developed at the end of 2008 by Nic Borg and Jeff Ohara who argued that it was necessary to develop a school environment that was connected with all activities in the world. The purpose of Edmodo's creation is that there is no gap between the lives of students in school and their daily lives. Edmodo is a social networking media that is safe for students and teachers who refer to Facebook social networks, so this system has features similar to Facebook. In fact, many say Edmodo is a Facebook school, because besides being a social networking media among its users, Edmodo also supports the online learning process [23]. At this site parents can also join and communicate with teachers and parents or guardians of other students, besides that of course with their own sons or daughters so they can find out the activities and results of their children [24]. In the learning process, Edmodo is equipped with several learning activities, such as Quiz, Assignment, Poll and File or Link if needed in a larger or different format, online library, closed group space and giving awards to students.

The advantages of Edmodo according to Daulay [25] include:

- Mmaking learning not dependent on time and place because it can be accessed wherever and whenever
- Alleviating the teacher's task to provide assessment to students
- Provide opportunities for parents / guardians of students to monitor learning activities and achievements of their children
- Make the class more dynamic because it allows teacher and student interaction between students and students in terms of lessons or assignments
- Facilitating multidisciplinary group work
- Encourage collaborative virtual environments that help process-based learning
- Easy to use
- Closed group collaboration, because only those who have a group code can take classes
- Free, accessible online, and available for smartphone devices
- Do not need a server at school

- Edmodo is always updated by the developer
- Edmodo can be applied in one class, one school, between schools in one city / district
- Edmodo is used to communicate using social media, learning material, evaluation, team teaching, and teacher collaboration.

### 2.3 Scientific critical thinking skills

The ability to think someone has been born since but must be trained at all times, because the ability to think will not be able to develop into a skill without being trained [26]. Therefore, to improve one's ability requires a different training process both in quality and quantity, because each student has different learning abilities, depending on which intelligence is most prominent in him. According to Ennis [27] ideal critical thinkers have at least five abilities, including: basic classification skills, basic abilities for analysis, the ability to make inferences, the ability to make further clarifications, and the ability to make predictions and integration. According to Fisher [28] critical thinking is defined as the ability that is responsible and able to control our own minds. Critical thinking involves various skills such as identifying sources of information, analyzing their credibility, reflecting on whether information is consistent with their previous knowledge, and drawing conclusions based on their critical thinking [29].

So, it can be concluded that critical thinking is reasoned thinking, reflective, responsible for making reliable decisions. A person who thinks critically can ask questions correctly, obtain information that is relevant, effective and creative in selecting and sorting information, logical reasons for information, and conclusions that can be trusted and convincing. Table 1 provide information about indicators of scientific critical thinking skills and operational definitions.

**Table 1.** Indicators and Operational Definitions of Scientific Critical Thinking Skills

| Number | Indicator of Scientific Critical Thinking Skills | Operational definition |
|---|---|---|
| 1 | Fact Analysis (Actual) | Students are able to analyze the meaning of the facts presented in the problem correctly and honestly. |
| 2 | Submission of Reason (Reason) | Students are able to organize thoughts and express reasons clearly, logically or reasonably. |
| 3 | Conclusion (Inference) | Students are able to distinguish between conclusions based on valid logic and invalid logic. |
| 4 | Submission of Arguments (Argumentation) | Students are able to refute an argument irrelevant and deliver relevant arguments. |
| 5 | Presentation of Implications (Implication) | Students are able to ask a view and question the implications of a view |

Source : Adoption of Facione [30]

## 3 Methodology

This study uses Pre-Experimental to determine the impact of a treatment on the research subject without a comparison class (control) and to describe whether there is an increase in motivation and scientific critical thinking skills [31]. The study design is One Group Pre-test Post-test Design. The study was conducted on 35 VIIIA students of Public Junior High School 10 Jember in the odd semester of the 2018/2019 academic year, because the school had school-based internet service and wifi installed since 2009 by having an adequate computer laboratory.

The instruments used were teacher activity observation sheets, student activity observation sheets, scientific critical thinking skills assessment sheets, and student motivation sheets. The steps used in the analysis of students' scientific critical thinking skills are as follows:

- Data from the results of the tests of scientific critical thinking skills are calculated on average test scores
- The increase in scientific critical thinking skills that occur before and after learning is calculated by the normalized gain (n-gain) formula with the Meltzer formula [32].

$$n-gain = \frac{Xm - Xn}{100 - Xn} \tag{1}$$

Remarks:
n-gain = normalized gain
Xm = post-test score
Xn = pre-test score

The criteria for n-gain level are: a) n-gain < .3; low, b) .7> n-gain ≥ .3; medium, c) n-gain ≥ .7; high.

The student motivation sheet is used to determine the attitudes, interests and encouragement that exist in students towards the use of edmodo-based blended learning models. This data will be analyzed and the results used to conclude whether student motivation increases during the learning process using the edmodo-based blended learning model. The steps used in the analysis of student learning motivation are as follows:

- Provide an assessment of each aspect of student learning motivation in accordance with predetermined criteria.
- Summing each aspect of student learning motivation.
- Presenting scores for each aspect of student motivation observed using the formula;

$$P = \frac{m}{M} x\ 100\% \tag{2}$$

Remarks:
*P*=percentage motivation score achieved by students
m = score obtained by students (motivation score)
M = maximum motivation score
The results obtained are interpreted using the criteria in Table 2.

**Table 2.** Interpretation Criteria for Student Learning Motivation Score

| Percentage of Motivation (%) | Motivational criteria |
|---|---|
| $86 \leq P \leq 100$ | Very motivated |
| $72 \leq P < 86$ | Motivated |
| $58 \leq P < 72$ | Sufficiently motivated |
| $44 \leq P < 58$ | Less motivated |
| $30 \leq P < 44$ | Not motivated |

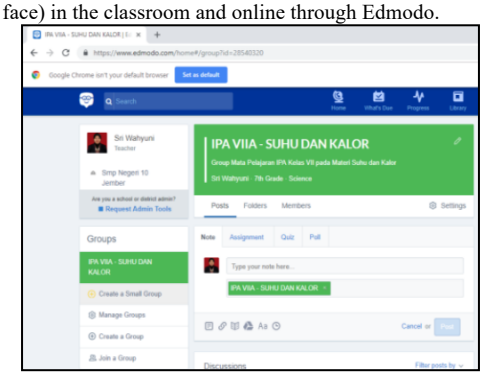
Source: Sugiyono [32]

## 4 Finding and Discussion

The implementation of edmodo-based blended learning models to improve students' motivation and scientific critical thinking skills is shown in Table 3.

The results of scientific critical thinking skills of class VIII students of Public Junior High School 10 Jember are shown in Table 4.

**Table 3.** The Syntax of the Blended Learning Model for Scientific Critical Thinking Skills

| Phase | Learning Activities | Indicator of trained Scientific Critical Thinking Skills |
|---|---|---|
| *Seeking of Information* | • Teachers deliver learning objectives for students' readiness to initiate and prepare students in the exploration of relevant concepts through learning activities face to face (face to face) in the classroom and online through Edmodo.   Figure 1. Teacher Edmodo's page | ▪ Fact Analysis *(Actual)* |
| *Acquisition of Information* | • The teacher guided the students to work on the Assignment through edmodo in a group discussion to inventory information, interpret and elaborate the concepts being taught face to face (face to face) and online through edmodo. | ▪ Submission of Reason *(Reason)* |

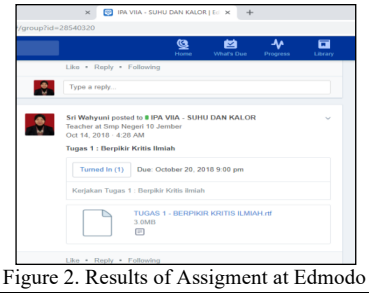
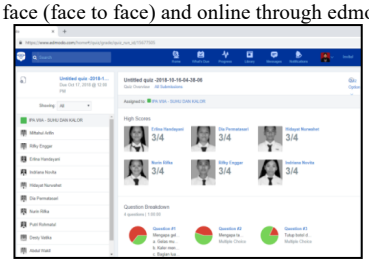
| Phase | Learning Activities | Indicator of trained Scientific Critical Thinking Skills |
|---|---|---|
| |  <br>Figure 2. Results of Assigment at Edmodo | |
| *Synthesizing of Knowledge* | • The teacher justifies the results of academic exploration and acquisition of concepts and together concludes the concept being taught.<br>• The teacher helps students synthesize knowledge in their cognitive structure.<br>• The teacher accompanies the students in reconstruction through the accommodation and assimilation process starting from the results of the analysis, discussion and formulation of conclusions on the information learned in face to face (face to face) and online through edmodo.<br>  <br>Figure 3. Quiz Results in Edmodo | ▪ Conclusion (Inference)<br>▪ Submission of Arguments (Argumentation)<br>▪ Presentation of Implications (Implication) |

**Table 4.** Results of Comparison of Pre-test and Post-test Values Each Indicator of Student Scientific Critical Thinking Skills

| Indicator | Activity | N | Mean | n-gain | Criteria |
|---|---|---|---|---|---|
| Fact Analysis (Actual) | Pre-test<br>Post-test | 35<br>35 | 27<br>53 | .55 | Medium |
| Submission of Reason (Reason) | Pre-test<br>Post-test | 35<br>35 | 23<br>40 | .28 | Low |
| Conclusion(Inference) | Pre-test<br>Post-test | 35<br>35 | 33<br>53 | .30 | Medium |
| Submission of Arguments (Argumentation) | Pre-test<br>Post-test | 35<br>35 | 20<br>33 | .19 | Low |
| Presentation of Implications (Implication) | Pre-test<br>Post-test | 35<br>35 | 13<br>33 | .30 | Medium |
| Average n-gain | .32 | Medium | | | |

Based on the results of the initial analysis of scientific critical thinking skills students' data showed that the average increase in classical critical thinking skills in classical was .32 with the criteria is medium. Students get the highest level n-gain value on the fact analysis indicator which is .55 and get the lowest score on the argument delivery indicator of .19. This is because students are still unable to analyze the process.Students still give responses without being followed by reasons or facts that support the argument. This can be seen from the included facts that are merely copying from the internet and other references. Students use reasoning to only restate the data, the principles of the reasons used are unclear. In the learning activities there is also no interaction between students and other students, such as refuting, supporting or responding to arguments put forward by other students so that reasoning has not developed. Thus it can be said that students' skills in delivering arguments must be trained. This is because argumentation skills are a process of thinking ability that requires time to habituation/practice [33].

Toulmin stated that the quality of argumentation skills was determined by the existence of 3 aspects, namely, claims, evidence, and reasoning [34]. Claim is a statement to answer the problem, evidence is scientific data that supports statements, and reasoning is the reason or justification that connects statements with evidence. The ability of states to claim corresponds to the ability to use supporting data to support the statement of claim. The ability of students to state a claim is also influenced by the student's ability to convey the reason (reasoning). It also correlates with the research of Berland & Mc Neill [35] stating that most students have difficulty to justify claims and convey reasons (reasoning) by providing evidence supporting claims. Inch, et al. [36] stated that the use of argumentation in science learning is the most important part of developing scientific critical thinking skills. Argumentation is a process used by someone to analyze information about a topic and then the results of the analysis are communicated to others.Learning activities with arguments have implications for better reasoning and evidence use [37].

The application of edmodo-based blended learning model can develop students' scientific critical thinking skills, especially on the fact analysis indicator, which is .55 which gets the highest score. This is consistent with the opinion of Vogel et al. [38] who argues that the availability of online-based learning can provide facilities for students to examine data and evidence based on supporting theories so that they are scientific, compare different perspectives on phenomena or issues- science issues, analyze and synthesize data to form conclusions, and argue according to data collected based on facts. Eskin states that students who have the skills to ask and argue based on facts can construct explanations to generate new knowledge, in which new knowledge can be a new theory, a new way of collecting data, or a new way of interpreting the data in order to improve the critical thinking skills of scientific [39].

The edmodo-based blended learning model turns out to be able to create a pleasant learning environment and motivate students to actively think scientifically. The following data on student motivation can be seen in Table 5.

**Table 5.** Student Learning Motivation Data for Each Aspect

| Number | Aspect | Indicator | The average achievement of each aspect (%) | Criteria |
|---|---|---|---|---|
| 1 | Students' interest and attention to learning activities | Like and actively use edmodo | 88.47 | Very Motivated |
| 2 | The enthusiasm of students to carry out their learning tasks | willingness to do assignments and quiz on edmodo | 77.35 | Motivated |
| 3 | Student responsibility for learning activities | not forget to do the quiz at Edmodo | 82.29 | Motivated |
| 4 | Fun in working on tasks that are on Edmodo | do assignments or quiz on edmodo | 71.62 | Sufficiently Motivated |
| 5 | The reactions shown by students to learning activities | active asking questions and opinions on edmodo | 70.93 | Sufficiently Motivated |
| **Overall student learning motivation** | **78.13** | **Motivated** | | |

Based on the results of the analysis, it is known that classical student learning motivation is 78.13% with motivated criteria. Students get the highest score on the likes and active indicators using edmodo, which is 88.47%, and get the lowest score on the indicator of activity asking questions and opinions at Edmodo, which is 70.13%. This is in accordance with the results of Anisa and Ratnasari's research [40], which suggest that students will be motivated towards learning if students know what they will learn,can access material first, so that they are better prepared to learn. Learning readiness will increase student participation in the learning process and can construct various knowledge and experiences to describe, analyze, and answer the problems given by the teacher according to their own ways. Constructing the knowledge to explore material has proven to be more effective than traditional methods.

## 5 Conclusion

Based on the results of research and discussion, it can be concluded that science learning with an edmodo-based blended learning model can:

- Motivating students to learn with motivated criteria. The highest value is in the indicator of likes and active using edmodo, which is equal to 88.47% and the lowest value on the indicator of activity raises questions and opinions in edmodo, which is equal to 70.93%; and
- Improving the scientific critical thinking skills of junior high school students, with an average n-gain of .32, moderate category, the highest value achieved on the indicator of fact analysis, which is equal to .55 and the lowest value on the argument delivery indicator, which is .19.

Based on the conclusions above, the teacher is advised to achieve the quality of the learning process by using the edmodo-based blended learning model, by making adequate preparations, especially for the connection of internet networks in computer laboratories, so that students can practice students' scientific critical thinking skills to the maximum. In addition, teachers are expected to be able to vary the use of learning resources that can avoid boredom and create a pleasant atmosphere.

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# Open Online Assessment Management System Platform and Instrument to Enhance the Information, Media, and ICT Literacy Skills of 21st Century Learners

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**Abstract**—Information literacy (IL), media literacy (ML), and information communication and technology literacy (ICT Literacy: ICTL) are some of the most important skills for 21st century learning and which help promote other skills, including life and career skills and learning and innovation skills. This kind of learning allows students to connect as a learning network without barriers or borders. It fully supports the use of equipment and technology to develop the skills necessary for life. The purpose of this research study is two-fold: first, to develop a research-based Open Online Assessment Management System (OOAMS), and second to develop the standardized measurement for an assessment of IL, ML, and ICTL for higher education learners. The sample group consists of 2,300 higher education learners and the methodology was divided into 3 phases: (1) developing the conceptual framework, definition, and features of IL, ML, and ICTL for higher education learners; (2) examining requirements, designing wireframes, and developing an OOAMS for higher education students; and (3) testing the quality of OOAMS for IL, ML, and ICTL using exploratory factor analysis (EFA) and confirmation factor analysis (CFA) statistical methods. The research result found that, first, the specific features of the system included development using PHP and MySQL database and the design to interact with users with a responsive UI framework. The system is compatible with MOOCs and the Open edX platform, or can be used as a stand-alone application. It can create, share, copy, and extend both Likert scales and rubrics evaluation forms. It can also generate reports in both CSV and PDF formats. Secondly, the results of this research provided a standardized measurement for assessing IL (49 items), ML (63 items), and ICTL (69 items). Also, it can be improved or enhanced for online learning in a ubiquitous learning context such as e-learning, blended learning, virtual learning and MOOCs effectively.

**Keywords**—Assessment Management System, information literacy, media literacy, information communication and technology literacy

## 1 Introduction

Higher education institutions around the world have set the guidelines for e-learning and MOOCs. Research has investigated the acceptance of e-learning and

MOOCs, as well as the design of e-learning and MOOCs to suit students and the context of each institute [1][2][3][4][5]. A challenge of online instruction has been identified as measurement and evaluation, which is an important component in learning that results in an effective learning process [6]. The change in instruction has made digital literacy increasingly important. Many organization have defined and provided the scope of the term 'digital literacy'. The report on 'Towards a national digital skills framework for Irish higher education' defines 'digital competency' as a combination of concepts, including information literacy, media literacy and information and communication technology (ICT) literacy. This is in line with the definition of digital literacy provided by the Partnership for 21st Century Skills organization in 2007 which has become widely accepted as one of the development frameworks in the 21st century. The organization advocates and encourages education institutes around the world to incorporate these skills into the educational system. In doing so, this will prepare students to acquire knowledge and skills beyond purely academic applications, including learning and innovation skills, information skills, media and technology skills, as well as life and career skills. Learners can apply and adapt their knowledge and skills to the situation creatively while studying, and after graduation, to the world of work effectively and productively for life [3] [7] [8] [9] [10]. In India, digital instruction has been developed to address the diversity of learners in different areas, using mobile technology adapted for remote areas, context enabled curriculum, along with flexible learning schedules. The results of the interviews showed that 90% of the learners who participated became more confident in using computers and the internet [11]. In Australia, instruction for media literacy and social understanding has been provided through Minecraft. Learning evaluation was conducted in media literacy across four nodes: digital materials, media production, conceptual understanding and media analysis [12]. Digital literacy assessment was done by online data collection through Moodle, self-assessment via Google Forms, and SPSS [13]. There are two types of evaluation and data collection to develop digital literacy framework. The first comprises multiple-choice measurement, Likert scale measurement, and short-answer questions. The second comprises the semi-structured interview [14].

In response to the importance of these issues, Massive Open Online Courses (MOOCs) have played an important role in teaching and learning that promotes lifelong learning, such as edX, Coursera, Udacity, Udemy, P2Pu and Khan Academy. In Thailand, Thai MOOCs have been developed using Open edX, the open source MOOC platform founded in 2012 by Harvard and MIT, as the main platform. Then, Open edX was released as code-sharing software for MOOCs. At present, several educational institutes around the world have installed Open edX for MOOC instruction. For example, edX (https://www.edx.org) has 10,000,000 students. As for Thai MOOC, there are currently more than 65,000 registered users with over 100,000 registered uses. However, the Open edX platform is still limited in terms of measurement as students can only be assessed by quiz.

In order to meet the educational needs of digital learners and the direction of international education with its focus on creating innovators, measurement should be improved to cover both traditional assessment and authentic assessment. It should focus on the well-rounded measurement of knowledge, attitudes, and skills. To be in line

with the concept of open learning and open content, there should be public spaces for exchanging, sharing, adjusting, and extending the evaluation form for instructors who teach similar subjects for the utmost benefit of the measurement. Therefore, this research has developed a research-based Open Online Assessment Management System (OOAMS) an Open edX extension system. It can be used, improved, and extended not only for MOOC, but also as a standalone system for other types of online instructions including e-learning, and blended learning effectively. This has produced MOOC instruction that is complete in terms of learning management, content, and measurement. This research also developed a standardized test that was accepted by using advanced research statistics analysis to test online measurement in accordance with the definition and attributes of those skills. This can be measured accurately and reliably. There are three sets of measurements: (1) information literacy (IL), (2) media literacy (ML), and (3) ICT literacy (ICTL). Both results of the research can help drive higher education institutions to raise teaching and learning to their full potential.

### 1.1 Research questions

- What areas do the conceptual framework, definition, and features of information literacy (IL), media literacy (ML), and ICT literacy (ICTL) for higher education learners cover?
- What are the specific features of Open Online Assessment Management System (OOAMS) and the evaluation criteria of IL, ML, and ICTL for higher education learners in OOAMS?
- What are the results of the quality testing of online assessment of IL, ML, and ICTL? What are the specific features of the measurement of IL, ML, and ICTL?

## 2 Methodology

The research was divided into 3 phases based on the research questions.

**Phase 1:** Development of the conceptual framework, definition, and features of IL, ML, and ICTL for higher education learners by studying the ideas, theories, and research relating to IL, ML, and ICTL for higher education learners to develop the conceptual framework, definition, and features of IL, ML, and ICTL for higher education learners. Then, experts checked the content validity, and the content was revised according to their suggestions.

**Phase 2:** Development of the online assessment system, the OOAMS, of IL, ML, and ICTL for higher education learners. This is an innovation designed and developed based on the research. There are two specific features:

- The specific features of the system
- The specific features of the measurement

This paper focuses on the specific features of the measurement.

Three initial measurements were developed and published. The three sets of measurements were standardized using advanced research statistics analysis as follows:

- IL
- ML
- ICTL

These comprise one of four important skills for 21st century learning. The system publishes the measurements for students in the above-mentioned three areas.

**Phase 3:** Testing of the quality of the OOAMS by testing the three measurements with a sample group of 2,300 higher education learners through three various means. The first was through an online test via an online assessment system (n=150) to test the quality of each item of the measurement using the item total correlation (IOC) method and selecting items with IOC above .20. The second (n=150) tested the initial quality of each item of the measurement by finding the correlation between the score of an item and the total score of each area of the measurement (IOC) and conducting an initial reliability test with Cronbach's alpha coefficient. The third tested higher education learners (n=1,000). The data was analyzed by exploratory factor analysis (EFA). Then the three measurements were tested again (n=1,000) using confirmation factor analysis (CFA).

## 3 Results

In the following section, the research findings are aligned with the research questions as follows.

### 3.1 The result of the development of the research-based assessment system

The result of the development of the research-based assessment system and online rubric that provides testing and evaluation for higher education learners is that it is compatible with the Open edX platform. The system is compatible with the MOOCs Open edX platform or can be used as a stand-alone application.

As mentioned above, the result of this research proves that the OOAMS system has two specific features:

- The specific features of the system
- The specific features of the measurement

The layout of the system was used to develop the system with the following features:

- An evaluation creation system for an Open edX platform which is compatible with the Open edX platform and that can also be used as a stand-alone application;
- The system can create, share, copy or extend an evaluation form with both Likert scales and rubrics, which instructors can apply to other subjects;
- It can be used for traditional assessment and authentic assessment for self-assessment, peer assessment, and instructor assessment;

- It was developed with PHP and MySQL databases and a user interface was designed with the responsive UI framework; and
- It can generate reports in both CSV and PDF formats [3].

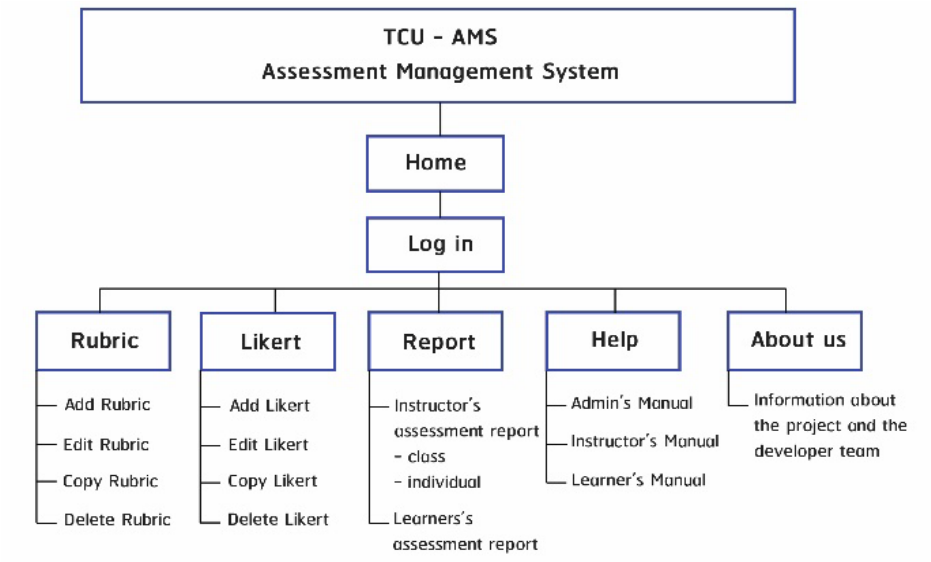


**Fig. 1.** Layout of OOAMS, referred to as TCU-AMS


**Fig. 2.** Special features of the system that can create, modify, share, copy, and extend Likert scale and rubric evaluation forms


**Fig. 3.** TCU-AMS (Likert page)


**Fig. 4.** TCU-AMS (Rubric page)

### 3.2 The results of the development of an online research-based standardized test on the IL, ML, and ICTL for higher education learners

This paper focuses on the specific features of the measurement. The three sets of measurements have been developed and published. These are standardized by using advance research statistics analysis. The measurements comprise:

- Information literacy
- Media literacy
- ICT literacy which constitute one of four key areas for 21st century learning

The system publishes the measurements that assess students in three dimensions. These were developed from the conceptual framework, definition, and features of information literacy, media literacy and information and communication technology literacy for higher education learners. The consistency and definition of the 21st century skills on information literacy was validated by the experts, with the media tested on 2,300 learners. The definition, scope, features of information literacy, media literacy, and ICT literacy for higher education learners were found to be appropriate. The criteria of behavior level are:

- Means having the behavior/ability as stated in the question at the lowest level
- Means having the behavior/ability as stated in the question at a low level
- Having the behavior/ability as stated in the question at a medium level
- Having the behavior/ability as stated in the question at a high level, and 5 having the behavior/ability as stated in the question at the highest level.

**Table 1.** Information Literacy : Definition, scope, and measurement

| Information Literacy (49 items) | |
|---|---|
| **Definition:**<br>Level of knowledge and understanding in using existing information accurately and that matches the needs. [15] [16] [17]<br>**Scope:**<br>Important features:<br>(1) Ability to identify the needs for information<br>(6 items)<br>(2) Ability to access information (3 items)<br>(3) Ability to manage information (9 items)<br>(4) Ability to apply information (6 items)<br>(5) Ability to have ethics in using information (13 items)<br>**Rating Scale:**<br>Score Ability Level<br>Higher than 246 Highest<br>209-245 High<br>168-208 Medium<br>131-167 Low<br>Lower than 130 Lowest | 1. You can select the information source by yourself.<br>2. You can set the searching words for information by yourself.<br>3. You regularly keep up to date on the information source.<br>4. You can classify the type of information source.<br>5. You set the method before searching for information.<br>6. You set the period for searching for information.<br>7. You understand the components of the information source.<br>8. You perform the search according to the goal.<br>9. You consider the information you receive before using it.<br>10. You can organize the information you receive.<br>11. You consider the information you receive before trusting it.<br>12. You can explain the difference between information sources.<br>13. You can evaluate the value of each type of information source.<br>14. You can analyze the good and bad effects of information. |

| | |
|---|---|
| | 15. You can organize the information you receive into categories.<br>16. The information source provides the information that meets your needs.<br>17. You know which information source is a quality source.<br>18. You always develop yourself to be up-to-date on information.<br>19. You understand the information you gain.<br>20. You know how the information is useful.<br>21. You can tell what kind of information cannot be searched from which source.<br>22. You recognize when information is needed.<br>23. You can create a system and structure to manage information.<br>24. You can utilize the information.<br>25. You can apply the information to work.<br>26. You can summarize ideas from the information.<br>27. You can use the information to develop yourself.<br>28. You can create a new information source by yourself.<br>29. You can ask a question from the information you find.<br>30. You can set the strategies for accessing information.<br>31. You understand the process of disseminating information.<br>32. You can discuss the information you receive.<br>33. You can write a reference for the information sources.<br>34. You can integrate information sources to access the information you need.<br>35. You can decide how to use the information by yourself.<br>36. You only search for useful information and knowledge.<br>37. You do not pass on illegal information.<br>38. You do not use an information source for commercial purposes.<br>39. You do not use the information obtained for illegal purposes.<br>40. When you find illegal information, you will notify the authorities.<br>41. You can recommend the right sources to others.<br>42. You consider the ethics in accessing information.<br>43. You respect the privacy of accessing personal information.<br>44. You are aware of the cultural context before disseminating information.<br>45. You are aware of the social context before disseminating information.<br>46. You consider the economic impact of disseminating information.<br>47. You do not corrupt the file during use.<br>48. You are careful not to have a computer virus spread.<br>49. You comply with requirements, laws, and act legally in accessing information. |

**Table 2.** Media Literacy: Definition, scope, and measurement

<table>
<tr><th colspan="2">Media Literacy (63 items)</th></tr>
<tr><td>

**Definition:**
Ability to access, analyze, evaluate and create the content in a variety of contexts. Aware of the impact of media exposure. Choose to receive useful content and avoid unwanted content that the media offers. [18] [19] [20]

**Scope:**
Important features:
(1) Assessing the media (15 items)
(2) Analyzing the media (22 items)
(3) Evaluating the media (6 items)
(4) Creating the media (14 items)
(5) Accessing the media from various sources (3 items)
(6) Using the media creatively (3 items)

Rating Scale:

| Score | Ability Level |
|---|---|
| Higher than 296 | Highest |
| 255-295 | High |
| 203-254 | Medium |
| 159-202 | Low |
| Lower than 158 | Lowest |

</td><td>

1. You access to the media by yourself.
2. You receive information of accessing to the media from your family.
3. You receive information of accessing to the media from friends.
4. You receive information of accessing to the media from school/university.
5. You study the characteristics of the media every time before access
6. You can access the media quickly.
7. You can use various media skillfully.
8. The media you choose to access is up-to-date and universal.
9. You access to the media at the right time.
10. You are in the area that is convenient to access to the media.
11. You participate in more than one social media.
12. You understand the meaning of vocabulary from the media.
13. You understand the mechanisms and techniques of the media used in the presentation.
14. You allocate your time to use the media.
15. You understand the motivation of the media producer.
16. You can differentiate the type of media.
17. You can interpret the hidden connotation in the media.
18. You can understand the sequence of the events from the media content.
19. You understand the content of the media.
20. You gain the idea from media exposure.
21. You can distinguish the fictional and fantasy stories in the media.
22. You can comment on the content of the media.
23. You use the pre-existing knowledge to access media.
24. You always compare the information received from the media.
25. You can analyze what is a passive advertisement in the media.
26. You know what the producer wants to communicate with the audience.
27. You can analyze whether the media is appropriate for the audience.
28. You can analyze whether the media is presented on the basis of democracy.
29. You can analyze the social values reflected in the media.
30. You can analyze the component of the media.
31. You can ask a question from the media.
32. You can analyze who or what the media fails to present.

</td></tr>
</table>

| | |
|---|---|
| | 33. You think the internet media is easy to access.<br>34. You think that language skills are needed to access the media.<br>35. You think the skills in using the media are important to access the media.<br>36. You can understand the meaning of the content effectively.<br>37. You think age is an important factor in accessing the media.<br>38. You think education level is an important factor in accessing the media.<br>39. You consider the content of the media before deciding to act.<br>40. You think reading and interpretation skills are necessary for media consumption.<br>41. You select the media to match your needs.<br>42. You can use the media for yourself.<br>43. You can use the media for others.<br>44. You use the correct written language to present information.<br>45. You use the knowledge from the media to develop yourself.<br>46. You use an audio to create the content of the message.<br>47. You offer an opportunity for others to participate in creating the media.<br>48. You consider the ethics in using the media.<br>49. You can build relationships with others through the media.<br>50. You can organize the information gained from the media.<br>51. You motivate yourself from the media.<br>52. You use the media to convey your knowledge.<br>53. You protect yourself from internet privacy violations.<br>54. You help the society through media channels.<br>55. You use social media to communicate and transfer knowledge among friends.<br>56. You use communication technology to structure the content.<br>57. You can create your own media.<br>58. You create the media that interacts with others.<br>59. You can create the media that promotes learning.<br>60. You have changed your behavior from the media.<br>61. You can use the media in creative ways.<br>62. You can associate the content of the message with a personal experience.<br>63. You can tell the limitations of each media. |

**Table 3.** ICT Literacy: Definition, scope, and measurement

<table>
<tr><th colspan="2">ICT Literacy (69 items)</th></tr>
<tr><td>Definition:<br>Ability to use digital technology, communication tools, and/or networks to access, manage, integrate, evaluate, and create information for learning society. [21] [22] [23] [24]<br>Scope:<br>Important features:<br>(1) Accessing ICT<br>(5 items)<br>(2) Communicating ICT (7 items)<br>(3) Managing ICT<br>(6 items)<br>(4) Integrating ICT<br>(6 items)<br>(5) Evaluating ICT<br>(23 items)<br>(6) Creating ICT<br>(22 items)<br>Rating Scale:
<table>
<tr><th>Score</th><th>Ability Level</th></tr>
<tr><td>Higher than 323</td><td>Highest</td></tr>
<tr><td>278-322</td><td>High</td></tr>
<tr><td>226-277</td><td>Medium</td></tr>
<tr><td>177-225</td><td>Low</td></tr>
<tr><td>Lower than 176</td><td>Lowest</td></tr>
</table></td><td>1. You can find information from an ICT source.<br>2. You can collect information from an ICT source.<br>3. You can retrieve information from an ICT source.<br>4. You can use a variety of ICT tools.<br>5. The ICT that you use is quick for accessing information.<br>6. You understand the system of each type of ICT.<br>7. You understand the language and symbols used in ICT.<br>8. You can describe the use of ICT to others.<br>9. You know the laws and regulations concerning the use of ICT.<br>10. You use ICT in electronic transactions.<br>11. You can create an ICT manual.<br>12. You use ICT to solve problems in learning/working.<br>13. You think that ICT results in integrating various media types.<br>14. You can use ICT to compare information.<br>15. You can use ICT to present arguments of information.<br>16. You can use ICT for research purposes.<br>17. You can use ICT to evaluate information.<br>18. You can use ICT for corporate management.<br>19. You can use ICT to synchronize information systems.<br>20. You can use the e-learning system to learn about ICT.<br>21. You think ICT is necessary in today's society.<br>22. You think that ICT enables broader access to information.<br>23. You think that ICT enables more rapid dissemination of information.<br>24. You think that ICT contributes to participation in information and information content.<br>25. You can identify the benefits of ICT.<br>26. You think that ICT can reduce travel costs.<br>27. You think ICT is a key factor in economic growth.<br>28. You consider ICT in making decisions before doing activities.<br>29. You use ICT to analyze the relationships of information.<br>30. You can use digital and communication technology to connect useful information.<br>31. ICT improves your thinking skills.<br>32. You think that ICT is an important factor in economic development.<br>33. You think that ICT is an important factor in the educational development of the country.<br>34. ICT enables communication without borders.<br>35. ICT creates learning outside the classroom.<br>36. ICT reduces the costs and time to travel.<br>37. You can distinguish the virtual world and the real world while using ICT.<br>38. You understand the results from what you have learned from and your use of ICT.</td></tr>
</table>

| ICT Literacy (69 items) | |
|---|---|
| | 39. You analyze and evaluate the impact of using ICT.<br>40. You think that ICT improves the efficiency of ICT development.<br>41. You can adjust the ICT format.<br>42. You can design ICT by yourself.<br>43. You can use ICT to respond to cultural differences.<br>44. You can invent ICT by yourself.<br>45. You can use ICT to express your position.<br>46. You can develop an ICT system or program.<br>47. You can use ICT to develop yourself.<br>48. You can use ICT to develop your organization.<br>49. You can develop ICT to meet the needs of users.<br>50. You may use ICT in accordance with the specific features of the media.<br>51. You can use ICT to respond to individual differences.<br>52. You can use ICT to create interesting information.<br>53. You use ICT to present information that is different from others.<br>54. You can use ICT to present propaganda information.<br>55. You can use ICT to link your devices for increased<br>efficiency.<br>56. You use ICT to apply to your work.<br>57. You can use ICT for designing.<br>58. You can use ICT to develop software packages.<br>57. You have the ability to apply ICT in a specific way.<br>60. You can use ICT to build community learning resources and information.<br>61. You can use ICT to present information to others.<br>62. You can use ICT to express your own opinions.<br>63. You understand how to use ICT to produce media that meet your goals.<br>64. You can use ICT to create social networking.<br>65. You can use ICT to present easy-to-understand information.<br>66. You understand the rules and ethics of communication through information technology.<br>67. You are aware of the impact on individuals and society when using information technology to communicate.<br>68. You provide opportunities for others to exchange information on ICT.<br>69. ICT allows you to do multiple activities at the same time, such as a smartphone or a tablet, which can be used to call, take a photo, send an email and record work schedules. |

The measurement method of the three tests comprises the following:

- Determining the date and time to measure information literacy, media literacy, and information and communication technology literacy for higher education learners,
- Preparing the measurement via an online system,
- Learners must study the test guidelines and test method to take the test correct ly,
- Taking an online test, and
- Collecting and interpreting the score.

## 4 Discussion

It can be seen that at present several organizations in many countries have focused on information literacy, media literacy and ICT literacy, and have developed a learning framework to develop these skills [11] [12] [14]. However, there is still a lack of a standardized test, especially for an online assessment system, which is compatible with Moodle LMS and Open edX platform used in MOOCs. Previous studies have designed assessment systems in Moodle platforms [13]. However, the assessment criteria are not compatible for both platforms. This study realized the importance of designing the measurement for current use in various online learning systems. The developed system can be used as an add-on to Open EDX and stand-alone applications.

The results of this research support the idea that an online assessment system is an important component of online teaching and learning. It can evaluate and return immediate results. Thus, it reduces the burden on the instructor. The system can create a variety of question types. It is a great challenge to create an assessment tool other than the traditional multiple-choice questions and one that can score automatically [3] [25] [26]. This is in accordance with [27] who studied online self-assessment system, which helped learners to learn better compared to offline assessment, which requires substantial time to prepare a test and analyze the results. The online test system plays an important role in helping learners get automatic scores and recommendations. In addition, the system supports the different levels of learning among the learners. The development of current technology helps to create a learning system and test that is suitable for each student. The results of the test can be evaluated and results compared immediately [28].

In addition, relevant research developed a test system for online learning that is consistent with this research. For example, the study of the development of an online assessment system by using an interactive test found that the test can evaluate a learner's real ability. The system has a special feature that enables the user to edit the test, test the system, automatically grade the score, share a template and test. This allows instructors to develop and use the test according to their needs and context [29]. One study looked at a web-based adaptive testing system to classify the learning ability of students.

The system consists of:

- An administrator mode for organizing test items, student information and instructor information,
- An instructor mode for student management and analyzing test trends
- A student mode for an online test and reporting the results [30].

As regards the consistency and benefits of the system development and standardized test, research has focused on the measurement of knowledge and skills in digital literacy. Self-assessment enables learners to become aware of their efficacy in a concrete and specific context [31]. The rubric-based model emphasizes the assessment of real conditions. The results show that the rubrics are a useful assessment and can identify potential learners to promote self-efficacy and self-development. This is because the criteria are clearly described and this helps to understand the behavior and ability in each dimension [32].

## 5 Conclusion

This research was developed in accordance with the 21st century educational framework of information literacy (IL), media literacy (ML) and ICT literacy (ICTL) in the online learning context. This is an important foundation for learning management at the present. The results of this research are divided into two main areas:

- The development of a research-based Open Online Assessment Management System (OOAMS). It can provide a test and evaluation for higher education learners. It is compatible with Open edX platform, which is a popular open source MOOC platform for higher education institutions around the world. Since it is an open source system, users can add or modify the source code according to the needs of each organization. It can also be used as a stand-alone system for other forms of online instruction
- The development of a research-based online-standardized test on IL, ML, and ICTL for higher education learners.

This is very useful in learning management in higher education. The suggestion for future research is to study the development of this assessment system by enhancing the effectiveness in processing and displaying learning results in a concrete and dynamic way to create a challenging learning process.

## 6 Acknowledgement

This paper was based on the research study titled "Development of Online Testing and Rubric Scoring System for Information, Media, and ICT Literacies for Higher Education Learners" which was conducted by the authors of this paper during 2016-2017. The research was first published at the 10th International Conference on Education and New Learning Technologies (2018). This research paper has added and fo-

cused on the results of the final stage to provide a more useful and concrete insight for further usage. The authors would like to express our sincere appreciation to the Thailand Cyber University Project, the Office of Higher Education Commission, Ministry of Education in supporting this research study. Our appreciation also extends to Educational Invention and Innovation research unit, the experts and subjects involved in the study for their advice and support. The authors hope that the findings in this research can be expanded to and widely used in ICT utilization in HEIs.

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# Score Equivalence, Gender Difference, and Testing Mode Preference in a Comparative Study between Computer-Based Testing and Paper-Based Testing

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**Abstract—**Score equivalency of two Computer-Based Testing (henceforth CBT) and Paper-and-Pencil-Based Testing (henceforth PBT) versions has turned into a controversial issue during the last decade in Iran. The comparability of mean scores obtained from two CBT and PBT formats of test should be investigated to see if test takers' testing performance is influenced by the effects of testing administration mode. This research was conducted to examine score equivalency across modes as well as the relationship of gender, and testing mode preference with test takers' performance on computerized testing. The information on testing mode preference and attitudes towards CBT and its features was supported by a focus group interview. Findings indicated that the scores of test takers were not different in both modes and there was no statistically significant relationship between moderator above variables and CBT performance.

**Keywords—**Computer-based testing, paper-based testing, score equivalence, testing mode Preference

## 1 Introduction

Sometimes technological developments have such great influences on human life that some scholars and sociologists categorize mankind history based on the produced technological tools. Our lifestyle has been considerably changed by technology; it has exerted a great impact on professions, thinking, communication, and also all aspects of our lives have been influenced by it. [1]. For example, technology is being used to provide students with useful information to create and connect learning groups to create a convenient learning environment [2]. According to the assessment researcher, Stuart Bennett- a quite committed and enthusiastic proponent of technology- who is interested in researching measurement, new technology's transformative impacts on assessment domain makes it possible to impel someone manages something well and satisfactorily by building some tests based on the conceptualization of preconditions and qualifications. He also declared that by enjoying technological assessment tools to

create tests, test takers' performance could be practically assessed through computer-based simulations, item, and item bank creation and also scoring process. Besides, the large-scale delivery test is made possible by enjoying technology and computer in the assessment domain [3]. The first talks about the new technology's transformative influences on assessment domain that were also mentioned by Bennett have been organized much earlier. It is highly likely that teachers utilize computers in administering tests as they are readily available [4].

CBT turned to a controversial research area as how to develop and administer high stakes computerized version of testing program in 70s A.D.; however it must be noted that ASVAB (Armed Services Vocational Aptitude Battery program done by USA Defense Department, the Graduate Record Examination (GRE), Test of English as a Foreign Language (TOEFL) and etc.) the real history of computerized fixed testing goes back to the decade of 30s A.D. dates back to 30s A.D. For the first time, the IBM model 805 machine was used in 1935.

It aimed at scoring objective tests of millions of American test takers each year. Use of computer in language testing has resulted in the birth of independent discipline named CBT (Computer-Based Testing) which has been expedited by CAL (Computer-Assisted Learning). CBT has changed the nature of the language assessment field with its potential benefits and capabilities. CBT may assist language assessment field by helping overcome many common administrative and logistical problems that are widespread in the traditional fixed-length testing environment. By offering new approaches and basic advantages such as easier and more precise test scoring and reporting, item innovation, item generation, greater security, standardization, and test efficiency, test booklets and answer sheet elimination, more flexible scheduling, reduced measurement errors, and etc., CBT opened new windows and laid foundations for future assessment in educational testing. Due to the paradigm differences in test delivery that range from linear or fixed to adaptive test delivery, CBT has been employed to refer to the fixed-length, fixed form computerized kind of a test without any adaptive nature of item selection seen in adaptive testing.

Bit by bit, for any fixed form computerized exam on any content Fixed-length kind of test delivery (i.e., Computer-Based Testing or CBT) has started to be utilized; thus, in the current investigation, CBT initialism was used to refer to test delivery of language content named after Computerized Fixed Language Test and to recognize computerized test of language content from the other kinds of computerized tests of any other contents.

The proposed CBT by this research meets the most advantages of computerized test administration among them presenting items on the screen, faster and easier test scoring and result reporting by a computer, greater security, revising the answers that are not allowed in most adaptive tests, and item innovation such as audio and video prompt can be mentioned. CBT characterized by a direct and uncomplicated scoring algorithm and quickly changing content (e.g., vocabulary to grammar, or grammar to any other content) has been considered an acceptable delivery method and is going to be typically applied to the small-scale educational achievement test delivered in educational contexts in Iran.

The issue that currently needs more attention and prompt investigation of researchers is to study the testing mode effects on comparability and equivalency of the data obtained from two modes of presentation, i.e., traditional paper-and-pencil (PBP) and computerized tests. According to [5], comparability researches and studies in second language tests are in short supply, and he also emphasized over the importance of conducting comparability studies in local settings to detect any potential test-delivery-medium effect especially when a traditional PBT test is converted to a computerized one.

The critical issue of establishing comparability and equivalency of computerized test with its paper-and-pencil counterpart is of prime importance. Some researchers have focused on the equivalency of computer and paper-administered tests in terms of scores [6]. Recently, some studies have been conducted to indicate that to replace the computer-based test with conventional paper-and-pencil one; we need to prove that these two versions of the test are comparable. In other words, the validity and reliability of computerized counterpart are not violated. Actually, there is no agreed-upon theoretical explanation for the test mode effects. The comparability is achieved through equivalent scores of two test versions.

In the past, limited availability and high costs of computer and the related technological tools restricted computer-based tests administration. But nowadays, the condition is reversed. Such developments and widespread access to a computer, especially in educational contexts, have greatly influenced many areas of interests and subjects [7] such as the English testing domain. In addition, this is the reason that some international macro organizations dealing with conducting TOEFL, IELTS, GRE, etc. started to give their offline or online examinations in the computerized version. Implementation of these tests through computers by the testing organizations is in the direction of findings of several studies in which a high level of agreement and acceptance to use computer-based tests is revealed [8].

Since in Iran, however, computerized testing is still at an early experimental stage, the present study would be conducted to provides some helpful and informative findings for those learners, teachers, testing practitioners and researchers who seek to know the possibility of replacing computerized tests with paper-pencil ones. It is done to show the comparability between two test modes of administration. In this study, the testing mode effects on the final performance of test takers will be investigated to show whether there is any significant difference between the two test versions. It means that whether there is any discrepancy that violates the reliability and validity of the computerized counterpart; the computerized version that is supposed to be replaced with the conventional paper-and-pencil version of the test. In the case of [6], significant cross-mode differences in mean of listening, grammar, and vocabulary subtests were observed. In this study, the largest cross mode discrepancy was observed in the reading comprehension subtest. But they explained that the indicators of incomparability seen in the results might be due to the discrepancy in various test layouts across test presentations rather than the content of the tests itself.

The results of these studies have substantially influenced current approaches to investigate comparability between two versions of a test. Though such tests are not prevalent and popular in Iran because of test takers' unfamiliarity with such kind of

exams, it is necessary to make individuals engaged in learning settings familiar with computerized tests. Familiarity with computer and testing settings in which computers are used as a medium to present items is so critical that some test takers asserted that their computerized test results are not representative of their proficiency level due to their lack of familiarity with computerized testing.

Following the researchers who have done studies to investigate the effects of using computers in testing and assessment and examining the administration mode effects of testing, we can observe some advantages of using computers as the most effective technological tool in testing and assessment field. Some prerequisites should be met to enjoy the positive effects of computers in the testing field. In this direction, [9] stated that to establish a valid and reliable computerized test and to replace it with its paper-and-pencil counterpart, equivalent test scores of two versions should be established. It is exactly what the comparability of CBT and PBT means.

To elucidate the concept of comparability, it should be stated that the basis of linear computer-based and paper-based testing is a test theory called classical true-score test theory that supports those set of testing standards that have to be observed within computer-based testing [10]. According to this theory, two sets of almost similar test scores should be received by test takers who are involved in the same test with two different administration modes.

The standards for developing computerized testing to administer and replace with its paper-and-pencil counterpart require that equivalent test scores be established for PBT and CBT modes. Although two testing modes have been nearly identical in some comparability studies, significant discrepancies of test scores can also be observed in some other ones. Therefore, the validity of replacing CBT with its PBT counterpart in educational assessment in academic contexts has often been under question. Then, as the first step to replace a CBT program with its PBT counterpart in Chabahar Maritime University of Iran, a comparability study comparing testing mode effects of two versions of general English Vocabulary Test on test takers' performance will be done to see whether the two sets of scores are comparable and consequently valid or reliable. And it is important to see whether test results received from the CBT version have the same features as the scores derived from the linear PPT version.

Converting the conventional PPBT version of a test into its computerized counterpart might become problematic when considering reliability and validity. Creating reliable and valid tests is the main issues and concerns in utilizing CFLT. Johnson and Green state that just a CFLT that is matched with its counterpart's validity and reliability can assist the test takers in fulfilling their needs [11]. The evaluation of validity and reliability issues is, therefore, the reason for doing many of the comparability studies between CFLT and PPBT [12] [13]. A test is reliable when it regularly measures what it is expected to measure by producing stable and constant scores on two testing occasions. In other words, a test can be considered reliable when constant similar results or scores are repeated under the same conditions [14]. For example, a vocabulary test that gives three various marks on three successive occasions without applying any change to the test would not be a reliable test. According to Bachman and Palmer, the degree to which a test produces reproductive and consistent results is defined as reliability [15]. Therefore, it is important to examine the reliability and validity of a computer-

ized test by conducting a comparability study, particularly, in a local contextto establish any testing mode effects that result from converting a conventional test into its computerized counterpart. The same scores obtained from two versions of the same test demonstrate that the test is reliable. One of the major goals pursued in comparability studies is to examine the interchangeability of test scores across different testing modes of administration. To achieve this goal, test items should be presented uniformly across two modes.

However, we can expect the same or evenly matched scores in both modes of administration when we administer two equivalent tests or two versions of the same test covering similar materials; the more identical and interchangeable the findings of two similar or equivalent tests are, the more reliable the test is [16] [17]. When tasks are moved from pen and paper to the computer, equivalence is often assumed, but this is not necessarily the case. For example, even if the paper version is valid and reliable, the computer version may not exhibit similar characteristics. If equivalence is required, then this needs to be established [18].

Hence, in brief, the main objective of the current investigation is developing a computerized version of English Vocabulary in Use test published by Cambridge University Press and to calculate the comparability and interchangeability of the PBT and CBT versions of the same test and furthermore, in spite of the existence of mode differences between them to check if the two versions of the test are equivalent.

The second and final aim is to study how gender difference and testing mode preference might affect test scores and test takers' performance (to what extent do these moderator factors moderate the effects of administration mode on the scores magnitude from the tests).

## 2 Literature Review

Employing computer-based testing is rapidly growing for several reasons [19]. Two identical paper-based and computer-based tests may not necessarily provide the same results; such empirical findings which help testing practitioners decide whether to replace computer-based testing with paper-based testing are referred to as "Testing Mode Effect." However, the researchers have not yet reached an agreement on a comprehensive theoretical explanation for testing mode effect. In several testing mode effect studies, although the content and the cognitive activity of two paper-based and computerized tests are identical, significant differences are usually observed between two sets of achieved scores. Bunderson and the colleagues reported the superiority of CBT over PBT in three studies [20]; Also, Khoshsima and Hashemi Toroujeni indicated the priority of CBT over PBT [21].

On the other hand, some other studies reported no statistically significant difference between paper-based and computerized tests [22].

Moreover, studying the testing mode effects on the equivalency of data gained from two different presentation modes, namely conventional PBT and CBT calls for more investigation. Even two identical tests or similar versions of the same test would not produce identical results due to some diversities including exact content on two versions of the same test, environmental variables such as fatigue in conventional paper-

based test or light of screen in onscreen tests, as well as students' error in responding. Even the same test that is administered in a day, to the same group of test takers may result in different sets of scores that do not coincide with each other in the other day due to the variables above. However, when two tests or the same test of two versions covering the similar materials are administered, one would prefer that students' scores be similar in both. The more comparable the scores are, the more reliable the test scores will be [23] [24].

Availability of computerized form of standardized tests provides users with the choice of taking the test in whichever mode. Converting paper and pencil assessment tools into computerized versions often requires that the computerized form be comparable to the conventional paper and pencil one and the scores and the results obtained from two identical test forms approximate to each other. Interchangeability is required when students may take the same test in either mode [25].

Converting PBT into CBT should be done through carefully well-organized empirical investigations. The empirical investigations examine the existence of distinctive effects caused by changing administration mode from conventional PBT to modern CBT. Conducting these kinds of comparability investigations help test practitioners to see if the scores obtained from computerized tests remain valid and that students are not disadvantaged by taking CBT.

Testing mode preference of test takers that are typically related to high stakes standardized test administration is being noticed in recent research. Like this study, some others have been done to examine the preference of test takers on testing administration mode [26] [27] [22] [28]. The researcher of the current study investigated the influence of test takers' preference on their test performance on CBT by employing questionnaire and interviews. While in several studies, the effectiveness difference of methods regarding race, age, and gender was examined, and no statistically significant difference in their actual performance was found [29], in some other comparability studies such as [30] [21], statistically significant difference was found. Additionally, [31] investigated the relationship of gender with CBT performance and the trends of female and male test takers towards the features of CBT.

Considering both theoretical and pedagogical perspectives, the following research questions were addressed to achieve the research objectives:

- Is there any statistically significant difference between the performance of computer-based testing and paper-and-pencil-based testing?
- Do participants' gender difference and prior testing mode preferences affect their performance on CBT?
- Do participants perform better on their preferred test mode?

# 3 Methodology

## 3.1 Research design

A mixed-methods approach which combined multiple-choice achievement tests, questionnaires and interviews was the methodological approach that was employed in this study. As the first critical step, this comparability study used a common person design to organize a testing group which is a powerful design in detecting differences especially in a smaller sample of test takers to collect good data for making score comparison. Participants were assigned to one testing group in which the testing mode of administration that was considered the treatment in this study was investigated.

## 3.2 Participants

The 120 intermediate graduate students as test takers of the research whose English proficiency level was intermediate were selected from those 165 homogenous students who took a placement test. The number of female students (n=57%) exceeds the number of male participants (n=43%). The age range of all the 120 students was between 22 to 26 years. Mean age was 23.5 years with a standard deviation of 2.51.

## 3.3 Instruments

Nelson Proficiency Test (test 150 C) which was selected from Nelson English Language Tests by Fowler and Coe [32] was the first research data collection instrument that was distributed to 263 graduate students of CMU to determine their proficiency level. After implementing the placement test to determine the homogeneity of test takers, paper and pencil version of English Vocabulary in Use Pre-intermediate and Intermediate Level Test was administered at the end of the course teaching period. A professional web-based testing service provided by Classmarker.com website was used to administer the CBT version of the test.

Nowadays, teaching and learning processes are becoming updated using the internet, and teacher-centered education is being substituted by learner-centered education [33].

Test takers were required to read a question on the computer screen and choose the most appropriate option under each question by clicking the mouse on the blank space next to the options. Like the PBT version of the test, test takers could review and change their answers by changing the tick from one selected option to another one. They could even go back to the previous page to review and change their answers.

Another instrument to collect the research data concerning to the second research question was a simple question mentioned at the bottom of exam paper and screen, i.e., would you prefer taking a test on paper – no difference – computer to examine the relationship between testing mode preference and performance. The feelings and impressions of test takers about CBT were studied after their exposure to CBT by a researcher-made simple questionnaire. This instrument that is a set of researcher-made questions regarding the testing mode preference assessed the development of positive

or even negative attitudes towards CBT. And the last qualitative instrument was a formal semi-structured interview through which a series of related qualitative data was collected and coded to be analyzed quantitatively. The participants were asked about their attitudes towards the features of two modes of testing administration, testing mode preference, development of positive or even negative attitudes and their reasons for possible changing mode preference.

## 4 Results and Discussion

First of all, the internal consistency for both paper and computer-based tests were calculated, and relatively high-reliability coefficients (for PBT, α=93 & for CBT, α=95) were achieved. Shapiro-Wilks and Kolmogorov-Smirnov statistical tests were used to provide objective judgment of normality rather than skewness and kurtosis. According to the results and given p=.752 for PBT version and p= 819 for the CBT version, it was concluded that each of the levels of the independent variable was normally distributed. Therefore, the assumption of normality was met for this study.

Furthermore, based on the results of Levene's Test, F (1,239) =7.7, p=.0, with an alpha level of .05, p (.697), the assumption of homogeneity of variances is satisfied, p (.697) > α (.05). It means that our data had similar variances and we can use parametric statistical tests.

Of the two formats of the test taken by the testing group, the highest mean score was found in PBT, with a relatively higher mean score by .53 points. Test takers' mean score on PBT (M = 46.66, SD=17.43) was a little bit higher than their mean score on the CBT (M=46.13, SD=13.8). On the other hand, the standard deviation in PBT was higher than in CBT. It meant that the dispersion of scores from the mean score in PBT was higher than in CBT; consequently, it was concluded that Standard Error of Measurement (SEM) in CBT was lower than in PBT.

According to the findings of the One-Way ANOVA test (Table 1), there was not any statistically significant difference in scores between PBT and CBT at a .05 level. Based on the results of the score analysis of two testing sessions, the Sig. value was .896 at P<0.05. This amount of significance value at 119 (N-1) degree of freedom in a .05 level revealed that there was no significant difference between two sets of scores obtained from two formats of the test and the test scores of participants were not different in paper-based and computer-based versions of the test (Sig=.896, P>0.05).

**Table 1.** One-way ANOVA comparing scores of participants in PBT & CBT

| ANOVA | | | | | |
|---|---|---|---|---|---|
| | ***Sum of Squares*** | ***D.F.*** | ***Mean Square*** | ***F*** | ***Sig.*** |
| Between Groups | 4.267 | 1 | 4.267 | .017 | .896 |
| Within Groups | 14338.133 | 238 | 247.209 | | |
| Total | 14342.400 | 239 | | | |

Additionally, based on the results, male participants' mean score on CBT (M=45.66, SD=14.98) was higher than female participants' mean score on CBT (M=44.66, 5.46) (Table 2).

Of the male and female CBT sessions, the highest mean score was found in male CBT, with a relatively higher mean score by 1 point. On the other hand, the standard deviation in male CBT was higher than in female CBT. It means that the dispersion of scores from the mean score in male CBT was higher than in female CBT; consequently, it was concluded that Standard Error of Measurement (SEM) in female CBT was lower than in male CBT. According to the results of the analysis on male participants' scores on CBT and female participants' scores on CBT, the Sig observed value was .875 at P<0.05.

**Table 2.** Distribution of Female Participants' CBT Scores versus Male Participants' CBT Scores

| Descriptive Statistics | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | ***N*** | ***Mean*** | ***Std. Deviation*** | ***Std. Error*** | ***95% Interval for Lower Bound*** | ***Confidence Mean Upper Bound*** | ***Minimum*** | ***Maximum*** |
| Male | 2 | 45.6 | 14.98 | 3.05 | 39.338 | 51.994 | 20.00 | 64.00 |
| CBT | 4 | | | | 6 | 7 | | |
| Female | 6 | 44.66 | 5.46 | 2.23 | 38.931 | 50.401 | 38.00 | 50.00 |
| CBT | | | | | 5 | 9 | | |
| Total | 3 | 45.46 | 13.54 | 2.47 | 40.40 | 50.523 | 20.00 | 64.00 |
| | 0 | | | | 4 | 9 | | |

**Table 3.** One-way ANOVA comparing CBT scores of female participants versus CBT scores of male participants

| ANOVA | | | | | |
|---|---|---|---|---|---|
| | ***Sum of Squares*** | ***D.F.*** | ***Mean Square*** | ***F*** | ***Sig.*** |
| Between Groups | 4.800 | 1 | 4.800 | .025 | .875 |
| Within Groups | 5314.667 | 28 | 189.810 | | |
| Total | 5319.467 | 29 | | | |

Therefore, one way ANOVA analysis showed that the differences between the male participants' scores in CBT version (n=68, M=45.66, SD=14.98) and female participants scores in CBT version of the test (n=52, M=44.66, SD=5.46) were not statistically significant, Sig=.875, p>0.05.

To answer research question two, responses to the simple question appeared at the bottom of PBT version of testing group one were correlated with participants' mean score on the computerized test to see if there was any significant correlation between their prior testing mode preference and testing performance on CBT. The researcher also performed multiple comparisons between different preference groups using descriptive statistics to examine the relationship between the prior testing mode preferences and performance on computerized tests. A Pearson's product-moment correlation was run to assess the relationship between pre and post-CBT mode preference and CBT performance of all the test takers of the testing group. There was a weak negative correlation between both pre and post-CBT mode preference and CBT performance of

the testing group, r (118) =.-.017, p < .918 and r (118) =.-.112, p < .490, respectively (Table 4).

**Table 4.** Pearson correlation of Pre-CBT and Post-CBT mode preference with CBT scores of testing group

| **Pearson Correlations** | | **Pre-CBT Mode Preference** | **Post-CBT Mode Preference** |
|---|---|---|---|
| Testing Group CBT Performance | Pearson Correlation | -.017 | -.112 |
| | Sig. (2-tailed) | .918 | .490 |
| | N | 120 | 120 |

In the next step, descriptive statistics of different testing mode preference groups of the testing group were used to gain a better view of the data. The descriptive statistics output is displayed in Table 5.

**Table 5.** . PPT Performance of different preference groups of testing roup

| **Pre-CBT Mode Preference** | **N** | **PPT Mean Score** | **Std. Deviation** | **Std. Error** | **95% Confidence Interval for Mean** | | **Minimum** | **Maximum** |
|---|---|---|---|---|---|---|---|---|
| | | | | | ***Lower Bound*** | ***Upper Bound*** | | |
| On Paper | 85 | 40.57 | 8.34 | 1.57 | 37.3368 | 43.8061 | 28.00 | 52.00 |
| No Difference | 15 | 47 | 1.06 | .377 | 46.1063 | 47.8937 | 46.00 | 48.00 |
| On Computer | 20 | 64 | .00 | .000 | 64.0000 | 64.0000 | 64.00 | 64.00 |
| Total | 120 | 44.20 | 9.98 | 1.57 | 41.0074 | 47.3926 | 28.00 | 64.00 |

As shown in Table 5, the PBT mean score of On-Computer preference group (PBT/M=64, (SD=.0)) was higher than the other two preference groups. It means that the persons who preferred CBT over PBT did better than those who preferred PBT (PBT/M=40.57, (SD= 8.34)) on the PBT version of the test. On the other hand, the persons who preferred CBT did better than the other preference groups on the PBT version. On the other hand, those who preferred taking the PBT version of the test in the PBT testing session had better performance on the CBT testing session (CBT/M=41.42, (SD=15.95)). But, the test takers who preferred taking the test in the CBT version did not perform better in their preferred testing mode.

To compare the results of different testing mode preference groups of testing group on PBT and CBT sessions, as Table 5 revealed, those participants who preferred taking PBT version of the test (PBT/M=40.57, (SD=8.34)) outperformed in their CBT exam (CBT/M=41.42, (SD=15.95)) (Table 6). Accordingly, those who preferred taking the test on CBT (PBT/M=64, (SD=0)) (Table 5), did the same on their CBT exam (CBT/M=64, (SD=0)). And those who didn't mind taking the test on either mode (PBT/ M = 47, (SD = 1.06)), did better on CBT (CBT/M=56, (SD=4.27)) (Table 6). However, the overall results of prior testing mode preference and testing performance of different preference groups' analysis indicated that there was not necessarily positive interaction between testing mode preference and testing performance. The reason might be either the testing orders, i.e., administration of CBT in the first testing session for testing group two or the novelty of CBT in the target setting [12] [22].

**Table 6.** CBT Performance of different preference groups of testing group

| Pre-CBT Mode Preference | N | CBT Mean Score | Std. Deviation | Std. Error | 95% Confidence Interval for Mean | | Minimum | Maximum |
|---|---|---|---|---|---|---|---|---|
| | | | | | *Lower Bound* | *Upper Bound* | | |
| On Paper | 85 | 41.42 | 15.95 | 3.01 | 35.2429 | 47.6142 | 14.00 | 66.00 |
| No Difference | 15 | 56 | 4.27 | 1.51 | 52.4250 | 59.5750 | 52.00 | 60.00 |
| On Computer | 20 | 64 | .00 | .00 | 64.0000 | 64.0000 | 64.00 | 64.00 |
| Total | 120 | 46.6 | 15.74 | 2.48 | 41.5652 | 51.6348 | 14.00 | 66.00 |

The CBT mean score of On-Computer preference group (CBT/M=64, (SD=.0)) was higher than the other two preference groups, regarding the performance of different preference groups of testing group on CBT version of the test (the second version that they took in their second testing session), and it was shown in Table 6, in the second testing session of testing group, i.e., CBT version.

It means that the persons who preferred CBT over PBT did better than those who preferred PBT (CBT/M=41.42, (SD=15.95)) on the CBT version of the test. On the other hand, those who didn't mind taking the test on either mode (PBT/ M = 47, (SD=1.06)) outperformed on their CBT session (CBT/M=56, (SD=4.27)). However, the persons who preferred CBT did better than the other preference groups on PBT. But, to compare the prior testing mode and testing performance of On-Computer preference group, it was revealed that those test takers who preferred their exam in CBT version did not have a better performance on their CBT version. Also, from Table 6, by examining the relationship between prior testing mode preference and testing performance of On-Paper preference group, it can be seen that those test takers who preferred taking the test on PBT version (PBT/M=40.57, (SD=8.34)) (Table 5), outperformed on their CBT exam (CBT/M=41.42, (SD=15.95) (Table 6). The findings revealed that there was neither significant effect nor interaction between prior testing mode preference and their testing performance on either of the testing modes.

The feelings of test takers towards two versions of the same test and the impressions that they developed towards CBT after being exposed in the study were examined by distributing a researcher-made questionnaire. The analysis of the internal consistency resulted in an accepted reliability coefficient (N=120, Items=10, α=87). The responses of all 120 test takers to the statements of the questionnaire are displayed in Table 7.

As the table indicates, more test takers developed a positive attitude towards features of CBT. For example, it was easier to navigate through the PBT questions for 35% of the test takers while for 45% of the test takers; it did not vary to read the question in PBT or CBT. The greatest percentage for statement three was for the persons whose responses were no different. However, for 67.5% of the participants, it was easier to record their answers in CBT than in PBT while 67.5% found it easier to review their answers in PBT than in CBT.

Furthermore, 42.5% of the test takers found changing their answers easier in CBT than in PBT while 55% and around 33% found the CBT and PBT versions of the test more comfortable to take, respectively. From the table, it was concluded that more than 55% of the test takers guessed they would receive the same score on the CBT

version of the test. Interestingly, 65% of test takers enjoyed taking the test on CBT and more interestingly, 47.5% of the test takers thought that the CBT version of the test was more accurate to measure their vocabulary knowledge while only 10% of them responded that the PBT version could accurately measure their vocabulary ability. It is worth mentioning that these statistical analyses are compatible with the test takers' post-CBT preferences in testing group one and two. While 30% of the test takers preferred to take the PBT version of the test, 60% preferred taking the CBT version in the testing group.

**Table 7.** Attitudes of Participants towards both Testing Modes

| N | questions | On paper in % | | No difference in % | | On computer in % | |
|---|---|---|---|---|---|---|---|
| | | ***F.*** | ***P.*** | ***F.*** | ***P.*** | ***F.*** | ***P.*** |
| 1 | In which test, were questions and items navigated more easily? | 15 | 35 | 51 | 42.5 | 54 | 32.5 |
| 2 | In which test, were questions and items easier to read? | 15 | 12.5 | 54 | 45 | 51 | 42.5 |
| 3 | Which test was less fatiguing? | 12 | 10 | 66 | 55 | 42 | 35 |
| 4 | In which test, was it easier to record answers? | 12 | 10 | 27 | 22.5 | 81 | 67.5 |
| 5 | In which test, was it easier to review given answers? | 39 | 67.5 | ----- | ----- | 81 | 32.5 |
| 6 | In which test, was it easier to change answers? | 39 | 32.5 | 30 | 25 | 51 | 42.5 |
| 7 | Which test was more comfortable to take? | 39 | 32.5 | 15 | 12.5 | 66 | 55 |
| 8 | In which test, would you be more likely to receive the same score if you took it a second time? | 12 | 9 | 42 | 35.5 | 66 | 55.5 |
| 9 | Which test was more enjoyable to take? | 42 | 35 | ----- | ----- | 78 | 65 |
| 10 | Which test more accurately measured your vocabulary knowledge? | 12 | 10 | 51 | 42.5 | 57 | 47.5 |

According to the post-CBT simple questionnaire responses of 60 participants of the testing group who were invited to have interviewed, 82.5% preferred computerized test and 17.5% showed a preference for paper-based test. In the interview, the participants confirmed their answers to the post-CBT and post-PPT testing mode preference questionnaire, i.e., would you prefer taking a test on paper/ no difference/ onscreen and then elaborate on their feelings and impressions of CBT and PBT and attitudes towards computerized counterpart of the conventional test. As the results of the quantitative part, the results of the post-survey analysis showed no correspondence between testing mode preference of test takers and their testing performance on the CBT version. The results of quantitative data revealed that those test takers of the testing group who preferred to take PBT (Table 5) outperformed in CBT (Table 6) and those who preferred CBT performed the same on both versions of the test. Based on the qualitative results, most of the participants showed high CBT preference as well as more advantages for CBT over PBT to rationalize why they prefer this mode of testing. It can be concluded that the participants' answers to the interview questions were in line with their responses to the simple questionnaire on their preferred testing mode and the questionnaire on their attitudes towards the features of PBT and CBT. 100% of the participants who favored CBT mentioned "Easy to read items," "Easy to choose answers," Easy to change answers," and "Immediate scoring reports" as the advantages

to choosing CBT as their preferred testing mode. More than 78%, 60%, and 57% of the CBT advocators had positive attitudes towards the CBT features including "Enhanced security," Faster decision making as the result of immediate scoring and reporting," and "less time and effort" to take this format of the test, respectively.

Despite the high percentage of CBT preference reported by the respondents of the interview questions, some of the participants still preferred the conventional format of the test. Among the advocators of PBT, 100% selected "Easy to navigate", "More familiarity with testing format and conditions", "Being accustomed to circling the questions and answers for later review", and "No need to extra task demand" as the advantages of PBT and their reasons to advocate this format of the test. They also declared that reviewing the answers was time-consuming in CBT (85.71%) because just one question was displayed in the screen and it was time-consuming to go back to question one if they were on question 35, for example.

## 5 Conclusion

The received results and two sets of scores of test takers have been analyzed by the statistical package to find out any statistically significant difference between the two modes. Although several researchers have concluded that CBT version of the test resulted in lower scores than paper-based tests on participants' achievement (e.g. [34]), analysis of participants' testing performance in both PBT and CBT revealed that there was not any significant difference between the two sets of scores obtained from two formats of the test, and the test scores of participants were not different in paper-based and computer-based versions of the test. Test scores of participants did not vary in both PBT and CBT. Then the findings of the present research on score equivalence of two versions of the same test are in line with some studies that declare that two versions of the test are comparable (e.g., [27] [23] [35]). The findings are also in contrast to the findings of some others who claim that they are not comparable [29] [7] [36] [21].

Another main purpose of the study was to investigate the difference between the testing performance of male and female participants who took both PBT and CBT versions of the test. As the findings revealed, no significant difference was found for male and female participant groups' scores across the modes. The results of present research which included both male and female participants were compatible with the results that [37] reached. The findings of the current research on gender difference in testing mode comparability study were compatible with the findings of some research [22].

For analyzing research question two which focused on testing mode preference, Pearson Correlation, as well as descriptive statistics, were used. The results revealed that there was no statistically significant correlation between testing mode preference of test takers before and after CBT version of the test and their testing performance. There was a weak negative correlation between both pre and post-CBT mode preference and CBT performance of the testing group. Moreover, the overall descriptive statistics of prior testing mode preference and testing performance of different preference groups' analysis answered negatively the research question two. These findings

indicated that there was not necessarily positive interaction between testing mode preference and testing performance. The reason might be either the testing orders, i.e., administration of CBT in the first testing session for a testing group or the novelty of CBT in the target setting [12].

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# Semantic Analysis of Conversations and Fuzzy Logic for the Identification of Behavioral Profiles on Facebook Social Network

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**Abstract—**In this article we describe a new multi-agent approach for the accompaniment and follow-up of learners (tutoring) in collaborative social networks via network technologies. To assist learners in their collaborative learning process, the system we propose offers the possibility to identify the sociological behavioral' profile of each learner on the basis of the automatic analysis of the asynchronous textual conversations exchanged between learners.

To achieve our aims, we first describe the sociological profiles that we use in our model. Then, we propose the approach for the semantic analysis of the messages exchanged (full text), as well as the proposed indicators for the determination of these profiles. After, we present the results of the implementation of the system developed as part of an experiment that we conducted with the students of the Master Program "Software Quality" in the Ibn Tofail University of Kenitra, Morocco. We did indeed obtain very good performances during tests on corpora of messages.

**Keywords—**Multi-agent system, Collective Learning, Semantic analysis, social behavior profiles, fuzzy logic, Social Networks.

## 1 Introduction

Our work is in the field of Computer Environments for Human Learning (CEHL). In this article, we are interested in Computer-Assisted Collective Learning, better known by the name: Computer-Supported Collaborative Learning (CSCL) [1].

In the context of collaborative distance learning, textual communication is of paramount importance [2].

Asynchronous text communication tools such as e-mail and the forum avoid face-to-face constraints [3]. These tools remain to this day the best compromise between flexibility and interactivity for the realization of an online collaborative work. Faced with the large number of messages posted in forums, tutors of a practice community often feel incapable to construct synthetic representation of the activity of individuals and groups.

Hence, the tutor may lack objectivity when he uses it to evaluate the involvement and place of learners in exchanges and to identify their social behaviors [4, 5, 6]. As part of the automatic analysis of collaborative activities of learners, we propose a semantic analysis approach of asynchronous textual conversations between learners to determine their social behaviors. In the context of distance learning where there is no interaction between the tutor and the learner, the data collected tend to be more imperfect than those obtained by the face-to-face interaction. The presence of imperfect information is an important factor that leads to errors in the determination of the learner's social behaviors [7]. These imperfections are the consequence of the approximations involved in the data collection due to the nature of human knowledge. It can also be the consequence of loss of information during the previous steps.

The theory of fuzzy logic is presented as a privileged tool for modeling situations with inaccuracies [8]. One of the main motivations for using fuzzy logic is the improved handling of information imperfections. Indeed, the reasoning of a fuzzy logic system is considered "easy", from the point of view of understanding and / or modification by designers and users. One of the factors that enhance this consideration is human similarity. Fuzzy logic can provide descriptions of knowledge as a human and imitate its pattern of reasoning about vague concepts. This is of particular interest in the design of a system modeling the interpretable knowledge of the learner that is based on the reasoning and conceptualization of the teacher-expert.

## 2 Human Behavior Profiles

In his work in ethology Robert Pléty has studied the behavior of students working in groups; in particular, he analyzed interactions between learners working in groups of four to solve algebra problems [3, 9]. Based on this work, we studied social behavior patterns in online collaborative work. Thus from the experiments, we managed to find the same patterns of behavior among students working in groups on social networks.

In order to determine these behavioral profiles, four kinds of observations are made for each student: the volume (number) of interventions, the different types of interventions, the communication gesture types (look and movement) and the reactions of other participants (consequences of behaviors). These behavioral profiles generalize behavior patterns and are called profiles in the rest of the paper. Pléty identified four different profiles: Animator, Checker, Seeker and Independent. The characteristics of these four profiles are summarized in table 1.

**Table 1.** Behavioral profiles of students working in groups [3, 9].

| Name | Volume of Intervention | Type of Interventions | Entrained Reaction |
|---|---|---|---|
| Animator | Important | Question or proposal | Followed by positive reactions |
| Checker | Enough important | Reaction, response and evaluation | No monitoring reactions |
| Seeker | Little important | (Very doubtful (question)) | Questions are well accepted |
| Independent | Low | Little or no proposal or evaluation. | Interventions remain unresolved |

## 3 System Architecture

The proposed approach is to automatically analyze the content of the messages. Following this analysis, a profile for each learner is determined. The challenge lies in identifying behavioral patterns of learners through the automatic analysis of the content of the messages exchanged. Each of these messages undergoes a sequence of treatments. In this article, we present four different profiles that we have identified and characterized through different criteria. In order to determine a profile, four treatments are performed. The first is to simplify messages by removing unnecessary information. The second treatment consists of a semantic message analysis. Using all the calculated indicators as well as a model of fuzzy logic. The fourth treatment makes it possible to determine a behavioral profile for each human actor in the system. We mention that the interactivity between tutor-learners or learner-learners is essentially through textual exchange. Below is the architecture that describes how the system works (Figure 1)

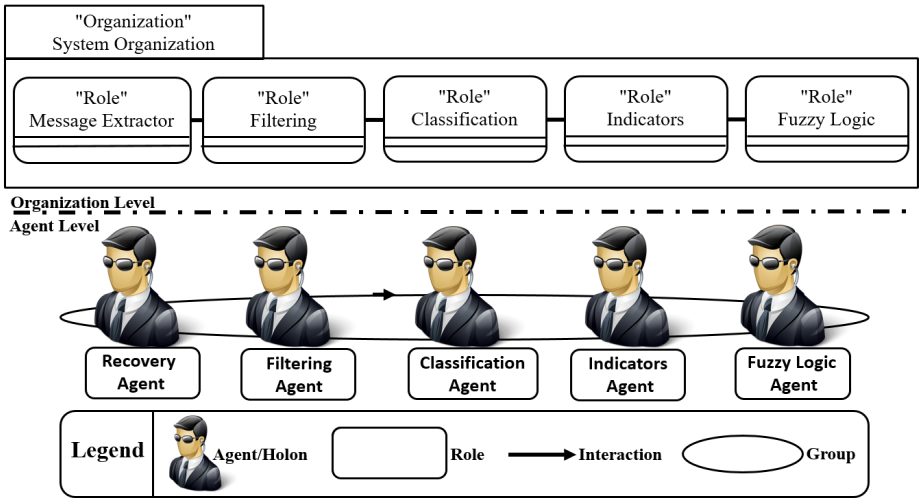


**Fig. 1.** The organization and group of a Behavior Analysis community in Janus

### 3.1 Recovery agent

First, a recovery module allows the extraction of interaction messages on social network using open graph protocol for Facebook, as well as their preparation for different subsequent treatments.

According to our experiment, a first treatment of the corpus resides in the correction of misspelling and grammar. Spelling and grammar errors can occur in text analysis for humans as well as for software. A misspelled word (or phrase) can completely change the analysis.

Spelling and grammar correction is obtained using a dictionary word (corpus) associated with an algorithm that takes into account the variation of the language (verbal conjugation, agreement nouns and adjectives). It consists in comparing the words of the text with the corpus, taking into account the context of the sentences. Nonetheless, the usefulness of the spelling and grammar checker, it cannot replace a careful personal check.

### 3.2 Filtering agent

After message extraction, the pre-filtering treatment automatically deletes the words that do not contain information. Indeed, in text messages, many words provide little information about the message concerned. These words are automatically deleted using "empty words" for each language.

The words that appear most often in a corpus are usually empty grammatical words (empty words): articles, prepositions, linking words, determiners, adverbs, undefined adjectives, conjunctions, pronouns and verbs auxiliaries, etc. These words constitute a large part of the words of a text, but unfortunately are weakly informative on the meaning of a text since they are present on the set of texts. According to Zipf law [10], their removal during message preprocessing allows to save time during the modeling and the analysis of the message.

### 3.3 Classification agent

The classification agent measures the semantic similarity that a new message belongs to one of the four categories (Animator, checker, seeker, and independent) from the proportion of training messages belonging to that category.

To begin, we want to clarify the context of extraction of training messages. We have worked regularly with a number of tutors on exchanges between learners; we have come to address a set of messages specific to each profile category.

Based on tutors' suggestions, the intuitive analysis of messages shows that messages can be classified as follows: messages that aim to initiate an interaction and to initiate a discussion topic proposition, messages asking for information or expecting a response from others, messages in which an answer to the requests of others is provided, finally previous messages that clarify or deepen a current topic of discussion.

**Semantic similarity measurement:** In many areas of research such as psychology, linguistics, cognitive science and artificial intelligence, the calculation of semantic

similarity between words is an important issue [11]. Semantic similarity (or semantic proximity) is a metric defined on a set of messages or terms, where the idea of the distance between them is based on the similarity of their meanings or semantic contents [12]. On the other hand, as opposed to semantic similarity, we find the type of similarity that can be estimated based on syntactic representations of terms. Mathematical tools are used to estimate the strength of the semantic relation between units of language, concepts or instances, through a numerical description. The latter is obtained by comparing information in support of their meaning or description of their nature.

Semantic similarity can be estimated by defining a topological similarity, using ontologies to define the distance between terms/concepts [13]. For example, a naive metric for the comparison of ordered concepts in a partially ordered set and represented as nodes of an acyclic oriented graph (eg, a taxonomy), would be the shortest path connecting the two concept nodes. Semantic proximity between language units (eg words and sentences) can also be estimated using statistical means such as a vector space to correlate words and textual contexts from an appropriate body of text.

**Taxonomy:** The concept of semantic similarity is more specific than kinship or semantic relation, since the latter includes concepts such as antonymy and meronymy, while similarity does not. However, much of the literature uses these terms interchangeably with terms like semantic distance [14, 15]. Essentially, the notions of semantic similarity, semantic distance and semantic proximity, provide an answer to the following question: "What is the degree of resemblance between the term A and term B?". The answer to this question is usually a number between -1 and 1, or between 0 and 1, where 1 means extremely high similarity.

**Topological similarity measurement:** There are essentially two types of approaches that compute the topological similarity between ontological concepts:

- Edge-based approach: uses edges and their types as a data source.
- Content-based approach: the main sources of data are nodes and their properties.

**Semantic similarity:** Or semantic relation is a concept of measuring the proximity of terms or documents in the context of their meaning. We have two different methods for calculating semantic similarity. One is to define a topological similarity, using ontology to define a distance between words. The other is based on the use of statistical means such as the vector space model to correlate words and textual contexts from an appropriate body of text. We choose the first approach using the WordNet ontology for semantic similarity calculation. The similarity calculation in this approach is based on the fact that the similarity depends on the common and distinct characteristics of the objects.

**WordNet:** Is a lexical ontology for the English language [16]. It is a semantic network developed by Princeton University that models lexical knowledge in a taxonomic hierarchy. WordNet contains three databases: one for nouns, one for verbs and one for adverbs and adjectives. Terms and concepts are organized in Synsets (List of terms or synonymous concepts). The basic part of WordNet is the Synset which brings together the synonyms of a concept. Synsets are linked in some models by relations such as: hypernymy (type of), meronymy (part of) and antonymy (opposite word) [17, 18]. The semantic similarity in WordNet can be calculated by two methods: the path length and

the information content. The first method calculates the number of nodes or relationships between nodes in the taxonomy. The advantage of this method is that it is not dependent on either the static distribution of the corpus or the distribution of words. In our context, we considered only two concepts (relationship and name) in the WordNet hierarchy. We use WordNet 2.1, which contains nine distinct name hierarchies where sometimes the path between two concepts may not exist (see Figure 2). Therefore, we create a root node ("Entity" see Figure 2) that includes all the nine hierarchies given in WordNet.

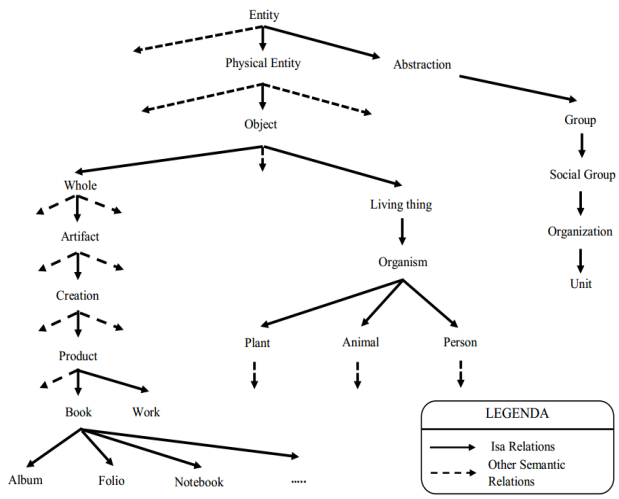


**Fig. 2.** Janus Extract from the nominal WordNet hierarchy

**Semantic similarity measurement process:** The classification agent makes it possible to carry out a complete sequence of treatment. The semantic similarity calculation process is illustrated in Figure 3. This process consists of three phases:

- Phase 1: Term construction module
- Phase 2: Calculate semantic module
- Phase 3: Semantic Similarity Measures

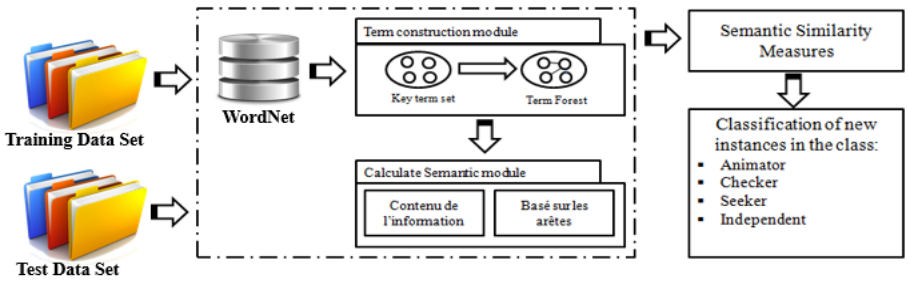


**Fig. 3.** Semantic Similarity Calculation Diagram

**Phase 1: Term construction module:** The objective of the module is to select all the words of the text that exist on WordNet and to obtain the relation between these words. We use WordNet to generate a richer text representation. In this module, we used the hyperlinks provided by WordNet as useful features for text analysis.

**Phase 2: Calculate semantic module:** We use the different algorithms that use the semantic similarity measures to find the appropriate meanings of the words according to the context at the level of the sentence or the text. We quote some algorithms that calculate the semantic similarity:

- Length of the path
- Similarity of Resnik
- Lin's similarity
- Distance from Jiang-Conrath
- Measurement of Wu and Palmer

In what follows, we will explain each of these algorithms.

*The path length algorithm:* When concepts are organized in a hierarchy, it is appropriate to measure similarity based on structural measures that find path lengths between concepts. In fact, there are a variety of such approaches proposed in English. [19] Rada, et al. (1989), developed a measure based on the length of paths between concepts in the WordNet hierarchy. The shortest path measurement emphasizes the proximity of two concepts in the hierarchy. In a thesaurus hierarchy graph, the shorter the path between two words, the more similar these words are:

- The words are quite similar to the parents;
- Words are less similar to words that are far from them in the network
- Pathlen (c1, c2) = number of edges of the shortest path
- Path-based similarity often involves a logarithmic transformation

The similarity based on the length of the path is (1):

$$simpath(c1, c2) = -\log pathlen(c1, c2) \quad (1)$$

*Resnik similarity algorithm:* According to (Philip Resnik) 1995 [20], Sun Microsystems laboratories offer an alternative to finding paths through the notion of informative content. It is a measure of specificity attributed to each concept in a hierarchy based on evidence found in a corpus. A concept with high informational content is very specific, while concepts with low informational content are associated with more general concepts. The information content of a concept is estimated by counting the frequency of occurrence of this concept in a large corpus, as well as the frequency of all concepts subordinate to it in the hierarchy. The probability of a concept is determined by a maximum likelihood estimate, and the information content is the negative log of this probability. Resnik defines a measure of similarity according to which these two concepts are semantically related in proportion to the amount of information they share. The amount of information shared is determined by the information content of the lowest concept in the hierarchy that covers the two given concepts. The similarity of the words based on the informative content:

- Still depends on the structure of the thesaurus
- Improves the path-based approach by using normalizations based on the depth of the hierarchy
- Represents the distance associated with each edge
- Adds probabilistic information derived from a corpus

The probability that the random word is an instance of the concept is (2):

$$p(c) = \frac{\sum w \in w_{(c)} \mathrm{count(w)}}{\mathrm{N}} \tag{2}$$

Where: words (c) is the set of words subsumed by the concept c
N is the number of words in the corpus and the thesaurus
P (root) = 1 since all words are subsumed by the root concept
More the concept is low in the hierarchy, the most probability gets weak
We need two other definitions:
The informative content of a concept (3):

$$IC(c) = -\log P(c) \tag{3}$$

Basic information theory
The lowest common subsume: LCS (c1, c2)
This is the lowest node in the hierarchy that is a hyperonym of c1 & c2
The similarity measure of Resnik is (4):

$$simResnik(c1, c2) = -log\ P(LCS(c1, c2)) \tag{4}$$

It estimates the common amount of information between words using the information content of the lowest common subsumer.

*Lin Similarity:* Lin's similarity is based on that of Resnik. Dekang Lin (University of Manitoba - Canada), 1998 [21] considers the information content of the lowest common subsumer (lcs) and the two concepts compared. For example, Animal and Mammal are subsumes of Cat and Dog, but Mammal is the lowest subsum. Similarity is more than common information. The similarity between A and B decreases if there are several differences between them (5):

Common point: IC (common (A, B))
Difference:

$$IC\left(description(A, B)\right) - IC(commun(A, B)) \tag{5}$$

Where description (A, B) describes A and B.
Theorem of similarity:
The similarity between A and B is measured by the ratio of the amount of information needed to state that there are common points between A and B, on the information necessary to fully describe A and B (6):

$$SimLin(A, B) = \frac{\mathrm{commun(A,B)}}{\mathrm{description(A,B)}} \tag{6}$$

The common information between two concepts is the double of the information in the lowest common subsumer. The final similarity function of Lin for the concepts in the thesaurus is (7):

$$SimLin(c1, c2) = 2 * \frac{\log\ \mathrm{P(LCS(c1,c2))}}{\log P(c1) + \log P(c2)} \tag{7}$$

*Distance from Jiang-Conrath:* This measure is related to SimLin expressed as distance instead of similarity. Jay J. Jiang (University of Waterloo - Canada) (1997) [14] considers the information content of the lowest common subsumer (lcs) and the two concepts compared to calculate the distance between them (8). The distance is then used in the calculation of the similarity measure.

$$DistJC(c1, c2) = 2 * \log P(LCS\ (c1, c2)) - (\log P(c1) + \log P(c2)) \tag{8}$$

This distance is transformed into a measure of similarity by taking the reciprocal (9):

$$DistJC(c1, c2) = 1/2 * \log P(LCS\ (c1, c2)) - (\log P(c1) + \log P(c2)) \tag{9}$$

Resnik's measure may not be able to make fine distinctions, as many concepts may share the same lowest common subsum and thus have identical similarity values.

*Wu and Palmer Measure:* Wu and Palmer (1994) [22] present a similarity measure for general English that is based on the search for the most general concept that subsumes the two measured concepts. The length of the path from this shared concept to the root of the ontology is scaled by the sum of the distances from the concepts to the concept that subsumes them.

The similarity measure of Wu and Palmer calculates the most specific common ancestor of the two concepts, with a minimal number of "is-a-bond" in the common subsumer's path (10).

$$Sim = \frac{2*\mathrm{h}}{\mathrm{h1+h2+h}} \tag{10}$$

h: is the depth of the subsume from the root of the hierarchy.

h1 and h2: the minimum number of "is-a-link" from concept c1 and c2 to the most specific common subsum (11).

$$Depth(x) = shortest\ is - a\ path(root, x) \tag{11}$$

The measure of the shortest way:

The measurement of the shortest path emphasizes the proximity of two concepts in the hierarchy (12).

$$Sim = 2 * MAX - 1 \tag{12}$$

Where MAX is the maximum path length between two concepts in the taxonomy and L is the minimum number of "is-a-link" between the concepts c1 and c2.

**Phase 3: Semantic similarity measures:** The semantic vectors for T1 and T2 can be formed from T and corpus statistics. The process of derivation of semantic vectors for T1 (13):

Word w, define

$$Sim(W_1, W_2) = max_{c1,c2}[smin(c1, c2)]$$

$$Sim(T1, T2) = \sum_{i=1}^{n} \left(\frac{sim(Wi, Wi+1}{n}\right) \quad (13)$$

We obtain semantic similarity measurement values for each of the above five algorithms between message 1 and message 2 (14):

- Sim Path (T1, T2) = value1
- Sim Resnik (T1, T2) = value2
- Sim Lin (T 1, T2) = value3
- Sim JC (T1, T2) = value4
- Sim Wu (T1, T2) = value5

$$sim(T1, T2) = Max(valeur1, valeur2, valeur3, valeur4, valeur5) \quad (14)$$

Messages are composed of words, so it is reasonable to represent a message using the words it contains.

Unlike traditional methods that use a precompiled word list containing hundreds of thousands of words, our method dynamically shapes semantic vectors only on the basis of the compared messages. Recent research in semantic analysis is usually adapted to automatically extract a semantic vector of words for a sentence [23]. With two messages T1 and T2, a set of words is formed with (15):

$$T = T1 \cup T2$$

$$= \{W_1, W_2, \ldots\ldots, W_n\} \quad (15)$$

The set of words T contains all the distinct words of T1 and T2. Inflectional morphology can cause a word to appear in a message with different forms that have a special meaning for a specific context. For this reason, we use the word form as it appears in the message.

### 3.4 Indicators agent

We present the formulas used by indicator agent to analyze the discussions in collaborative works. These heuristics formulas were determined from the work of Pléty and were refined in experiments.

**Volume of interventions:** The following formula calculates the ratio of participation of a learner by dividing nbMsgLearner(p) which is the number of messages sent by learner P, by NbrTotalMessagesGroup(x) that is the number of messages sent by students of the same group.

This ratio refers to the volume of intervention "VI" for a learner (p) belonging to a group x (16):

$$VI = \frac{\text{nbMsgLearner(P)}}{\text{NbrTotalMessagesGroup(x)}} * 100 \quad (16)$$

**Type of interventions:** Four expressions are used to calculate the Type of Interventions for each learner. The ratios of interventions is calculated as follows (17):

$$RatiosAnimator = \frac{\text{AnimatorMessage(P)}}{\text{Message(A,C,S,I)}} * 100 \tag{17}$$

In this formula, Animator Message (p) is the number of messages of category "animator" (for Example propose, encourage etc.) sent by learner (p). Message(A,C,S,I) is the total number of messages (respectively animator, checker, seeker and independent) sent by the learner. The Calculations of other ratios types (checker, seeker and independent) are obtained similarly.

**Entrained reaction:** According to the characteristics of the defined profiles (Table 1), the volume of reactions triggered by a message allows to characterize a behavioral profile. For example, an animator profile requires a very large monitoring of reactions compared to that of a checker. We calculate, for each message, direct reactions (first reaction to a message) and indirect reactions (number of interventions after the creation of the message). According to the tree structure defined for messages, the nodes represent the identifiers of messages sent by the learners and the size of this tree is equivalent to the number of interventions made after the creation of the topic. Two expressions, using the n-ary tree structure of the messages, are used to calculate subsequent reactions of each message:

The direct reaction is the number of direct responses to the messages of the learner divided by the total number of direct answers on posted messages by learners in the group.

$$Reaction_{Direct} = \frac{\sum_{i=1}^{m} ReplyToMessage_i(Learner)}{\text{TotalOfReponse(Group)}} * 100 \tag{18}$$

Indirect reaction is the depth of discussion minus the number of direct reaction divided by the sum of the depths of the subjects send by learners.

$$Reaction_{Indirect} = \frac{Depth - Reponses}{\text{TotalDepth}} * 100 \tag{19}$$

### 3.5 Fuzzy logic agent

Most of the problems encountered can be modeled mathematically. But these models require assumptions that are sometimes too restrictive, making them difficult to apply to the real world. Real world problems must take into account inaccurate and uncertain information. The knowledge that humans have about the world is almost never perfect. They are almost always tainted with a number of uncertainties and inaccuracies. We are not talking here about scientific reasoning, the purpose of which is precisely to get rid of all imperfections, but of all the other reasoning's that we make every day, unceasingly, about things, people and thoughts surrounding us. Fuzzy logic therefore seems to reproduce the flexibility of human reasoning in taking into account the imperfections of accessible data. It would therefore be interesting to use it at the heart of expert systems, systems whose purpose is to reproduce the cognitive mechanisms of an expert in a particular field. Fuzzy logic can also be used for a decision-making system

during the data analysis phase, for example. It can be useful for decision-making, either to discover rules or fuzzy inferences allowing to better understand the data and thus to enlighten the decisions, or to make requests said vague based on the knowledge of the experts.

Indeed, the fuzzy algorithm takes place in 3 steps:

- Transformation of quantitative variables into fuzzy logical variables;
- Use logical rules to evaluate new fuzzy variables at the output;
- Transformation of these fuzzy variables into qualitative variables.

**First step: Fuzzification**, or definition of the membership functions of the input and output variables, consists in determining for each variable the linguistic values as well as the form of the membership functions and the degree of belonging to different states that one must define. A fuzzy set is characterized by a membership function f: E → [0, 1], which positions the members of the speech universe E in the unit interval [0, 1]. The value 0 means that the member is not included in the given set and the value 1 describes a fully included member. Values between 0 and 1 characterize fuzzy members. The discourse universe of a variable will cover all the values taken by this variable. In our case, the universe of the speech E corresponds to the following percentages: percentage of intervention, percentage of type of intervention and percentage of direct and indirect reactions. The universe of speech E is discredited into 11 elements {0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100}. For an element x of E, the value f (x) represents the degree of membership of x in a fuzzy subset.

**Input variables:** The input variables are: (E1) Percentage of intervention, (E2) Percentage of intervention, (E3) Percentage of direct reactions and (E4) Percentage of indirect reactions. Three linguistic variables {Low, Medium, High} qualify our input variables.

**Output variable:** The output variable is the "Behavioral Level" which is a qualitative characterization of the social behavior of the learner "(Animator, Checker, Seeker and Independent)". (S) Behavioral Levels: {Insufficient, Medium, Good, Excellent}. The discourse universe of each input variable is divided into three fuzzy subsets {Low, Medium, High}.

To represent the linguistic variables of the inputs, we defined in collaboration with the expert teacher the membership function of trapezoidal form. The teacher-expert specifies the degrees of belonging of the learner's behavioral levels to each of the fuzzy subsets obtained. The fuzzy subsets associated with the output variable, "Behavioral Levels" are {Low, Medium, Good, Excellent} defined with line-shaped membership functions (Figure 8). The generation of the output variable is done by the system using the center of gravity method [5], in which the system calculates the output variable rounded to the nearest whole number. The ranges of the output variable have been defined from the intuitive analysis statistics made by the tutors. We estimated the ranges of results according to the statistics of the intuitive analysis by the tutors. If the percentage is between:

- 0% and 20%, then the result is Insufficient
- 20% and 50%, then the result is Medium
- 50% and 70%, then the result is Good
- 70% and 100%, then the result Excellent

**Second step: Inference engine** Now that we have linguistic variables, we will be able to use them in the inference engine. Each rule of the inference engine is written by the designer of the fuzzy system based on the knowledge he has. Designing a fuzzy rule base is an iterative process. The bulk of the work is in the collection of expert knowledge. Thus, using data corresponding to the different inputs and outputs, the expert teacher provides a series of combinations based on the conditions (Table 1) that characterize each behavioral profile "animator, checker, seeker and independent". One of the interests of fuzzy logic in formalizing human reasoning is that the rules are stated in natural language. For example, here is a rule for determining a learner's social behavior:

If
(Volume of intervention IS High) AND
(Type of intervention as Animator IS High) AND
(Direct Reaction IS High) AND
(Indirect Reaction IS High)
THEN
(Level Behavior as Animator IS Excellent)
(Facilitator animator level is excellent)

**Third step: Defuzzification:** The last step to having an operational blur is called defuzzification. Once the inference is complete, the fuzzy output set is determined but it is not directly usable to give accurate information. It is necessary to move from the "fuzzy world" to the "real world". To do this, there are several methods and the most used is the calculation of the "center of gravity" of the fuzzy set. Once the value of the "Behavioral Levels" output (animator, checker, seeker and independent) is evaluated using the rule base and then "defuzzified", it gives an estimate of the learner's profile based on indicators.

Finally, our system will have a qualitative assessment of the learner's social behaviors (Figure 4), allowing him to identify his shortcomings and weaknesses and to balance the groups according to their social behaviors.

## 4 General Context of Experimentation

The purpose of this work is to automate some (laborious) tasks usually performed by a human tutor. In this sense, we carried out a comparative study between the human evaluation and the one produced: result of our model. We conducted intuitive analysis experiments on learner conversations. We are interested here in qualitative and quantitative analysis of 4 tutors. A corpus of messages was elaborated from a sample submitted by 9 groups of 4 learners, over a period of 4 months (from March 2nd to June 2nd),

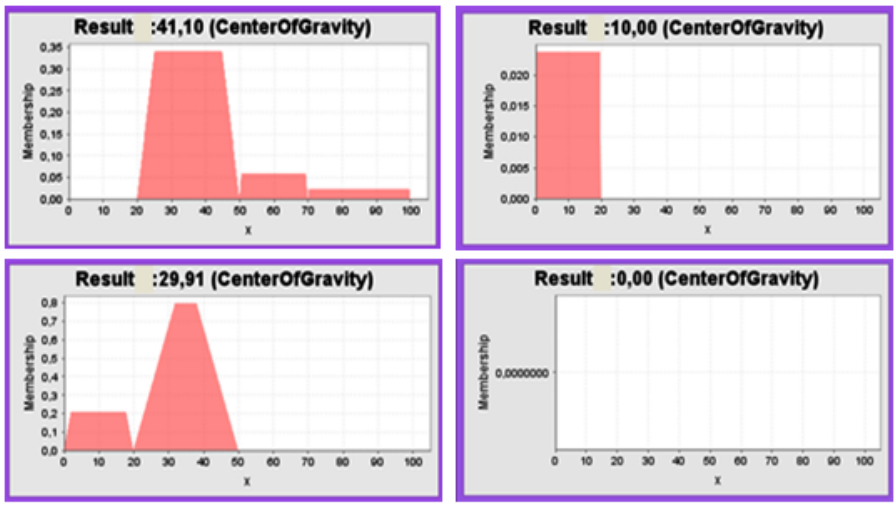


**Fig. 4.** Centers of gravity Profile animator, checker, seeker and independent

organized in 6 phases, corresponding to different tasks. Our corpus consists of 100 to 120 messages exchanged by the students within their same group for each phase of the project. This analysis of textual conversations is based on the characteristics of the behavioral profiles defined above (Table 1). Intuitive message analysis involves:

- Associating a profile with each message
- Identifying the language acts that determine the profile
- Associating a profile with each student

In the context of project-based pedagogy, for example, these observations provide the supervising teacher with indications to understand, react and intervene with the group. In the same way, for the learners, the perception of the behaviors of the individuals of the group makes it possible to better regulate the collective work.

Figures 5 and 6 illustrate the results of the intuitive analysis done by the tutors during the first two phases of the project, whose objective is to associate a behavioral profile to each learner. For greater clarity, in this analysis, each tutor will associate a profile to each learner according to his social behavior. Indeed, after having identified the learning profiles, we asked the tutors to do (by analysis of the contents) a classification of the messages (type: animator, checker, seeker, independent) by identifying the acts of language which characterize them: proposition, message of organization and/or encouragement, intervention to calm a conflict, reaction to a proposal, expression of doubts about an approach or proposal, etc. (see Table 1). From the tutors analysis results for group 1 during periods 1 and 2 (Figure 5 and 6), the profiles of the learners, during each project period, are confirmed by the data collected by the student system through the analysis of message contents (Figure 7 and 8). For example, for group 1 during the requirement period, the learner 1 mainly held animator role that corresponds to the

analysis of the data recorded by the tutor: high intervention volume (44.32%) and high level of intervention.

When we submit the same interaction data between learners to the automatic analysis system that we propose, we obtain the results shown in Figures 7 and 8, for the same group and for the same periods.

| | Intuitive result analysis for Group N°1 Phase Requirement | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Learner profile | Intuitive message classification | | | | Volume Intervention | Entrained Reaction | |
| | | Type Intervention | | | | | | |
| | Profil | Number of Messages category "Animator" | Number of Messages category "Checker" | Number of Messages category "Seeker" | Number of Messages category "Independent" | | Direct reaction | Indirect reaction |
| Learner 1 | Animator | 15 (34,88 %) | 21 (48,83 %) | 07 (16,27 %) | 00 (00 %) | Important (44,33 %) | 36,53 % | 38,70 % |
| Learner 2 | Animator | 11 (47,82 %) | 11 (47,82 %) | 01 (4,34 %) | 00 (00 %) | Important (23,71 %) | 26,92 % | 35,23 % |
| Learner 3 | Independent | 3 (50 %) | 3 (50 %) | 00 (00 %) | 00 (00 %) | Low (06,19 %) | 04,80 % | 09,25 % |
| Learner 4 | Animator | 13 (52 %) | 11 (44 %) | 01 (04 %) | 00 (00 %) | Important (25,77 %) | 28,84 % | 39,50 % |

**Fig. 5.** Results of the intuitive analysis for group 1, phase 1 Requirement

| | Intuitive result analysis for Group N°1 Phase Analysis and Design | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Learner profile | Intuitive message classification | | | | Volume Intervention | Entrained Reaction | |
| | | Type Intervention | | | | | | |
| | Profil | Number of Messages category "Animator" | Number of Messages category "Checker" | Number of Messages category "Seeker" | Number of Messages category "Independent" | | Direct reaction | Indirect reaction |
| Learner 1 | Animator | 22 (53,65 %) | 12 (29,26 %) | 05 (12,19 %) | 02 (4,87 %) | Important (39,05 %) | 42,59 % | 23,11 % |
| Learner 2 | Checker | 03 (15,78 %) | 13 (68,42 %) | 02 (10,52 %) | 01 (5,26 %) | Enough Important (18,10 %) | 20,37 % | 15,16 % |
| Learner 3 | Independent | 1 (16,66 %) | 3 (50 %) | 00 (00 %) | 02 (33,33 %) | Low (05,71 %) | 00,92 % | 02,88 % |
| Learner 4 | Animator | 16 (48,48 %) | 12 (36,36 %) | 03 (09,09 %) | 02 (6,06 %) | Important (31,43 %) | 27,77 % | 20,21 % |

**Fig. 6.** Results of the intuitive analysis for group 1, Phase 2 Analysis and Design

| | Result Analysis System for Group N°1 Phase Requirement | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Volume Intervention | Type intervention | | | | Entrained Reaction | | Profile |
| | | Animator | Checker | Seeker | Independent | Direct | Indirect | |
| Learner 1 | 44,33 % | 33,60 % | 46,54 % | 15,62 % | 00,00 % | 36,53 % | 38,70 % | Animator |
| Learner 2 | 23,71 % | 46,50 % | 46,00 % | 04,00 % | 00,00 % | 26,92 % | 35,23 % | Animator |
| Learner 3 | 06,19 % | 48,80 % | 49,00 % | 00,00 % | 00,00 % | 04,80 % | 09,25 % | Independent |
| Learner 4 | 25,77 % | 51,84 % | 43,69 % | 03,38 % | 00,00 % | 28,84 % | 39,50 % | Animator |

**Fig. 7.** System-Calculated Indicators for Group 1 Phase 1 of the Project

| | Result Analysis System for Group N°1 Phase Analysis and Design | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Volume Intervention | Type intervention | | | | Entrained Reaction | | Profile |
| | | Animator | Checker | Seeker | Independent | Direct | Indirect | |
| Learner 1 | 39,05 % | 52,59 % | 28,50 % | 10,00 % | 03,11 % | 42,59 % | 23,11 % | Animator |
| Learner 2 | 18,10 % | 14,37 % | 66,15 % | 09,20 % | 04,55 % | 20,37 % | 15,16 % | Checker |
| Learner 3 | 05,71 % | 15,92 % | 47,86% | 00,00 % | 31,88 % | 00,92 % | 02,88% | Independent |
| Learner 4 | 31,43 % | 47,77 % | 34,10 % | 08,50 % | 07,50 % | 27,77 % | 20,21 % | Animator |

**Fig. 8.** System-Calculated Indicators for Group 1 Phase 2 of the Project

The analysis of these results in the light of the characteristics of the defined learner profiles (Table 1) allows associating a sociological profile to each learner. Seen the results of the semantic analysis to calculate the type of intervention, two profiles emerge: animator and checker. However, by analyzing the resulting volumes of interventions and associated reactions, we find that they are important and characterize the Animator profile. Thus, for the example considered and for period 1, the learner (1) will be qualified as "Animator". The same approach was used to define the learning profiles in periods 1 and 2 for students in group 1 (Figures 5 and 6).

The idea is to compare the types of intervention which are qualitative. The results are presented in brief in table 2. They illustrate the results of the error margin calculation between the intuitive analysis (by tutor) and the analysis performed by our system.

We have considered the result of intuitive analysis tutors as a reference. All these results are averaged for every learner and profile to produce a single indicator called "Total results". This later allowed us to verify that the system has an error rate of 2.95 % compared with the intuitive analysis.

**Table 2.** Comparison between analysis system and intuitive analysis.

| | **Comparison between analysis system and intuitive analysis.** | | | | **Result** |
|---|---|---|---|---|---|
| | ***Animator*** | ***Checker*** | ***Seeker*** | ***Independent*** | |
| Learner 1 | 96,33 % | 95,31% | 96,00 % | 100 % | 96,91 % |
| Learner 2 | 97,32 % | 96,19 % | 92,37 % | 100 % | 96,47 % |
| Learner 3 | 97,60 % | 98,00 % | 100 % | 100 % | 98,90 % |
| Learner 4 | 99,96 % | 99,29 % | 84,50 % | 100 % | 95,93 % |
| **Total results :** | | | | | **97,05 %** |

Through this study, we have been able to appreciate the usefulness of the notion of semantic analysis of conversations and fuzzy logic in the evaluation of the learner's behavioral levels.

Fuzzy subset theory provides an appropriate method for incorporating the knowledge of an expert teacher by using qualitative terms that are close to human reasoning. It allows to manipulate inaccurate information and to model subjective knowledge. In addition, the use of fuzzy rules in the system inference algorithm provides the user with greater flexibility and ease of judgment. In addition, we have shown the evolution over time of the profiles (Animator, checker, seeker and independent) of a learner (1) present on the social media discussion groups (Figure 9).

For example, the graph indicates that the learner (1) played a leading role during the first phase of the project. On the other hand, we can notice that this learner became checker at the second phase.

This view makes it possible to identify the role played by the learners in their group through the different phases of the project. This variation is the result of the learners' preference for tasks related to each phase of the project.

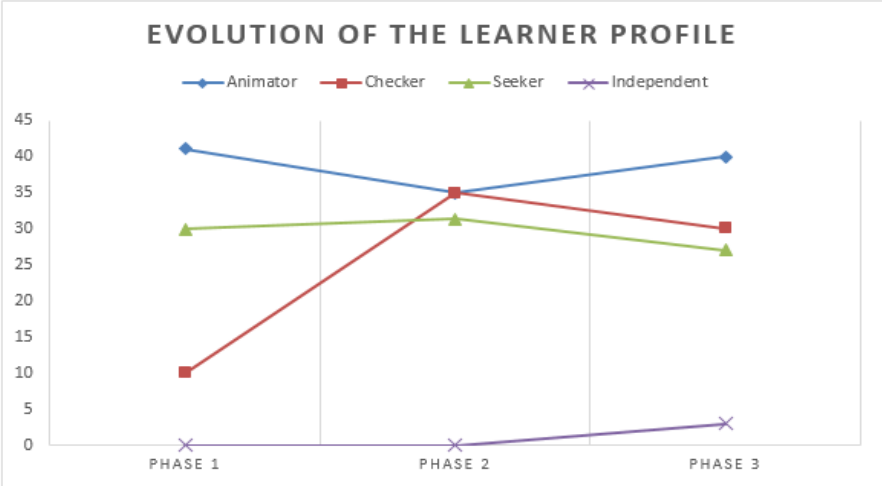


**Fig. 9.** Evolution of the learner profile (1) over the entire duration of the project

In view of these results, we find that the observations made by the tutors are confirmed by the automatic analysis made by our system, which leads us to affirm that our approach makes it possible to find the behavioral profiles in the groups of learners working remote.

## 5 Conclusion

The present work is part of the development of automatic interaction analysis systems, widely used to meet the constraints faced by remote tutoring via network technologies.

We propose a complete procedure of "full text" analysis of textual exchanges for the determination of sociological profiles of learners within the framework of collaborative distance learning processes. This analysis consists of 2 steps (Recovery and Filtering) at the end of which, we perform a semantic analysis of conversations that will subsequently contribute to the classification of messages (type animator, checker, seeker and independent). Based on the profiles defined and adapted from the work of Pléty [2], we compute indicators, which, coupled with the message classifications described above, make it possible to assign a sociological profile to each learner on the basis of fuzzy logic. The approach was tested on a real situation, which showed a great concordance between the results observed by human tutors and those automatically determined by our system.

As a development perspective for this project, we plan to integrate a recommendation system. System that generates automatically some recommendations that are suitable for every learner.

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# Digital Backchannel: Promoting Students' Engagement in EFL Large Class

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**Abstract—**Students' engagement is generally believed to be the independent predictor signifying the continuous existence of learning process. It is generally reflected in active participation such as listening to presentation, expressing opinions, asking questions, and working on assignment. However, the idea of being embarrassed in front of peers and the feeling of being reluctant to disturb others can often be intimidating for many students and might prevent them to ask questions during class discussion. As a result, meaningful discussion that is expected to happen during the lesson oftentimes takes another form of side conversation such as whispering, note passing, and text messaging, the so-called backchanneling. In addition to this, the class size has also been generating another issue. The larger the class is, the greater challenges the teachers face to engage students in their learning. To address this issue, this research investigates how a digital backchannel chat platform promotes students' engagement in an Indonesian EFL large class and transfers the side conversation to the forefront. A number of 41 college students took part in this single-case study approach. The research data were taken from interviews, classroom observations, and students' task submission. The degree of students' engagement was measured in 3 types of engagement, i.e. emotional, behavioral and cognitive engagement. Research findings suggested that the digital backchannel promoted students engagement with the learning activity, and enabled lecturers to provide immediate feedback on the students understanding over the lesson material in a large class.

**Keywords—**Students'engagement, digital backchannel, large class

## 1. Introduction

Students' engagement is widely recognized as important in the learning process. It is reflected mainly in active participation such as listening to presentation, expressing opinions, asking questions, and working on assignment. However, the idea of being embarrassed in front of peers and the feeling of being reluctant to annoy their peers can often be intimidating for many students, and might even prevent them to ask questions during class discussion. As a result, meaningful discussion that is expected to happen during the lesson oftentimes takes another form of side conversation such as whispering, note passing and text messaging, the so-called backchanneling. It has

become actual challenges for most lecturers, especially in large classes, to motivate and engage students in their learning. In fact, the larger the class is, the greater challenges the teachers are going to face. The first challenge is that it is common in large classes that only a small percentage of students are identified as being active in classroom discussions. There are few students participating in the discussion, other students hesitantly decide to take the opportunities because of their slower pace to develop ideas, and the rest remain passive. The second challenge is to promote students' engagement in which teacher needs to know "where their students are in their understanding" and "what questions to ask to make the learning process occur", and this is certainly no less important. The last but not least is lecturers need not only to select meaningful learning activities but also useful tools and valuable resources to motivate and engage their students in the learning process.

Information and Communication Technology (ICT)-Pedagogies integration is potential not only to promote but also to transfer learning [1]. This claim supports findings that increasing students' motivation and engagement was one of the three major contributions brought by the (ICT)-Pedagogies integration to learning, and the integration has a direct positive relationship with students' engagement and self-directed learning [2-6]. Llorens et al. (2007) as stated in [7] also found evidence that learners' belief in their sufficient resources leads to the increase of self-efficacy, which leads to learners engagement's increase, which then spirals up to gain greater self-beliefs.

Moreover, of the 26 relevant research found in the Web, recent research on ICT in education emphasized the needs of teaching and learning using technology for teacher educators [8] and can be considered as a positive reinforcement to a research finding within Indonesia context. It was found in the research that the majority of teachers feel comfortable using ICT as a tool for teaching and learning, and they agree that using ICT is fascinating and interesting [9]. This is also in agreement with the claim that students felt positive about technology in the classroom and its use has a direct positive relationship with students' engagement [5] [10]. In teaching English as Foreign Language (EFL) context, a recent evidence also suggests that by embedding ICT into classes, students with lower interest and less intrinsic motivation will get a greater level of comfort and a higher degree of engagement during their task performances [11-13]. However, the two studies were conducted in considerably small classes. A question then was raised. i.e., when the ICT has been integrated, how to promote students' engagement in a large class considering that in large classes the communication between students and lecturers could be complicated? [10]

Large classes, in many situations, seemed to bring problems instead of challenges in the process of teaching and learning. Such problems as the quality of teacher-student interactions, the effectiveness of teaching, teacher's effort in fostering students' attentiveness are questionable. In addition to this, in a large class, even the classroom seating arrangement should be a problem as well. Wannarka and Ruhl (2008) stated in [14] believed that teachers' decision in seating arrangements could result in the improvement of students' engagement and development. In short, Xu (2001) concluded that most English teachers tend to have a negative view on teaching English in large classes. He puts forward that when teaching in large classes, the

teacher has to deal with not only physical problem but also psychological and technical problem [15].

How large is a "large class"? Then might be the next question to ask. To answer the question, there are certain characteristics to define a large class that need to be attended. Hess and Ur in [16] claimed that the number of students in a large class would be around 30, but does not exceed 50 students. However, Ur (1996) as stated in [17] also suggested that "the exact number does not really matter: what matters is how you, the teacher see the class size in your own specific situation". A different thought was put forward on the size of a large when they say: "A large class can be any number of students if the teacher feels there are too many students for them all to make progress" [18]. Therefore, what labeled a 'large class' is context-dependent. Taken together, from what have been discussed, there is no exact number can be used to define the "large" as there are no certain characteristics that can be taken into account to consider whether or not a class is large. However, whatever it is, either the size of the class or the number of students accommodated in affects the way teachers cope with it. For this reason, lecturers need to be aware in adopting resources and techniques to the needs of their class.

### 1.1 Students' engagement

Students' engagement is a "psychological investment" in learning and the efforts put into the enhanced engagement takes form of active involvement, commitment, and concentrated attention [19]. It implies that an engaged student feels as if she or he is part of the learning process. Engagement could take form in various kinds such as paying attention to lecturer's or peer's presentation, expressing opinions, asking questions, and working on assignment. Due to its importance, Tinto and Kuh (2003) in [20] [21] claimed engagement as the single most significant predictor of persistence and lead to students success and development. Researches have also shown that there were significant relationships between the students' academic achievement and students' engagement, and that engagement leads to better grade [20] [22].

In a broader context, student engagement is articulated as the active involvement of listening to individual and collective perspectives of students, about matters, which relate to the students' experiences of higher education, which aimed to promote the students learning and experience in higher education institutions [23]. However, these forms of active involvement can often be intimidating for many students. The idea of being embarrassed in front of peers and the feeling of being reluctant to annoy their peers might prevent them to ask questions during class discussion. It is claimed that such problems are very typical in many universities these days [11]. This, of course, has also been a challenge to the lecturers of STKIP Kusuma Negara, a private school of education for pre-service teachers located in Jakarta, Indonesia, which is the research context for the present study.

Previous researches on EFL have reported that studies on lectures, with their roles as events, were conducted not only to determine what has been considered the facilitators in student comprehension but also to examine how to give the most benefits of these events to the linguistic and communicative competence of second and foreign

language students [24]. Wesch and Ready (1985) as stated in [25] found that gains in second language proficiency are best achieved in situations where the second language is used as a vehicle for communication about other subjects rather than itself. It was also implied from other studies of lectures in non-English speaking countries that most interactive lectures will be beneficial not only for the sake of students' comprehension but also for the improvement of students' linguistic and communicative competence [12] [24] [26]. It means lecturers must look for ways in involving their students to actively take parts in the lectures. On the other hand, to address this challenge, Social Constructivism offers a foundation to learners to actively create meaning when interacting with another, and impact greatly on online educational practice especially where the aims of instruction are broader than can be easily accounted within traditional approaches [27]. For this reason, backchanneling is worthy of being considered a medium through which certain types of learning activity can take place to promote students' engagement.

Measuring students' engagement could be done in three psychological levels. "First, students' engagement with material which is primarily cognitive in nature, or with learning, The next level is students' engagement with groups or community which is social in nature; and the last is students' engagement with schooling which might be considered sociological or anthropological in nature, that all should be well thought-out to promote learning" [28] [29]. The first level was the focus of the study. In line with the aforementioned, Fredricks, Blumenfeld, & Paris (2004) in [30] described and assessed students' engagement in three distinct types of engagement: behavioral, cognitive and emotional. These were explained as follows. [30] "*Behavioral engagement* involves: positive conduct, e.g., adhering to classroom norms, the absence of non-disruptive behaviors; involvement in learning tasks, e.g., effort, persistence; and participation in school-related activities, e.g., athletics, governance. These behaviors which may be academic or nonacademic assess the extent to which students are actively participating in relevant learning tasks presented. *Emotional engagement* involves affective reactions in the classroom, e.g., interest, happiness; affective reactions to the teacher, e.g., liking, respecting; and identification with school, e.g., belonging and valuing which sometimes intersects with constructs used in motivational research. These criteria assess the level of students' investment in, and emotional reactions to the learning tasks. *Cognitive engagement* comprises psychological investment in learning, e.g., desire to go further than the requirements, preference for a challenge; inner psychological investment, e.g., desire to learn, desire to master skills; and self-regulation, e.g., use of metacognitive strategies, evaluating cognition when completing tasks." Cognitive criteria determine the extent to which students are expending mental effort in the learning tasks [31].

There are also several considerations to be taken in measuring student engagement. Firstly, teachers should view engagement as a multidimensional construct uniting the three components. It is also vital that the teacher plan should include at least one indicator from each of the three engagement components behavioral, emotional and cognitive [29] [30]. Secondly, teachers should choose relevant indicators aligned with the learning outcomes. The number of indicators should reflect the purpose and the extent of the learning activity at which the students' engagement is being measured. Thirdly,

the method of measurement should be reliable for each indicator. More than one form of self-reporting, teacher-reporting and observational methods of measurement should be used. Lastly, teachers should remember that the level of engagement of a student may vary during the learning activity and so measurement of indicators should not be timing-dependent.

To help teachers develop their plan to measure student engagement, it was proposed in [29] an example of Engagement Measurement Plan which was used when students were involved in a learning task integrating the use of Multimedia. The plan comprises of types of engagement, the indicators of each component, and the measurement methods. In line with the purpose of the present study and the example of the plan, two indicators were developed to measure behavioral and cognitive engagement, and one indicator was developed for emotional engagement so that it can be observed via digital backchannel and a Learning Management System, which were employed to support students' learning.

### 1.2 Digital backchannel

Preceding the internet chat room context, Yngve (1970) in [3] defined backchannel as conversational devices used by listeners to signal engagement. At present, the advance of technology has empowered teachers to make use digital backchannels, defined as "online interaction spaces that run parallel to spoken remarks" in [32], to engage their students with their learning. Several studies, interestingly, have revealed that digital backchannels offered students a sense of engagement and make them feel more sociable. It also offered students opportunities to participate more in class discussion. It was found that the low-performing students could be excelled to be active participants in the backchannel discussion. Through digital backchannel, all students would make positive experiences toward the learning process, especially in crafting their thoughts deliberately. As stated in [32] the backchannel tools made these possible because of the "public anonymity/private accountability options". It appeared that students who felt less competent than others were encouraged to take the challenge of expressing their opinions aloud in the backchannel discussion because of the supporting features. It was remarkable that the feature would allow a particular student to express their opinion, to share ideas, to ask questions, etc., unidentified by his/ her peers during the discussion, yet the lecturer could still have his/ her name on the screen.

Not only facilitating students' voice, backchannel tools also benefited students from questions posed by others [36]. It also assists teachers in formative assessment of students' understanding as well help teachers to timely response to students' questions. Furthermore, it offers opportunity for teachers to monitor the dynamics of the group to be studied and improved for future classes [6] [34] [36]. Backchannels can be introduced using a variety of Web-based or social media and microblogging platforms, including Facebook, Twitter, and Edmodo, which require user accounts. However, other services, such as TodaysMeet do not require account-creation and can be utilized by instructors with ease [3] [36]. Students can easily join and start rooms with no registration, and immediately start conversations that augment the traditional class-

room. It is specially designed for teachers and takes great care to respect the needs and privacy of students while giving educators the tools to support learning. For example, to join a TodaysMeet chat room is as simple as visiting a web page. Students can enter the chat room by typing the room's address into their browsers, copying the URL shared by teacher, or just scanning the QR codes to help students with phones or tablets join without typing the URL. These ways are mostly applicable to similar services offering the backchannel. This research used TodaysMeet as its backchannel for its free service and user-friendly. It is also so unfortunate that TodaysMeet has been shut down by his own creator in June 2018, a year upon the completion of this study. However, there are several replacements offering the same features to such as Backchannel Chat, GoSoapBox, Mentimeter, Pear Deck, etc.

### 1.3 Research questions (RQs)

To address the challenge on how to promote students' engagement, two research questions were raised.

- **RQ1** : Can digital backchannel promote students' engagement in the learning process in a large class?
- **RQ2** : If so, can digital backchannel help lecturer to know students' understanding over the lesson material?

## 2 Methods

### 2.1 Study participants and settings

This single-case study took place in a natural setting and involved 41 college students. They were 5 male students and 36 female students attending "*ICT in English Language Teaching*", a subject course for the semester 6-students with its main aim to introduce students to the key concepts of English language teaching methodologies and the use of new technologies. The principal working language of the course is English.

In order to determine how backchannel influenced students' engagement in the learning session which consisted of 14 meetings were divided into two parts. The first half was dedicated to lecture-mode sessions, while the other half, 7 meetings in total, were sessions in which TodaysMeet was used as a backchannel chat platform to support the lectures. Every session began with a lecture to introduce the basic concepts and was followed by group presentation and class discussion on the assigned readings. The TodaysMeet was introduced in the 7$^{th}$ meeting at which the topic was "*Using chat in teaching English*". As a matter of fact, this was also the 7$^{th}$ topic to be covered in the course.

## 2.2 Procedures in collecting data

This study used a mixed-method approach. To give a more valid and reliable view of engagement, the measurement should include more than one perspective on the engagement. To this end, the Engagement Measurement Plan proposed by Chris Reading in [29] was adapted to collect data in this study:

- Classroom observations,
- Students' task submission in Edmodo LMS at https://www.edmodo.com/home#/group?id=21237523
- A semi-structured online interview to students. To support the observations and interview, any data considered useful for the research was recorded as field notes.

The behavioral engagement component was measured using observation techniques, i.e. classroom observation and students task submission recorded within Edmodo Learning Management System.

The emotional engagement was visualized through a semi-structured online interview where the students' perspectives were gathered through open questions. Through this, students were allowed to reflect on their own experience and to report on what they believed or what they remembered had promoted engagement in their classroom.

The cognitive engagement was measured through students' responses in the backchannel using observation technique.

To sum, the types of engagement along with indicators which were measured, the methods of measurement, and the sources of data are presented at the following table (see Table 1).

**Table 1.** Summary of students engagement measurement method and data source(s)

| Type | Indicators | Measurement Method | Data Source(s) |
|---|---|---|---|
| **Behavioral** | | | |
| • Conduct | Numbers of the question asked through the backchannel. | Observation | Digital Backchannel |
| • Work involvement | On-time task submission | Observation | LMS (Edmodo) |
| **Emotional** | | | |
| • Affective Reactions | Enthusiasm for using digital backchannel | Semi-structured online interview | Digital Backchannel/ ? |
| **Cognitive** | | | |
| • Instructional discourse | • Posing questions | Observation | Digital Backchannel |
| | • Response to lecturer's question. | Observation | Digital Backchannel |

### 2.3 Data analysis

A combination of quantitative and qualitative approaches was used in the data analysis. The quantitative data comprised of numbers were analyzed based on descriptive statistics and frequency distributions, while the qualitative data comprised of students responses were analyzed through data description, data display and verification.

## 3 Findings

### 3.1 Digital backchannel promoted students engagement

**Behavioral Engagement:** Based on the classroom observation, the frequencies of questions posed in the backchannel sessions was five times greater than the lecture mode sessions. The average frequencies of the students asking questions during the backchannel discussion was 32.95%, comparing to only 5.97% of the students during the lecture session. It means that during the whole sessions in the research, there were at least 14 students who were fully engaged with the materials discussed in each backchannel session. This evidence was over researchers' expectation (see Table 2 for details). It is also a supporting evidence that digital backchannel can increase students' engagement. On the contrary, there were still 27 students who did not ask questions. However, they might not be considered passive, because they might be in their efforts to get used to the online interaction during class.

**Table 2.** Frequencies of students' questions

| | Lecture Mode | | | | | | | Digital Backchannel-Supported Mode | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sessions** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| **n** | 41 | 41 | 40 | 37 | 41 | 40 | 39 | 39 | 41 | 41 | 40 | 36 | 41 | 41 |
| **Frequencies** | 3 | 2 | 2 | 4 | 3 | 1 | 2 | 7 | 14 | 13 | 21 | 13 | 9 | 15 |
| **Percentage** | 7.3% | 4.8% | 4.8% | 10% | 7.3% | 2.5% | 5.1% | 17.9% | 34.1% | 31.7% | 52.5% | 36.1% | 21.9% | 36.5% |
| **Average** | 5.97% | | | | | | | 32.95% | | | | | | |

Another behavior indicating students' engagement is submitting the task on time. It was found that the frequencies of students' task-submission in lecture session and backchannel session was slightly different. This was unexpected as the previous behaviour (students' frequencies of asking questions) was greatly increased. Edmodo Learning Management System recorded that 90.4% students (in average) submitted their task on time in each session. While in the lecture session, there were 89% of

students (in average) submitted on-time. The comparisons of the two different mode sessions can be seen in the following table (see Table 3).

**Table 3.** Frequencies of students' task submission

| | Lecture Mode | | | | | Digital Backchannel-Supported Mode | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Assignment** | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| **Frequencies** | 40 | 36 | 34 | 36 | 36 | 36 | 36 | 41 | 36 | 36 |
| **Percentage** | 98% | 88% | 83% | 88% | 88% | 88% | 88% | 100% | 88% | 88% |
| **Average** | 89% | | | | | 90.4% | | | | |

The visualization of students' frequencies in task submission for the two different sessions is illustrated in Figure 1.

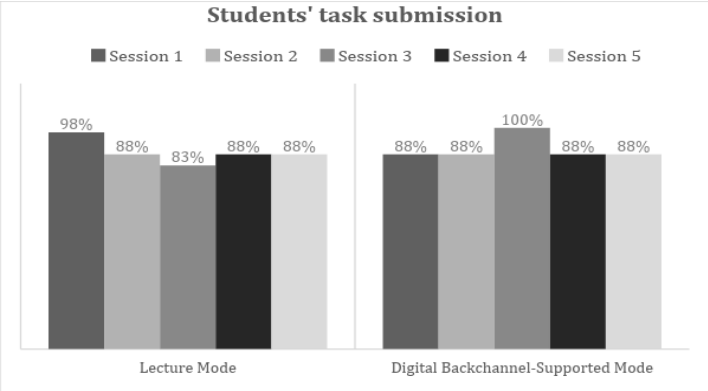


**Fig. 1.** Visualization of students' frequencies in task submission

Although the average frequencies were slightly different, students' engagement with the material was quite enhanced in the digital backchannel. It was based on the visualization, the bars' height happened to be more stable in the digital-backchannel session. The highest bar had even reached 100%, meaning all the students were actively engaged with materials by submitting the task on-time. On the other hand, the lecture session was satisfactory as well. But, once the bar's height was only 83%. This should be an input to improve students' engagement in the frontchannel.

During the submission time, it is important also to consider the external factor that might have a direct impact on students' failure in submitting task on-time. At the end of the digital backchannel session, the researcher found that a few students experi-

enced the poorly performing internet connection so that they failed to submit the task on-time. This could be the major factor for the slight increase in students' engagement through digital backchannel.

**Emotional Engagement:** Students' emotional engagement was reflected in their response which was recorded in the digital backchannel.

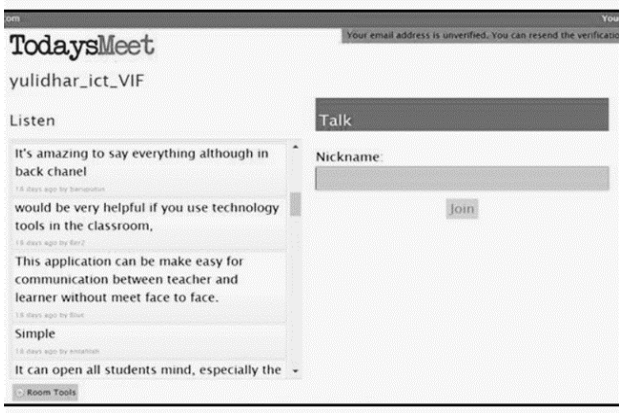


**Fig. 2.** Students' responses within Backchannel

The students' responses were coded as either:

- Positive response
- Neutral responses
- Negative responses

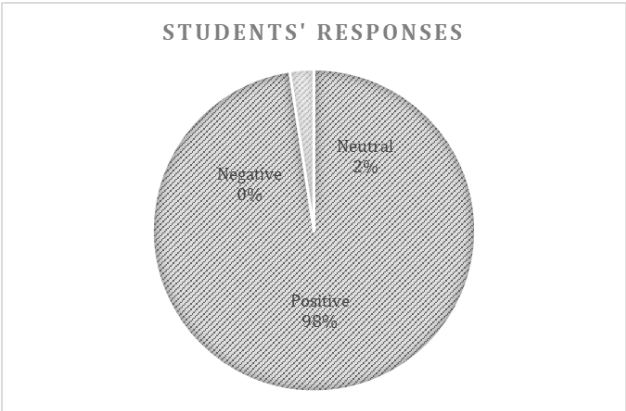


**Fig. 3.** Visualization of students' responses to Backchannel

Overall, students' responses were positive affective reactions to the learning experiences during the backchannel session. It was indicated that 97.6% of students (equals to 40 students) supported the use of digital backchannel in the learning pro-

cess. Only one student, out of 41 respondents in the backchannel session, responded neutrally by typing "*simple*". See Figure 3 for details.

**Cognitive Engagement:** Students' posing topic-relevant questions was considered as one indicator of cognitive engagement.

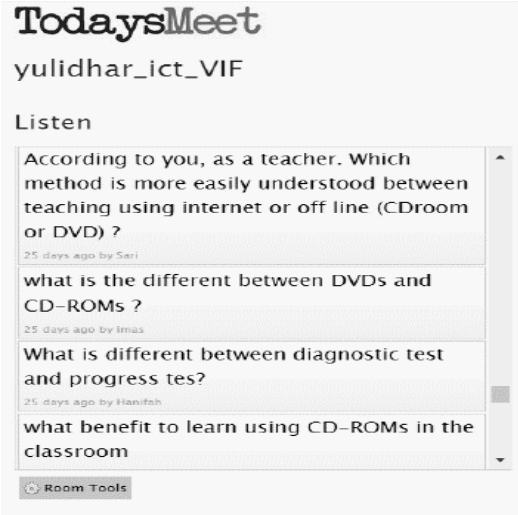


**Fig. 4.** Screen-shot of students' topic-relevant questions recorded in Backchannel

For the frequencies of the relevant questions posed by students can be seen in Table 4.

**Table 4.** Frequencies of Topic-Relevant Questions Students Posed

| Meeting | Number of Questions | Number of Relevant Questions | Percentage |
|---|---|---|---|
| 8th | 7 | 7 | 100% |
| 9th | 14 | 13 | 92% |
| 10th | 13 | 13 | 100% |
| 11th | 21 | 17 | 80% |
| 12th | 13 | 13 | 100% |
| 13th | 9 | 9 | 100% |
| 14th | 15 | 15 | 100% |
| Average | | | 96% |

Disregarding the relevance of questions posed, it was obvious that there were always questions asked during the digital backchannel session. Whereas when topic relevance was considered, 96% of students in average asked relevant questions to the topic being discussed during the digital backchannel-supported mode. This means students had invested their desire to learn through backhannel discussion.

**Students' Response Showed Better Understanding of the Material:** In the 13th meeting, a quiz on e-learning was prepared for the students using digital backchannel. Figure 5 provides a screen-capture of students' responses to the quiz.

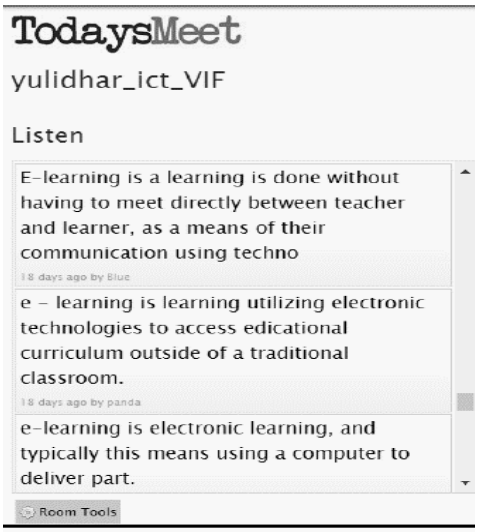


**Fig. 5.** Screenshot of students' responses on a quiz

Of 37 students responded to question, "What is e-learning?" 34 students showed a good understanding of the material. While 3 of them only gave very short responses such as *"technology", "electronic learning"* and *"everything related to the internet."*

## 3 Discussion

Based on the findings, it was obvious that a large class was neither a problem nor a challenge for a lecturer when the digital backchannel was utilized. Moreover, during the backchannel session, it was found that students' engagement was mostly promoted in the basis of the indicators assessed. Of the three engagement types measured, behavioral engagement was promoted extendedly. This was shown in students' effort to actively participate in class discussions and to submit the task on-time. "It is students' nature to primarily engage with the learning material" [28} which was enhanced. Their efforts were the reflection of Alderman's statement in [28] that students' engagement promoted in line with the increase of students' confidence to self-control their own learning. Students' failure in submitting task on-time should be considered

input for subsequent comprehensible research. Carpenter [32] took this as one of the challenges foreseen in the utilization of digital backchannel, other than distraction and quality.

From the emotional engagement's indicator, it was found that students' enthusiasm to use the digital backchannel was relatively stable. Students' engagement was promoted indicated by the increase in students' sense of belonging and valuing the learning process shown, i.e., their positive responses in the online interview. These were also the resemblance of students' positive affective reaction toward the utilization of digital backchannel in class. As a consequence, it is much easier for lecturers to improve students' proficiency in a language, and it is much easier for students to achieve their proficiency through a vehicle, the digital backchannel [3].

Students' frequencies of asking questions and students' asking relevant questions were promoted during digital backchannel session. Disregarding the relevance of the questions posed, it was obvious that there were always questions asked during the digital backchannel session. The desire to ask questions during the session should be considered as students' strategy to expand their knowledge by mastering the materials discussed. Whereas when topic relevance was considered, almost all students asked relevant questions to the topic being discussed during the digital backchannel-supported mode. This means students had invested their desire to learn through backhannel discussion. Based on these facts, students' cognitive engagement was greatly promoted by utilizing the digital backchannel.

## 4 Conclusion

The intended aim of this study was to reveal digital backchannel can promote students engagement in EFL large classes. The combination of quantitative and qualitative data analysis had confirmed that digital backchannel had made students engage during lectures and class discussions. It was obtained from the study that digital backchannel offered students a sense of engagement and that students also felt more positive about classroom discussions and that use of technology has a direct positive relationship with students' engagement and self-directed learning. The results also suggested that appropriate technology could be a useful tool to facilitate the development of an active learning environment. Returning to the questions raised at the beginning of this study, it is now possible to state that communication between students and lecturers should never be complicated in the so-called "large classes" when the digital backchannel was utilized. As a result, a large class will neither be a problem nor a challenge for a lecturer. Utilizing digital backchannel should also enable lecturers to provide immediate feedback on the students' understanding over the lesson material in a large class.

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# New Methods for Collaborative Experiential Learning to Provide Personalised Formative Assessment

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**Abstract**—Supporting diverse and rapidly changing learning styles of new digital age generations is one of the major hurdles to higher education in the age of massification of education markets. Higher education institutions must now utilize unprecedented network speed and mobile technology to create stimulating learning environments for new digital age generations. This paper presents a new learning and teaching model that combines dynamic learning space (DLS) and mobile collaborative experimental learning (MCEL) for supporting diverse learning styles of students. DLS assists students with state-of-art modern wireless network technologies in order to support fast-paced, multi-tasking, data and content intensive collaborative learning in class. The model further extends student learning activities beyond classroom by allowing students to continue their learning anywhere and anytime conveniently using their mobile devices. MCEL provides automated continuous personalized formative-feedback 24/7. The main objectives of the model are to improve student engagement and to provide ownership of their learning journey, experiential learning, contextualized learning, and formative assessment at low cost. The model employs three factors that influence collaborative experiential learning and formative assessment. The three factors are:

- The use of learning space within the classroom
- Wireless learning technology
- Mobile learning system (m-Learning)

Pilot studies of the model are conducted and evaluated on two groups of postgraduate students. Their participation is observed, and a survey is conducted. The results show that (1) DLS encourages high-level learning and diverse learning styles to move away from passive low-level knowledge intensive learning activities; (2) MCEL supports Bigg's constructive alignment in curriculum design, contextualized experimental learning, and personalized formative learning.

**Keywords**—Mobile learning, collaborative learning, experiential learning, dynamic learning space, formative assessment.

# 1 Introduction

In the age of massification of education market, all educational institutions must now accommodate changing student profiles and diverse student populations through technological and pedagogical advancements [1]. Institutions need to accommodate diverse learning styles and preferences of students often comprising working professionals, different age groups, and culturally diverse groups. For instance, in science learning, a typical laboratory setup would expect students to replicate the results of certain experiments done by previous scientists, such as creating oxygen, setting up computer networks, and implementing software functions for sending SMS messages. However, not all student projects can have clear and direct outcomes to measure against the outcomes of students. For example, designing a more fun and engaging interaction for an interactive product for travel sector can be more challenging and time consuming to assess. In both cases, however, the main challenges are stimulating students, facilitating effective learning, extend learning beyond classrooms within limited resources.

Researchers have been trying solve these challenges through flexible learning [1] [2] [3] and blended learning [4] approaches. Faced with new digital age generations [5], young learner [6], unprecedented network speed and mobile technology, education researchers now frequently quote mobilized curriculum [7], social-interaction oriented learning [8], personalized learning [9], online community [10] and collaborative mobile learning [11] in their studies. These previous studies suggest that collaborative learning spaces and mobile learning approach hes can be used to create learning environments that can stimulate students, facilitate effective learning, and extend learning beyond classrooms by providing personalized learning more efficiently.

However, these studies have focused mainly on re-designing curriculums taking advantage of mobile technology, and improving communication and access to learning contents. In this paper, we focus on exploring ``how'' mobile devices can be used to create collaborative experiential learning environment in education. We envision that mobile learning can allow students to access simulated learning laboratories anywhere any time through mobile devices, providing experiential and contextualized learning in digital space, and formative assessment through continuous feedback from the simulated lab. The objectives of this new research direction are to

- Improve student engagement
- Provide ownership of their learning journey
- Provide experiential, contextualized and formative assessment at low cost.

To achieve these goals, a new combined teaching and learning model based on Dynamic Learning Space (DLS) and Mobile Collaborative Experiential Learning (MCEL) has been developed using design-based research approach [12]. DLS uses Wireless Learning Technology (WLT) to provide flexible learning space.

MCEL combines service-orientation design paradigm and context-free grammar parser to provide easy to use curriculum development platform and natural-language-

based user interaction. Teachers can express learning contents and objectives using event-condition-action rules and students can interact with MCEL using structured SMS message. A pilot study was conducted to evaluate the effectiveness of MCEL. The evaluation results show that MCEL is usable, students' learning activity continued beyond classes, students received feedback anywhere anytime, and they felt sense of ownership of their learning journey.

The paper introduces the two methods respectively and is organized as follows. In Section 2, we identify gaps in current studies by reviewing literature on dynamic learning spaces for improving social interactions, mobile learning, mobilized curriculum, formative assessment, and enhancing social experiences. Section 3 summarizes learning types, research methodologies, and evaluation approaches. Section 4 details the pilot study and evaluation approach that are designed based on the literature review. In Section 5, the evaluation results are reported. Section 6 concludes the paper with remarks.

## 2 Background

This work is based on m-learning, collaborative learning, social interaction in learning, mobile technologies, service-orientation design paradigm, and natural language parsing. The following sections provide a brief overview of the core techniques, focusing on developments of flexible learning approaches, mobile learning for mobilized curriculum, formative assessment, and enhancing social experiences.

### 2.1 Motivations of flexible learning

Starting from Bloom's taxonomy [13][14][15], existing literature clearly encourage various forms of blended learning to better support the changing student profile. Bloom's taxonomy broadly classifies educational learning objectives into three psychological domains: Cognitive (knowing), Affective (Feeling), and Psychomotor (Doing). This Bloom's taxonomy stimulated research on evaluation approaches and reflection on their effectiveness, and helped teachers guide their students to higher-levels of the taxonomy for deeper level of learning.

Bloom's taxonomy was further revised by other researchers in to levels of learning [16] [17], which are now frequently stated in graduate attributes and learning outcomes of Australian tertiary education. It provides a benchmark, against which an educator can measure a student's level of understanding. The six levels of learning (remember, understand, apply, analyse, evaluate, and create) cannot be achieved by simply standing in front of students and delivering lectures in classes. Due to recent developments in internet-based communication technologies, and interactive media authoring tools, educators can now enrich the student learning experience and impact of learning by combining the variety of educational tools and technologies available to them.

Kolb's Learning Cycle [18] provides a learning model to address different learning styles similar to Felder's learning model [19]. It places students within one of four cycles based on two preference dimensions: why, what, how, and what if. Therefore, it is recommended to teach around the circle by starting in the "why" cycle and ending in the "what-if" cycle to address all learning styles.

The 3P model of teaching and learning [20] encourages high-level learning through constructive alignments guided through the three teaching and learning activities: please (motivate and contextualize), process (learning focused activities), and product (assessment of learning outcomes). As students learn what they think they will be assessed on [21], the assessment tasks should mirror the desired learning outcomes and the teaching and learning activities should be directed towards the same desired learning outcomes.

The 5E approach of instruction model [22] [23] has been used in science education to provide a rich environment for doing science. The approach was adopted in Australia (e.g., Primary Connections teacher-professional learning program) and trialled in 56 schools in year 2005. The approach follows inquiry-based learning [24] using open investigations, cooperative learning, integration of assessment with teaching and learning. The objective is to encourage teachers to be facilitators of the processes of science in a sequence of teaching and learning activities: engage, explore, explain, elaborate, and evaluate.

The advancements in new internet-based educational technology now ask us to rethink pedagogy or even to reinvent the art of science of pedagogy [25][26] as digital technology provides a new context for learning.

### 2.2 Dynamic learning space: wireless learning technology & spaces of learning

Wireless Learning Technology (WLT) in education includes the subsets of mobile technologies as well as the WLTs systems used in new 'networked' classrooms. Thus, the broad term WLTs encompasses the use of mobile devises such as handheld smart phones, tablets and laptops; WLT platforms installed in fixed spaces such as classrooms using Wireless LAN (WiFi); as well as the use of mobile technologies connecting to classroom WLT platforms. Each of these technologies has formed an active area of research within the teaching and learning arena. The following literature review sets out the broad range of WLTs and approaches to understanding their importance to the future direction of education.

### 2.3 Mobile wireless learning technology (WLT)

Mueller et al. [27] studied the use of mobile (handheld) devices in higher education. Conducted at one university over one teaching period of sixteen weeks, the researchers documented students' use of one mobile technology, that of the smart phone, in a designated undergraduate subject. Students reported that the smart phone device was easy to use, and they were optimistic regarding its potential role as an instructional tool. The findings indicated that students were self-directed in their use

of the device, building their capacity as both interdependent (collaborative) and independent (individual) learners. The students explored smart phone functions and uses beyond the tasks provided by their instructors. They found innovative ways to use the smart phones within and outside of the classroom. Exchange of information and ideas emerged as the single most frequent use of the smart phones. Findings recognized that academic staff need to ensure that clearly defined instructions for the use of smart phones as teaching devices are communicated and explained to students [27].

It is important to note, however, that although the study supported the use of a handheld device as a learning tool, their use as a "classroom instructional" device for learning and teaching purposes was more limited than student-directed use of the device for social communication (chatting and texting) in and out of the classroom [28]. This study highlighted that the affordances of technology are dependent on high student uptake. Absence of student interest and motivation in the use of technology for learning will reduce the intended positive outcomes of the technology. The researchers suggested that student participation in identifying device uses for learning and teaching purposes increases student participation with the mobile devices [27].

Similarly, Ross et al. [29] discuss the positive influences of wireless technology on learning experiences in education. Although this study was conducted in the context of a secondary school, it nevertheless has implications for higher education. The study employed a qualitative methodology of interviews to explain the use of new technology tools, such as the iPad, within the school curriculum. Findings indicated that the use of the tablet devices improved the efficiency of teachers and the workflow of students with neither group constrained by time or space. Students reported being able to use multiple functions and applications of the iPad, namely: writing memos, calculating, and online information searches. For teaching staff, the device promoted technology leadership and efficacy - augmenting their ability to lead a technologically advanced teaching and learning space. Wireless technology tools, including tablets and smart phones, were identified by participants as "remarkably fashionable". Students and teachers were eager to use them, thus changing their worldview of learning and teaching. The authors maintain that exponential growth and adoption of wireless tools will shape learning and teaching practices in the near future. The availability of high-speed internet connection will be a primary factor in the efficient and effective use of this technology.

Morgan et al. [30] explains how mobile learning can be enriched by utilizing audio-visual methods of communication coupled with the technological facility to communicate. Referring to student engagement in education, Morgan deliberates on the use of handheld wireless devices such as laptops, tablets and smart phones. This study explores the additional utility of using mobile devices with publicly available applications such as mind mapping software and the WIKI collaborative platform. It reveals the popularity of social media platforms to further enrich the quality of mobile learning facilities.

Findings from the above studies suggest that mobile technologies in educational spaces are highly useful. This is primarily due to the quality returns from the devices

utility; specifying, effective and efficient communicative methods are enriched by the technologies' convenient accessibility in time and space.

With respect to the introduction of on-line education in courses offered in Singapore, Koh et al. [31] identify certain benefits of wireless learning technology: motivation for student learning enhanced capacity for assimilation of knowledge, and greater knowledge retention of the subject matter. The researchers make reference to increases in motor coordination which arise due to stimulation caused by the activity of on-line game playing. They further explain 'push factors', which refer to the external forces influencing the utility of gaming; as well as 'pull factors', which refer to the internal motivating factors that stimulate teachers to utilize gaming in the field of education.

Tay et al. [32] highlight the positive influence of learning with technology, referring to it as 'ease to learn'. These researchers conclude that the use of web 2.0 online social applications, in conjunction with open-source learning management systems, can be highly beneficial. They contend that success is due to the nature of the collaborative activities and teaching experiences that are derived when these technologies are put into practice.

However, the need for caution over the over-zealous and under-analysed take up of wireless learning technology has been noted by Gay et al. [33]. The authors warn that wireless technology for educational purposes cannot be adequately understood and adopted through a one-size-fits-all mentality. They argue that different learning and teaching environments, course content, pedagogical models and curricular philosophies influence how wireless technologies can be used most effectively.

At this time of rapid change, both technologically and pedagogically, the paper by Gay et al. [33] is a sobering reminder of the importance of an integrative matrix for the analysis of new 'networked' spaces of learning. Such a thinking matrix involves the simultaneous consideration of philosophy, learning and teaching practice, learning space design, and wireless learning technologies – both mobile technologies and WLTs platforms.

### 2.4 WLTs & spaces of learning

In recent years, there has been a paradigm shift from the traditional teacher-oriented to a more interactive, student-oriented, higher education environment. Engagement with, and participation of, students is prioritized, with teachers encouraging students to use familiar technology as part of their learning experience. While many new audio visual and IT related products have been developed to meet this demand, no one product has met all the needs of the contemporary classroom as effectively as Wireless Learning Technologies. Newly designed classrooms use a combination of students' individual mobile WLT gadgets with LCD screens connected to keyboards, computer consoles, WLT platforms, and Wireless LAN (Wi-Fi).

In a recent case study of a WLT classroom in Hong Kong, Salter, Thomson, Fox and Lam [34] evaluated the implementation of prototype technology-rich collaborative classrooms at the University of Hong Kong (HKU). The learning spaces

were designed as a retro-fit of an existing studio. Through the development of collaborative learning spaces, the University hopes to provide an enhanced learning and teaching environment for both staff training – including training in teaching in the new space – and student learning.

The Salter et al. [34] team utilized an outcome-based approach to student learning (OBSL) to promote creative teaching methods and activities to meet learning objectives. The study reports positive feedback from the majority of students pertaining to the use of technology and collaborative interaction in the learning spaces.

### 2.5 Mobile learning for enhancing social experiences

One primary goal of educators is creating a harmonized environment where students could construct their learning upon both physical and social contexts augmented on the learning content. Therefore, social interaction is considered as the key advantage and ingredient in the designs of mobile learning practices. In particular, some researchers viewed that mobile learning could enable students interact with peers, teachers, and subject contents more efficiently and unobtrusively [8]. Furthermore, [11] proposed that mobile-learning can provide efficient collaborative learning environment to enhance in-class learning experiences. On the other hand, [8] proposed a curriculum design practice, called interwoven learning interactions, for creating more socially interactive learning environments.

### 2.6 Mobile learning for formative assessment

In education, competency assessments are typically assessed summatively due to the unique curriculum design in this sector. In a similar reason, not much research has been done in the use of mobile learning in education. Furthermore, the use of mobile technology in education initially met with scepticism [6]. Elsewhere, Kneebone and Brenton [35] reported that the usage of mobile devices did not improve the quality of assessment tasks or even reduced efficiency. Other studies even suggested that special types of mobile devices were required to solve these problems [36].

However, Coulby, Hennessey, Davies, and Fuller [37] suggested that identifying an appropriate use of mobile devices is key to solving the problems. They hypothesized that m-learning could be used to conduct formative assessment in competency assessments in education. This was an important observation as competency assessments were typically assessed summatively in education.

In a similar attempt, but independently, McIntyre [38] studied use of mobile technology by management students. The study findings acknowledged that students generally positively motivated towards 'mobiles' as social and personally integrated lifestyle and organisational aids. They argued that awareness of constant communicability, conspicuous technology consumption, solipsistic, diversionary and 'lazy' learning drawbacks were the key negative attitudes towards Mlearning due to the extensive use of mobiles as learning facilitators. The researchers designed a new learning experience and incorporated defined limits around various elements of

technology within a UbiComp environment relating to social, study or work technology utility (tec-utility) zones with only limited crossover zones of tolerance. The research findings suggested that controlled environment has better outcomes.

### 2.7 Mobilized curriculum

Zhang et al. [7] developed a methodology for re-designing existing curriculums into mobilized curriculums. The mobilized curriculums were designed to allow students to participate in inquiry-based learning in class or out of class using their mobile devices. The authors hypothesized that mobilized curriculums, referred to as "mobilized lesson" by [39], might be able to provide an infrastructure that fosters student-centred learning due to the pervasive nature of mobile technologies. Students would have 24/7 accesses to the mobile devices to participate in both informal and formal learning in class or out of class. They reported that there were significant changes in students' learning behaviours. Students engaged in more collaborative learning with peers and teachers, asked more questions, and became more creative.

On the other hand, Song et al. [9] proposed a design process for creating a mobile-assisted personalized learning environment within Kolb's experiential learning model [18]. The authors viewed that the mobility of learners enabled by mobile technologies would allow learners personalize both their learning goals [40] and context [41]. To overcome the limitations of experiential learning, the researchers incorporated goal-based approach [42] into their mobile-assisted personalized learning environment to provide sustained experiential learning experience for science education.

### 2.8 Technologies for automating assessment

Now, over 87% of the global population and 79% of developing world's population has access to Simple Messaging Service (SMS). This pervasiveness of mobile technologies has created both challenges [35] and opportunities [37]. As seen in previous sections, we are still learning how to integrate these new technologies. In particular, we need to develop platforms for designing curriculums, methodologies for re-designing existing curriculums [7], and automated methods for providing formative assessments [37]. One particular technology that has been proven to be intuitive and efficient in capturing and implementing business requirements in business process automation is event-condition-action (ECA) rules. ECA is the basis of event-driven architecture (EDA) pattern adopted by SOA (Service-Oriented Architecture) 2.0 for more natural modelling of business processes. ECA can be converted into Business Process Execution Language for Web Services (BPEL) [43], allowing an easy migration between different modelling tools. BPEL is supported by major business process management software and development tools (e.g., Eclipse IDE).

Formal language processing [44] has been proven efficient and effective in processing structured languages, such as formulas and statements of programming languages. Its advantage over natural language processing [45] is their reliability and accuracy, which are very important usability aspects. Re-searchers can now build

custom grammars using lexers and parsers (e.g., ANTLR [46]) defined using simple rewrite rules to automatically process structured SMS messages.

## 3 Types of Research Methodologies and Methods Utilized in M-Learning Research Papers

Table 1 summarizes learning types, for which m-learning researchers tried to integrate mobile technology into teaching and learning. It shows that mobile technology can be applied to most of learning environments, such as in-class, out-of-class, and inquiry-based learning. It also showed that m-learning were applied to new emerging learning types as well, such as personalized learning, mobilized science curriculum, and social-interaction oriented learning. Table 1 summaries research methodologies and evaluation approaches used by m-learning researchers. It shows that pilot studies utilizing observation, interviews, and questionnaires data gathering approaches were commonly employed to evaluate their proposed methods.

**Table 1.** Learning Types and Research Methodology and Evaluation Approaches

| **Learning Types Supported** | **Literature** |
|---|---|
| Project-based or Inquiry-based learning | [7][8][9] |
| In-class learning | [7][11] |
| Out-of-class learning | [9] |
| Personalized learning | [9] |
| Curriculum design: A methodology for designing mobilized science curriculum | [7] |
| Interwoven learning interactions | [8] |
| Social-interaction oriented learning | [8] |
| Formative Assessment | [37][47] |
| Collaborative learning environment in classroom | [11] |
| **Evaluation Approaches** | **Literature** |
| Curricular materials in classroom settings | [7][8][11] |
| Design-based | [9][11] |
| Pilot formative assessment | [37] |
| Pilot training | [47] |
| Ellaway's [48] descriptive framework of e-learning | [47] |
| David et al's [49] contextual mobile learning approach | [47] |
| Student Perceptions on m-Learning | [50] |

These previous studies suggest that m-learning can be used to create learning environments that can stimulate students and facilitate effective learning by providing personalized learning more efficiently. However, these approaches mainly focused on re-designing curriculums taking advantage of mobile technology, and improving communication and access to learning contents.

# 4 Research Methodologies

This paper employs a range of methodological consideration. The methodology is organised into two sections. The first section outlines the research approach to study WLT and dynamic learning spaces.

## 4.1 Wireless learning technology & collaborative learning spaces

Participant observation is the primary research method adopted to analyse the learning space of the classroom. Participant observation technique is useful in seeking deeper insights on the research subject matter [51]. The researcher in this study entered a scheduled class and took notes based in the classroom based on the observation. Photographs of student interaction were taken to provide context to discussion. A survey of the literature [51][52] reveals good examples of the use of photographs as a research instrument in drawing attention and providing focus to the research study [53].

Purpose built and designed 'networked' spaces of learning across its three tropical campuses: [omitted for de-identification of the manuscript]. Similar to HKU, the new model classrooms at our campuses have been retrofitted. Currently the campus has two technology enhanced collaborative learning spaces. One uses Apple WLT and the other uses the ProVEOS WLT system developed by the Singaporean company WOW Vision. The second room is outlined here.

The learning space is rectangular with two doors along one length of the room and a bank of windows along the opposite wall. The room consists of six tables that jut out from the four walls like rectangle satellite-isles. Six chairs on rollers are arranged three either side of each table. Above each table hangs a large 40-inch LCD screen it is wire connected to a keyboard and mouse, which rests on the table's surface. Across the breadth of two walls of the room run long whiteboards. The new 'networked' room is covered with a designated Wireless LAN (Wi-Fi) which students and academics can connect to using their mobile devices in order to project their work wirelessly on the LCD screen. However, not all mobile devices are compatible with the ProVEOS wireless learning technology. For instance, the installed WLT system does not support iPad. As all fulltime students and academics are issued with iPads at the campus, this non-compatibility is a problem. Laptops and smarts phones are compatible. Alternatively, the keyboard and mouse attached to each LCD screen allows a 'designated driver' at each table to edit work directly on the screen with input from the student team. The room is well lit from the bank of windows installed at table level, blinds soften the tropical sun, and combined with the monochromatic grey-scale of the room, allows the space to feel light and airy. This sense of space is enhanced by the view out of the window. The room is on the third level and a glance outside takes in the tops of clumping palms.

### 4.2 M-learning system & automating assessment

The section explains the methodology adopted to study M-Learning System & automating assessment. MCEL is developed and evaluated using design-based research approach [12]. The initial prototyping is done using wizard-of-oz prototyping, in which human instructors simulate the automated system using structured instructions and rules. After the usability and technical feasibility problems are addressed, the system is implemented on an Android tablet.

Figure 1 shows the overall system diagram of MCEL, which is a simulated lab running on an Android tablet. It can continuously interact with students in order to deliver personalized assessment via simple text messages. The learning script is formulated based on Event-Condition-Action (ECA) paradigm, which is now adopted by SOA (Service-Oriented Architecture) 2.0. This approach will provide more natural modelling of business processes. ECA can be converted into Business Process Execution Language for Web Services (BPEL) [43], allowing an easy migration between different modelling tools. BPEL is supported by major business process management software and development tools (e.g., Eclipse IDE). An Android tablet with Android OS v3.0 is used to host the simulated lab. ANTLR [46] is used to generate simple lexer-parser Java-code for our structured SMS messages.

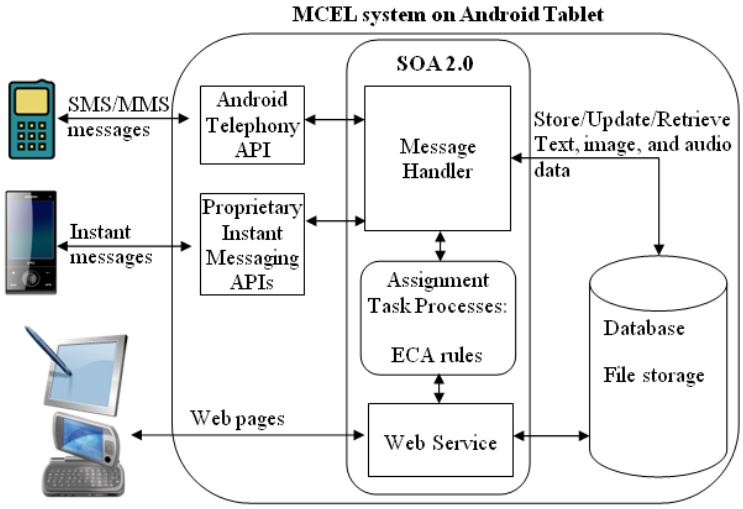


**Fig. 1.** Mobile Collaborative Experiential Learning (MCEL) System

The resulting MCEL developed through the design-based research approach [12] is evaluated. For the evaluation, a learning script for two questions was prepared. Students were told that an automated system will guide their learning by interacting with them through simple text messaging services. Survey questions were designed based on previous mobile education studies done by Nokia in 2008. Three sets of questions were selected from the question set used by these previous researchers:

- User-friendliness

- Technical feasibility
- Cost effectiveness

The survey was designed to investigate if MCEL would improve learning experience, and it would be usable (effective, efficient, and enjoyable to use), technically feasible, and cost effective.

This study was approved by JCU Human Research Ethics Committee (Approval ID H5402). Participants were be recruited from students who are studying at JCU Singapore campus. First the participants were given detailed description on the project, their rights, information sheet and consent form. Once they signed the consent form, they were given information on the tasks to complete. The tasks varied depending on which subject they are undertaking. For example, problems were given to students enrolled in Management subject and the problem in Event Management were provided to students enrolled to Conference and Event Management subject. Each task took less than 20 minutes and no more than 2 tasks were given to each participant. The students were allowed to complete the tasks anytime anywhere. Once the participants have completed the evaluation, they will fill in the questionnaire. After the questionnaire, an informal interview session was held and students provided their experience of using the prototype. The participants were then thanked and provided with small tokens of appreciations.

# 5 Experimental Results

## 5.1 Dynamic learning space

During our trial of DLS, the active interaction with fellow classmates and the facilitator in the classroom provided immediate formative feedback and enhanced learning experience. In addition, the use of technology and smart devices facilitated access to information and enriched the discussion. Unlike conventional teacher oriented and teacher directed classrooms, students were able to move between groups to form various sizes of groups spontaneously based on their topics of interest. Mobile WLS allowed them to connect to one of the displays near a group to share information with the group members. Students were able to exchange their ideas with rich multimedia aids, such as texts, audios, images, and videos. This allowed students to contribute to discussions and problem solving spontaneously and in many different ways. Instead of relying on recall of text book or lecture materials, students demonstrated creativity in constructing their solutions through information sharing using various methods, such as demonstration, visualization, role playing, and including conventional form of discussions.

Like the Hong Kong case study, the new '-networked' classrooms at JCU Singapore are still being trialled and academics are still discovering the affordances of these spaces of learning – both spatially and technologically. The observation suggests that DLS encourages high-level learning moving away from passive low-level knowledge intensive learning activities. It also supports diverse learning styles

through blended learning [13][14][15]. Students exercise Cognitive (knowing), Affective (Feeling), and Psychomotor (Doing) through verbal communication, drawings on iPads, text messages, and electronic documents. It clearly shows that DLS can encourage these forms of blended learning to better support the changing student profile.

### 5.2 Mobile ccollaborative eexperiential learning

Table 2 show the survey results of MCEL. Most of the participants viewed MCEL useful (user-friendly both in learning and technical accessibility) and cost effective.

**Table 2.** Perceived Usefulness, Usability, Technical Feasibility, and Cost-effectiveness of Students

| Question No. | Questions | Rating |
|---|---|---|
| ***Student user-friendliness (5-point Likert scale response: (1-Strongly Disagree, 2-Agree, 3-Neutral, 4-Agree, 5-Strongly Agree)*** | | |
| U1 | It was easy to use the equipment in this mobile learning course | 4.14 |
| U2 | This mobile learning experience was fun | 4.29 |
| U3 | According to my experience I would take another mobile learning course if relevant to my learning needs | 4.43 |
| U4 | I would recommend mobile learning as a method of study to others | 4.29 |
| U5 | Mobile learning increases the quality of e-learning | 3.86 |
| U6 | Course learning objectives can be met by mobile learning | 3.43 |
| U7 | Communication with and feedback from the tutor in this course was easy | 4.29 |
| U8 | Mobile learning may be convenient for communication with other course students | 4.14 |
| Technical feasibility (5-point Likert scale response) | | |
| T1 | Navigation through the mobile learning course was easy | 4.14 |
| T2 | For mobile learning to be effective it is necessary to use graphics and illustrations | 4.57 |
| T3 | Evaluation and questioning in the mobile learning course was effective | 4.14 |
| Cost effectiveness (5-point Likert scale response) | | |
| C1 | Mobile learning increases access to education and training | 4.00 |
| C2 | The cost of communicating in the mobile learning course with the tutor and other students was acceptable. | 4.00 |

Some students sent replies even at midnight, clearly showing evidence of their interest and engagement. Out of 22 participants, 6 students completed the questionnaires. The survey results demonstrate that most of the participants viewed MCEL useful: user-friendly in terms of both learning and technical accessibility and cost effectiveness.

The following comments made from the participants also illustrate that MCEL could provide new learning experiences. In particular, students felt that they can take the learning on their own personal pace:

"It is really useful to do answers in our own convenient time & it was new and attractive to do."

"Sometimes, type in the correct format is not easy, when the wrong format sending, the cost has already happened, but the communication is no useful this moment."

"Typing answers with mathematical operators took time. But the experience was good."

The survey results and our observation suggest that MCEL supports Bigg's constructive alignment in curriculum design [53], contextualized experimental learning, and personalized formative learning.

## 6 Conclusion

The study identified a gap in the current literature and proposed a new approach for providing more engaging teaching and learning model. The new model makes use of new emerging technologies such as networked classrooms and mobile technologies to create dynamic and creative learning spaces in class and provide continuous personalized formative feedback extending beyond classrooms at much reduced cost. The proposed model can be supported with many available off-the-shelf systems allowing education institutions to create more engaging and vibrant learning environment for diverse student groups at low-cost. Unlike existing mobile and wireless learning technologies, our approach is designed to support resource poor areas in South East Asia and diverse student cohort and evaluated in South East Asian context. The new learning environment is particularly suitable for developing-countries, where limited learning space or no proper wireless network services are available. DSL can be adjusted based on the different requirements. Furthermore, MCEL can be operated on conventional inexpensive GSM mobile services to provide personalized learning experiences. Unlike previous approaches, MCEL uses automated tutoring system that are customisable by teachers in order to reduce the cost of education. In many resource poor areas in South East Asia, this is particularly important and will have significant impact in improving access to education.

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# Student's Performance Assessment and Learning Skill towards Wireless Network Simulation Tool – Cisco Packet Tracer

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**Abstract**—Practical Learning is a great way of learning as it aids to increase a learner's interest in a certain subject. It entails the use of visual aids to convey ideas even more effectively. Students can more easily understand and adapt the information from the subject, when they can visually see how it really works. Rather than just explaining the theory concepts, using animating slides, simulation software that explain the theory concepts easily can be used by the instructor to develop the student's skill in the particular subject. Simulation tools provide significant cost savings in Education. This is because a topic can be taught effectively to large numbers of people without the need of buying expensive equipment. Like wireless networking labs, if we want to construct the lab with the equipment like wireless router, access points, different cabling it is more cost effective. Now in net, we can find out more simulation software for networking. One of the best simulation tools for Networking is Packet Tracer which can be freely downloadable from Cisco Networking Academy Students. It includes assessment task with automatic scoring and reporting. This paper presents the features of the simulation tool and analyzes the student's performance over this simulation software with the given questionnaires. This study provides evidence in support of the instructional effectiveness of the use of Simulation software tool for the teachers and the learners who are interested in networking concepts.

**Keywords**—Packet Tracer, wireless access points, basic service set, extended service set, independent basic service set, DNS, HTTP.

## 1 Introduction

Visual learning engages the use of visual aids like video to deliver educational content even more effectively. It greatly benefits and enhances the learning process as interactive effects are used to reinforce the material being studied. Visual learning is a great way of learning as it aids to increase a learner's interest in a certain subject, makes the learning process more enjoyable, and retains the student's interest for longer periods. By using visual learning, an audience is better

served when they are provided certain elements that classroom notes or text cannot fully convey. Over the last ten years, several national efforts have been initiated to develop multi-media and web-based educational material [4]. It is a proven method in which ideas, concepts ,data and other information are associated with images and animation, resulting is an easier and more effective method of transmitting skills. With the rapid advancement of information technology, virtual reality technology has also gradually developed, accompanied by the dramatic growth of virtual reality experiment technology [5]. Students can understand theoretical concepts of wireless networks much easier if they can see them, or interact with them in virtual environment. Learning networking course with packet tracer simulation tool helps students to open their minds, understand the concepts easily and think broadly about networking. Packet tracer is a GUI environment and user friendly tool. It is very tough to teach wireless networking course to the diploma community college students. In this paper, we discuss the teaching learning experience of wireless network course with the packet tracer as a practical tool.

The rest of the paper is organized as follows. In section II, we give brief introduction about the available wireless devices in the packet tracer simulation software. Section III deals with Research Methodology and Results, final Section discuss the Conclusion and future work.

## 2 Wireless Devices Available in Packet Tracer Simulation Tool

Wireless networks are growing everywhere. We can find Wi-Fi hotspots at most public places. Packet Tracer has a limited number of wireless devices but provides an unlimited number of possibilities.

### 2.1 Wireless Access Point (WAP)

In computer networking, a wireless access point (AP) is a device that allows wireless devices to connect to a wired network using Wi-Fi, or related standards. The AP usually connects to a router (via a wired network) as a standalone device, but it can also be an integral component of the router itself.

- Access points are the basic elements of a wireless network – They scan for the wireless devices in its range and all the neighboring Wi-Fi systems connect to the Access Point to communicate with the network.
- Access points offer a standard for connectivity – a, b/g, b/g/n which are all ratified by IEEE so that the Wi-Fi systems from various vendors can connect to the network.
- Access points connect to PC's, laptops, PDA's, mobiles, Wi-Fi phones, Wi-Fi Cameras, Wi-Fi display management systems and a host of other devices that work on the Wi-Fi standard.
- Access points can also scan the network for wireless threats and attacks
- Packet Tracer has wireless end devices as well as access points.

- Access Point-PT / Access Point-PT-A / Access Point-PT-N: These are generic wireless access points with minimal configuration options. All of them have an antenna and a port to connect to a device, such as a router or DHCP server.
- Tablet PC-PT / PDA-PT / Wireless End Device-PT: These three devices provide the same functionality, they only represent different things. These devices come with a built-in wireless interface.
- Linksys-WRT300N: This wireless device provides a web interface similar to the one provided by a real Linksys model for configuring a SSID (Service Set Identifier) , wireless authentication, WAN port, and much more. This device has four Ethernet LAN ports and 1 Ethernet WAN port, which can be connected to a router or model that provides internet.

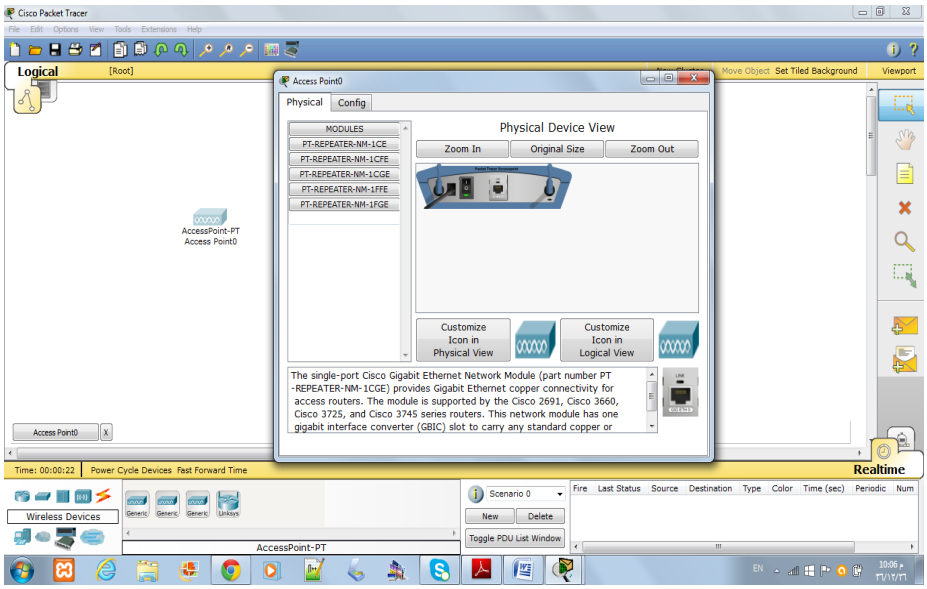


**Fig. 1.** Wireless Access Point in Packet Tracer

The function of a wireless access point is to allow wireless devices such as projectors, laptops and PDAs to access a local area network. Wireless access points mainly act as switches to spread connections wirelessly. The difference between an access point and a router is that access points do not assign IP addresses nor do they have firewalls; they only lock out traffic that does not have the wireless key.

In Fig.2 given configuration of AP in that port status is on. SSID which in our case it is default [It can be changed by other names] also we can set any numerical value for simple security purpose and also given different security protocols like WEP and WPA. According to the channel authentication, we can choose the Encryption types.

Fig. 3, Fig. 4 and Fig. 5 show the three devices namely PDA-PT / Tablet PC-PT / Wireless End Device-PT. These all devices provide the same functionality,

they only represent different things. These devices come with a built-in wireless interface. No need of reconfiguration.

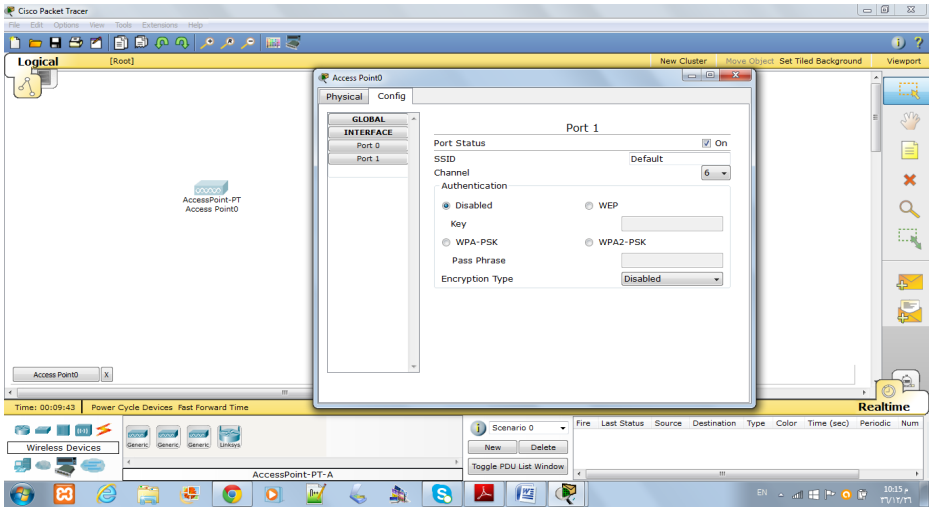


**Fig. 2.** Wireless Access Point Settings in Packet Tracer

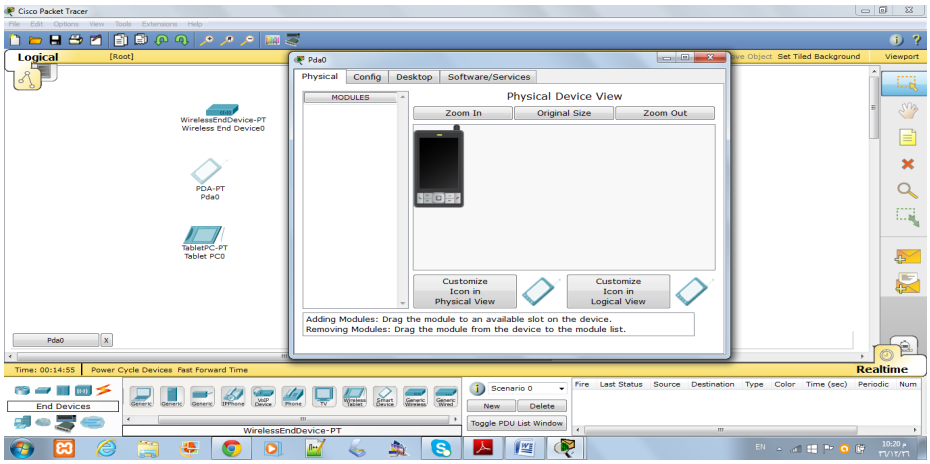


**Fig. 3.** Wireless PDA -PT in Packet Tracer

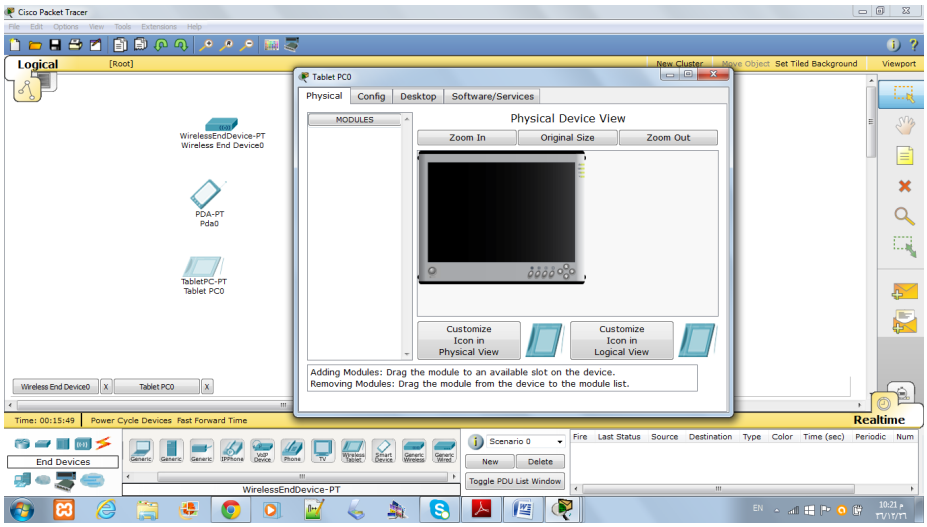


**Fig. 4.** Wireless Tablet PC -PT in Packet Tracer

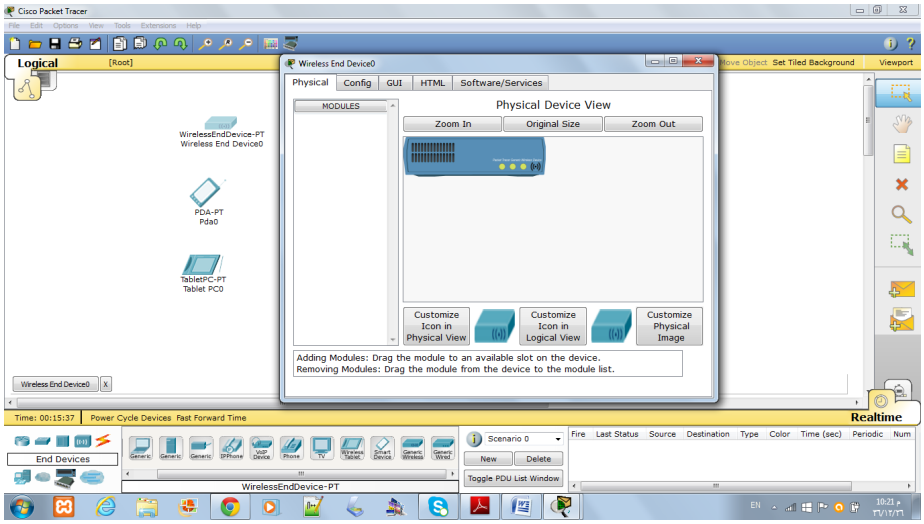


**Fig. 5.** Wireless End device PC -PT in Packet Tracer

As given in Fig 6 and Fig 7 wireless router configuration is given in packet tracer so by practical, students will easily know how to configure original physical router.

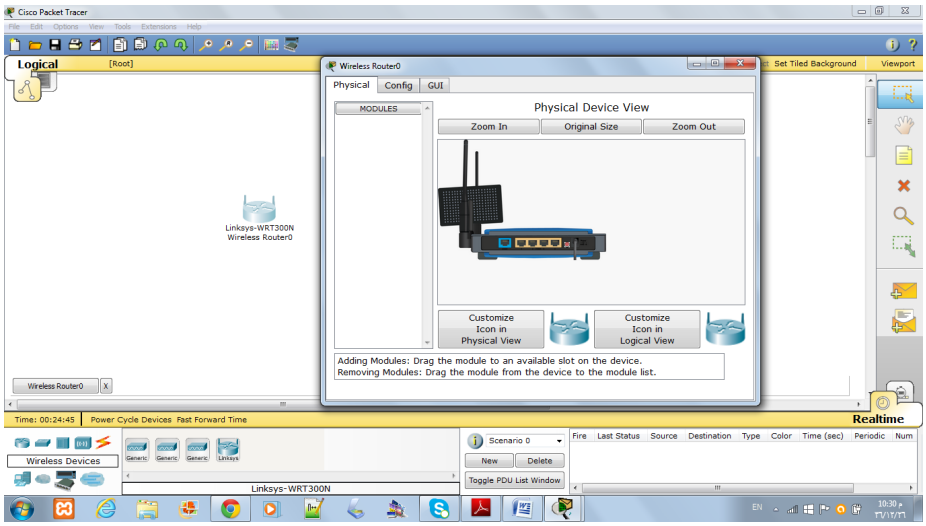


**Fig. 6.** Linksys Wireless Router in Packet Tracer

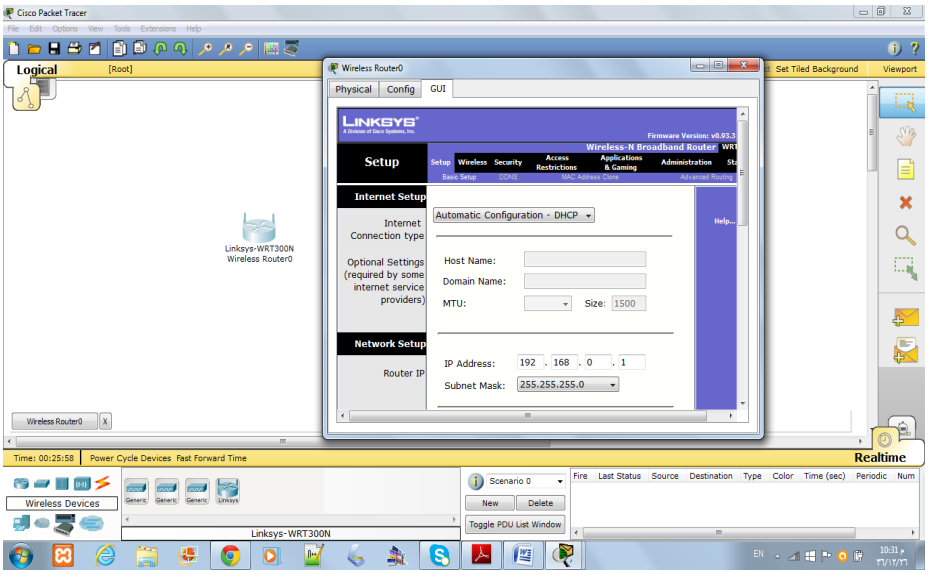


**Fig. 7.** Linksys Wireless Router with GUI based Configuration

## 2.2 Wireless Network Interface Card(NIC)

Every host you want to connect to a wireless network needs a wireless network interface card (NIC) to do so. Basically, a wireless NIC does the same job as a traditional NIC, only instead of having a socket/port to plug a cable into; the wireless NIC has a radio antenna. [1]

As given in Fig 8 and Fig 9 facility provided in packet tracer by which we can remove Ethernet connector (wired NIC) and by drag and drop we can add wireless NIC card to PCs and Laptops.

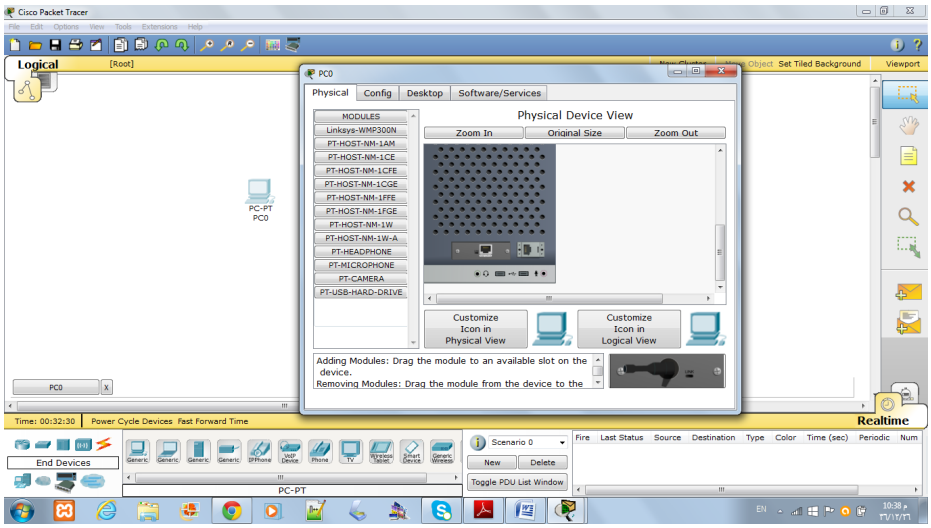


**Fig. 8.** Wireless Configuration of PC - PT

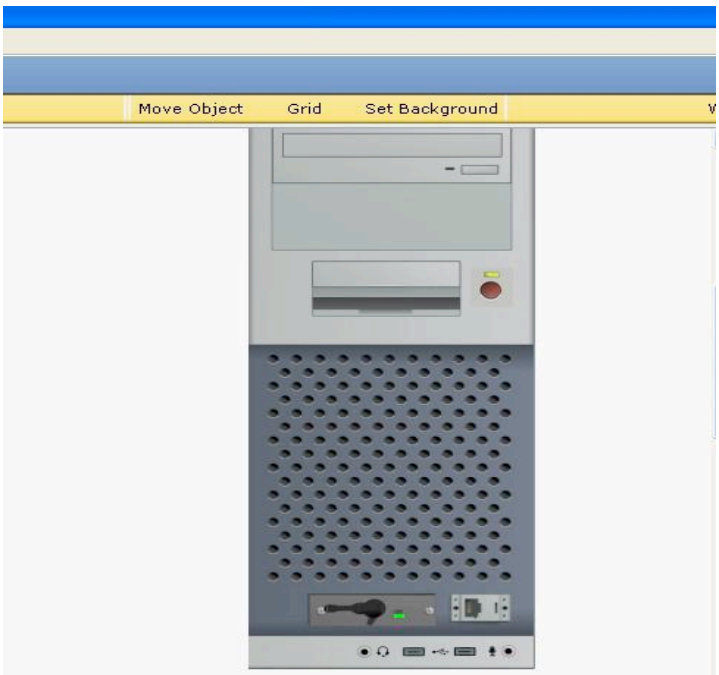


**Fig. 9.** Wireless NIC is attached with PC

### 2.3 Students Assessment in Packet Tracer

Activity Wizard facility is provided in packet tracer as given Fig 10. The activity wizard is an assessment tool that allows you to create detailed networking scenarios for students or other users. Grouping of networks users and resources connected to administrative defined ports on a switch. When you create VLANs, you are given the ability to create in our session we have given students to complete scenario given as.

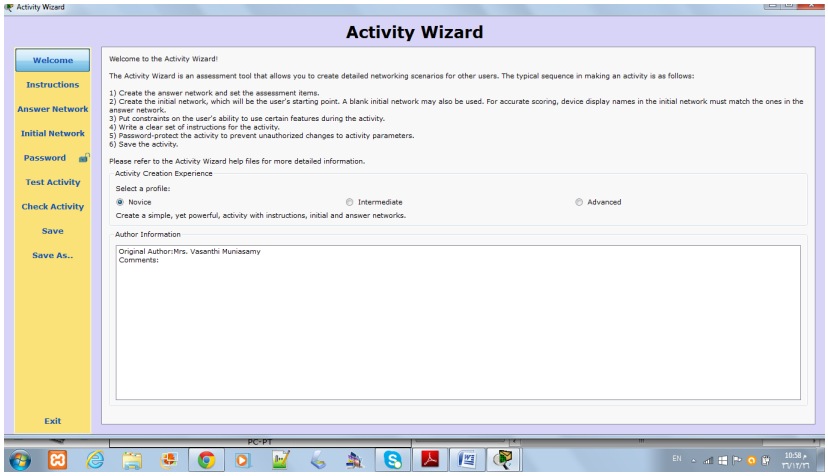


**Fig. 10.**Activity Wizard Module in Packet Tracer

As Shown in Fig 10. And Fig 11: Activity Wizard Module and activity steps. Teacher can create their activity given as below. If activity is completed or not, message will be display on the screen after clicking on check activity button and also how many activities completed out of total activities. Here I have given one example of such activity. That we have given during our class session.

**Activity 1:** Adding and configuring network devices Open the "Wireless.pka" file and follow the Instructions, which are repeated here:

**Step 1:** Add a server, a printer, a wireless access point, and two generic PCs.

**Step 2:** Remove the Ethernet modules and add wireless modules for the 2 PCs and the printer. Make sure to power off the devices before removing the modules and power on the devices once the wireless modules have been added.

**Step 3:** Connect the server to the wireless access point using a crossover cable.

**Step 4:** Change the name of PC0 to Workstation, PC1 to Laptop, Server0 to Server, and Printer 0 to Printer.

**Step 5:** Configure the devices with the following addresses:

- Workstation – IP Address 192.168.1.1/24
- Laptop – IP Address 192.168.1.2/24
- Server – IP Address 192.168.1.3/24
- Printer – IP Address 192.168.1.4/24

**Step 6:** Verify connectivity. From Workstation, use the ***PING*** command to test connectivity to Laptop.

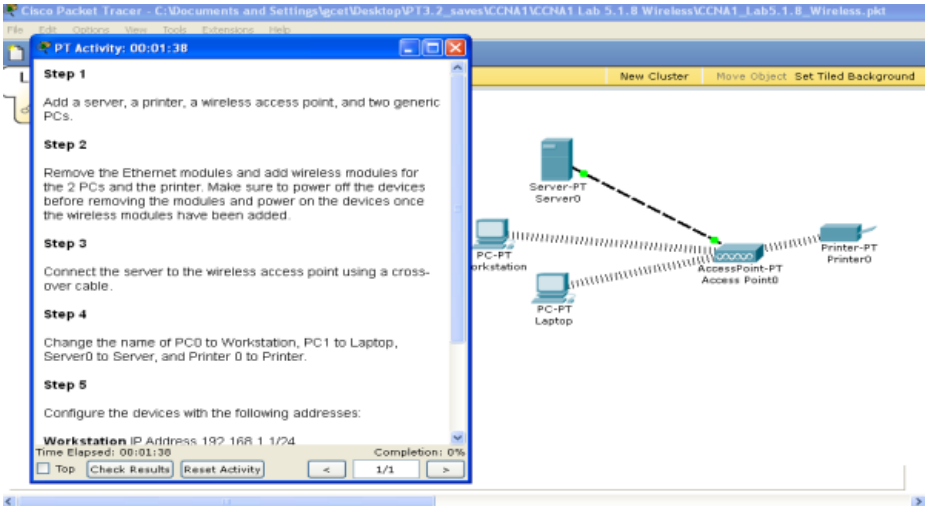


**Fig. 11.**Activity Wizard with steps in Packet Tracer

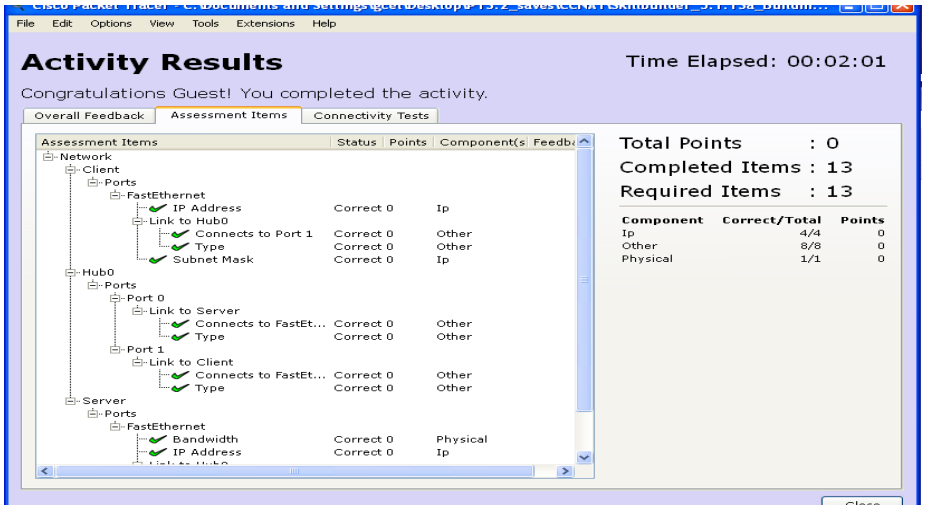


**Fig. 12.**Activity Result in Packet Tracer

Activity Results given in above Fig 12.in our session several such activity have been given to the students and after completion, assessment result will be generated which include time Elapsed, completed items, required items etc.

# 3 Research Methodology and Result

## 3.1 Purpose of the Study

The purpose of this study was to examine the student's experience and learning skills and assessments towards the simulation software packet tracer for constructing the Wireless networking environment virtually.

## 3.2 Participants

The sample included 41 students of level 5 Diploma Community College under King Khalid University enrolled in a course entitled "Computer Wireless Networking" in the Fall Semester 2015. This course is a traditional lecture-style course for one semester. The class met 2 days a week for one hour theory session for 2 day and two hours practical session for 1 day. First two weeks we explained the concepts of Packet tracer, various wireless devices and how to configure the devices based on our choice to construct wireless networking. The third week we prepare and give one activity wizard to the students to construct the wireless networking to send and receive the packet in between two laptops by using two access points and one Router. After completion of Activity Wizard, Feedback was collected from each student in the form of simple questions to evaluate student's understand towards the concepts, viewpoint of their experience in the sessions as well as participating in the activities. Questions are showed in Table 1. There are 5 questions in the feedback form. The students sample is less than eighty and the questionnaires are simple to understand, we received full response from the students.

**Table 1.** Students Feedback Form

| Q. No. | Questions | Yes | No |
|---|---|---|---|
| Q1 | Have you ever before used Packet Tracer for constructing Wireless Network? | 0 | 80 |
| Q2 | Do you understand the Concept of Access point and Router in Wireless Networking through Packet Tracer easily? | 66 | 14 |
| Q3 | Whether you feel Packet tracer is a user-friendly tool? | 70 | 10 |
| Q4 | Do you understand how to configure the IP address, Subnet Mask and Port Status in Router, SSID Setup in Access Point? | 68 | 12 |
| Q5 | Do you understand how to make a physical configuration in Laptop with Linksys - WPC300N? | 80 | 0 |

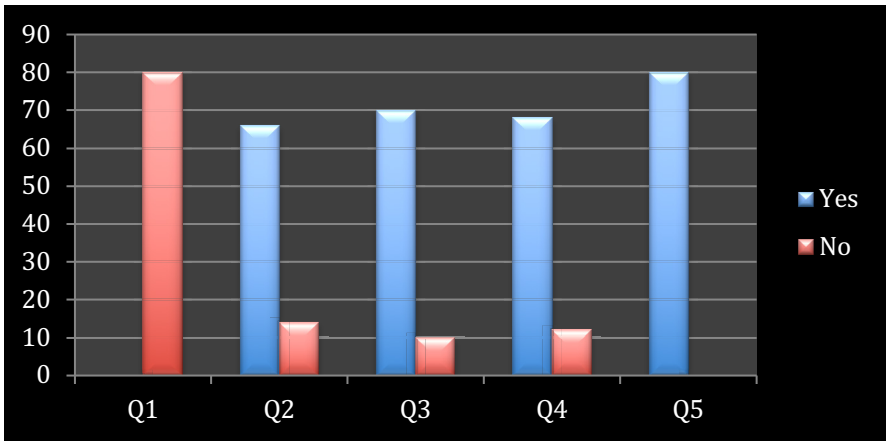


**Fig. 13.**Students Feedback Result Chart

## 4 Conclusion

Simulation is a rising subject recently, along with the methods and application techniques of simulation researching deeply, with digital computer the simulation to practice system or imaginary system has been more and more recognized. Because a lot of high and new techniques have progressed, as net technique, graphics and image technique, multimedia, software engineering, information processing and auto-control etc., these have expedited the progressing step of simulation technique [6]. Wireless network is complex concepts that are not easy to understand at first glance. To facilitate the teaching and learning process of Wireless networks, visual tools can be used. . Cisco Packet Tracer is a network simulator that can be used not just by students but also by instructors and network administrators. This software provides a wide range of Cisco switches and routers running on IOS 12 and IOS 15, wireless devices from Linksys, and several end devices such as PCs and servers with a command line. It is more than just a simulator and provides physical simulation as well as an assessment tool. The assessment tool can be used to create practical networking questions with a complex scoring model. The physical workspace provided can be used to determine the range of wireless devices

In this paper, we presented a well-known tool (Packet Tracer) that can significantly help students to become familiar with wireless networks. This tool allows users to do labs with several simulated access points with number of PCs or Laptops with wireless NICs, that is, without the need of a real and expensive devices and software like AP wireless routers etc. They have advanced GUIs to ease settings, and animations to facilitate the understanding of ideas. This tool enables a virtual look inside of a different configuration of wireless devices. Therefore, students can visually see and therefore more easily understand that what is really going on in the Wireless networks. We recommend the teachers, students, and networking professional to use this packet

tracer as a practical tool for improving their knowledge in networking both wired and wireless networking areas through virtual learning.

## 5 Acknowledgement

The authors would like to thank Scientific Research Deanship, King Khalid University, Abha, Kingdom of Saudi Arabia for supporting this study.

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# Educational Benefits of Using Business Strategy Game (BSG) in Teaching and Learning Strategic Management

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**Abstract**—In today's education system develop students with high level of competencies and capabilities are very challenging task for every instructor. Graduates are anticipated to possess a wide-ranging of competencies such as critical thinking, problem solving and cognitive skills to enter the job market. The world economic trend is changing swiftly creating more necessities towards the students to develop the ability to be expert, flexible and adaptable. That requires a revolution of teaching practices and learning techniques. Business strategy game (BSG) serves as a realistic representation of the actual practices in a virtual setting, and use it to cultivate managerial skills mainly in decision making. This paper explored the educational benefits of the game based approach in teaching and learning strategic management at School of Business Management, Universiti Utara Malaysia (UUM). Approximately, 21 strategic management students participated in this research. Overall, the respondents provided a positive response about the benefit of the game based approach in teaching and learning process. In a nutshell, this study increases the understanding about the educational benefits of using BSG in teaching and learning strategic management for UUM undergraduates.

**Keywords**—Business strategy game, game based approach, strategic management

## 1 Introduction

In today's education system, developing students with high level of competencies and capabilities are very challenging task for every educator. Students are anticipated to possess a broad range of skills; critical thinking, problem solving and cognitive skills to manage efficiently in their future workplace. The global economy is changing rapidly, which demanding ever more skills, flexibility and adaptability among the students. Nonetheless, the conventional approaches and techniques used in teaching business and management skills are insufficient to handle the difficulty of modern organizations and unpredictable market dynamics [1] [2] [3]. In order to survive in these unpredictable marketplace, students' need an innovative teaching method for business education. Business games permit management students to experience the competitive dynamics, common tendencies, business encounters, interdependencies,

and productivity drivers that are distinctive to an industry, and consequently, the business games are beneficial technique in the development of future human capital.

### 1.1 Research question and objective

This study explored the educational benefits of simulation game approach for teaching and learning strategic management offered by School of Business Management at Universiti Utara Malaysia (UUM). Approximately, 21 strategic management students participated in this research. The aim of this research is to present the findings on what are the educational benefits using a simulation game in teaching and learning strategic management for undergraduates at UUM. By answering this question, the researchers able to justify the simulation game as an innovative teaching method for business educators to teach a strategic management course.

## 2 Literature Review

### 2.1 Business strategy game (BSG)

Business Strategy Game (BSG) is a comprehensive online exercise game where the students run a footwear company in one-on-one rivalry against companies run by other classmates. Just as in the real world, companies strive in a global market, selling footwear's in four geographic regions; Europe-Africa, North America, Asia-Pacific, and Latin America. All features of the BSG are equivalent to the operative of the real-world footwear market, therefore permitting the students to think realistically and sensibly in determining what to do and acquire valuable practice in making a different business choice under situations that mirror real-world competitive conditions.

### 2.2 Business strategy game as innovative teaching method

Business simulation games combine the advantages of other methods, especially those focusing on student participation and decision-making. That is why they are considered as one of the most comprehensive methodologies that best grows the pedagogical skills of the users [4]. Students will learn to manage a business from the strategic management perspective, thus enlightening their ability for negotiation, as they will have to execute operations with other businesses and be able to formulate and implement competitive strategies. Hence, business games can be considered as a completed form of the case method to conduct a practical class.

Currently, the strategic management, teaching method is being criticized for being excessively emphasized on theoretical understanding rather than crafting strategic thinking, creativity and innovative skills [5]. Current hyper-competitive business environment requires highly talented human capitals to drive the business to achieve success. Apart from theoretical understanding, every strategic management student should possess additional skills, namely strategic thinking, decision-making skills, communication skills, and multidisciplinary knowledge.

Therefore, strategic management scholars suggested that simulation based approach is one of the best methods to teach strategic management effectively, where the student have opportunities to expose the real business world.

# 3 Methodology

## 3.1 Data sources and collection

This research used quantitative research designs to understand the benefits of simulation based approach in teaching and learning strategic management. The students were divided into 5 groups consisting of 4 to 5 students in each group. Students required to respond to a questionnaire at the end of the course. The reason of the questionnaire is to assess the educational benefits of the students towards a BSG approach in teaching and learning Strategic Management. Since, this is a classroom research, the research used census as the method to study the population. So, the instructor selected 21 strategic management students who registered for the instructor's class for semester A162, 2016/2017 session.

## 3.2 Instrumentation

The instrumentation for this research adapted from [5] and [6]. The survey is divided into 2 parts, namely

- Demographic profiles
- Understand the educational benefits of simulation game

This research used 5 point likert scale from strongly disagree/ highly ineffective to strongly agree/ highly effective. The frequency analysis of this study is created on the percentage of the agreed statements.

# 4 Findings

The majority of respondents were female (90.48%). 85.71% respondents were from semester 6. About 52.38% of the respondents were Malays and 33.33% were Chinese. 47.62% of respondents were from Bachelor of Accounting (Hons), 19.05% were Bachelor of Muamalat (Hons) and 14.29% were Bachelor of Business Administration (Hons). Table 1 clearly illustrated the demographic profiles.

**Table 1.** Demographic Profile

| | Frequency | Percentage (%) |
|---|---|---|
| ***Gender*** | | |
| Male | 2 | 9.52 |
| Female | 19 | 90.48 |
| Total | 21 | 100 |
| | | |
| ***Semester*** | | |
| 9 | 1 | 4.76 |
| 8 | 0 | 0 |
| 7 | 1 | 4.76 |
| 6 | 18 | 85.71 |
| 5 | 1 | 4.76 |
| Total | 21 | 100 |
| | | |
| ***Ethnicity*** | | |
| Malay | 11 | 52.38 |
| Chinese | 7 | 33.33 |
| Indian | 2 | 9.52 |
| Somalia (International) | 1 | 4.76 |
| Total | 21 | 100 |
| | | |
| ***Program*** | | |
| B.Acct. (Hons) | 10 | 47.62 |
| B.Sc. AgriBus. Mgmt. (Hons) | 1 | 4.76 |
| BBA (Hons) | 3 | 14.29 |
| BBA (Log.&Tpt.) (Hons) | 1 | 4.76 |
| BHRM (Hons) | 2 | 9.52 |
| BMA (Hons) | 4 | 19.05 |
| **Total** | **21** | **100** |

### 4.1 Educational benefits

The majority of the students provided positive response on the benefits of the business game in teaching and learning strategic management. The highest scores are acquiring new knowledge about business and management (100%) and the exercise added a lot of realism to the strategic management course (100%). Besides these two, students' also claimed that the simulation game is integrating the learning from functional areas (accounting, finance, strategy and marketing) (95.22%), increase ability to identify problems (85.72%), increase ability to solve practical problem (85.72%) and increase ability to communicate clearly and effectively with peers (85.72%).

Furthermore, students' also stated that this simulation game increases competency for planning business operations (81%) and motivate people who work with them (81%). The lowest score goes to increase ability to implement your decisions (28.56%), increase confidence in work independently (28.56%), add to ability to provide meaningful feedback to group members (28.56%), experiment with new behaviour (28.56%) and gain top management perspective on the operation of an organiza-

tion (28.56%). Table 2 shows the evidence that students' felt about the benefits of simulation game in teaching and learning strategic management.

**Table 2.** Education benefits

| Items | Agreed statement | Ranking |
|---|---|---|
| Acquire new knowledge about business and management | 100% | 1 |
| Integrate learning from functional areas (accounting, finance, strategy, marketing etc.) | 95.22% | 2 |
| Increase ability to identify problems | 85.72% | 3 |
| Add to understanding of how to seek and use information for problem solving. | 38.10% | 5 |
| Learn how to seek and use information for problem solving | 38.10% | 5 |
| Increase ability to solve practical problems | 85.72% | 3 |
| Increase competence for planning business operations | 81.00% | 4 |
| Increase ability to implement your decisions | 28.56% | 8 |
| Increase confidence in work independently | 28.56% | 8 |
| Become more aware of own feelings and beliefs | 38.09% | 6 |
| Become more aware of the feelings and beliefs of others | 38.09% | 6 |
| Add to ability to provide meaningful feedback to group members | 28.56% | 8 |
| Motivate people who work with you | 81.00% | 4 |
| Learn to help people resolve conflicts | 38.10% | 5 |
| Increase ability to communicate clearly and effectively with peers | 85.72% | 3 |
| Increase effectiveness as a participant in group problem solving | 33.33% | 7 |
| Experiment with new behavior | 28.56% | 8 |
| Learn new behavior | 33.33% | 7 |
| Gain top management perspective on the operation of an organization | 28.56% | 8 |
| Learn something important about yourself as a manager | 81.00% | 4 |
| The exercise added a lot of realism to the strategic management course | 100.00% | 1 |

## 5 Discussion

This paper presented an empirical test on the educational benefits of using a simulation game in teaching and learning strategic management. This paper shows that using simulation game in teaching and learning helps to acquire new knowledge about business and management. The students' felt that, this simulation game really gives realism to the strategic management course. Furthermore, this simulation game integrating learning from functional areas, which is really necessary when learning strategic management. The ability of identifying a problem, solving practical problem and communicate clearly with peers is very significant skills in strategic management because strategic management is entirely about decision-making. Thus, this simulation game explains about the application of strategic management concept and helps to translate this concept to practice.

### 5.1 Implications on teaching and learning

BSG is a hands-on learning exercise that pulls together the lessons of previous courses, combines knowledge about running a company. Students get some beneficial knowledge and practice in measuring business risk, investigating industry and competitive situations, making decisions from a company's extensive outlook, think cleverly about a company's market position and developing strategies and reviewing them in light of shifting environments, and applying what they have learned in business courses. Essentially, BSG is firming up the preparation for a career in business and management areas.

In addition, the BSG makes the students' more competitive and have a lot of fun. Utilizing game based approach in teaching and learning strategic management course will create numerous benefits than the traditional teaching methods. This experimental learning approach will develop the cognitive perspective and essential motivational mechanism. The possible advancement in business simulations is enormous, and it will really enhance the students' participation.

Past studies suggested, that game based approach should not be looked as an alternate but game based approach is should be considered as a main pedagogy that will efficiently enrich the knowledge [7]. Without doubt, the application of the game based approach will strengthen strategic management, teaching and learning as well as produce highly skilled managers to the job market.

## 6 Conclusion

This paper suggested that game based approach is one of the best methods to teach strategic management effectively, where the students' have opportunities to expose the real business world. The usage of information technology is vital in planning new methods of teaching [8]. The use of simulation games as a pedagogic method is well established though its effective use is context-driven [9].Recent study found that computer based simulation games can be beneficial and may lead to better learning outcomes, skills acquisition as well as enhance students' team work through team based learning. [10]. Previously, lecturers tend to use face-to-face lectures and exam based evaluation. But, these methods brought some undesirable benefits among students, where they tend to perceive that general decision framework is applicable for any industry and situation. In a nutshell, this study increases the understanding about the educational benefits of using a simulation game (BSG) in teaching and learning strategic management for UUM undergraduates.

## 7 Acknowledgement

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# Expertise in the Selection of Electronic Educational Resources – Conceptual Vision

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**Abstract**—The current stage of training of pedagogical specialists is associated with the search for opportunities for the continuous development of their digital competences. It is viewed as a dynamic system that integrates the constantly expanding set of competencies given the dynamic development of information and communication technologies and the requirements for training in a digital environment. The main component (competency) in the digital competency profile of pedagogical specialists is the expertise in the selection and combination of electronic educational resources for the creation of a dynamic technologically enriched digital environment, which guarantees higher quality of education and consequently – highereducational results. This article presents an author's system of criteria and indicators as a conceptual vision for expert evaluation of electronic educational resources, which can be enriched and expanded in a technological and methodological context.

**Keywords**—Digital competency, electronic educational resources, selection and experts' knowledge.

## 1 Introduction

Enhancing the quality of education and training of pedagogical specialists is an issue that is gaining momentum and relevance.Its solution is increasingly associated with the use of information and communication technologies, given the spread of modern technologies and learning environments such as: learning in virtual and digital environments, cerebral-compatible environment, project-based training, problem training, discovery/research training, electronic and mixed training, computer-based cloud training, virtual and reversed classrooms, Web 2.0 training technologies, etc.

The digital educational environment is an opportunity for transformation of education into an open one, which according Y. Rasheva-Merdjanova's understanding [1] is a dynamic state of the educational system. In her opinion, it is genuinely ready (in a legal, resource-based and personal aspect) to flexibly determine the entry-transition-exit of that state (in their conventions) through a balance between age, socio-demographic, socio-cultural and personality parameters with flexible mechanisms for legitimate free (and regulated) movement across its borders. Such an open mode of training can be realized through a transformed flexible balance between the functions

of the trainers and trainees, which leads to their real participation in the traditional functions of information, organization, and evaluation, to a real participation of the social partners, as well as to opening up (transformation) of all the components of the process (open content, open methods, open learning environment, open homework, open evaluation) – they become its mechanisms for providing the educational environment [1].

This directs the attention initially to the possibilities of integrating training in digital environments and traditional learning as complementary in the context of the concept of mixed learning and, consequently, to digital transformation in education that guarantees its continuity. However, learning in digital environments far exceeds a mere auxiliary role in traditional learning and cooperative learning. This is *because digital learning is basically multisensory, multimedial training that aims to* form and empower students' ability to simultaneously process, transform and use information coming from their various sensor systems in the process of learning and problem solving by organizing the learning content and the didactic environment of multisensory principle. The result will be a development of multi-sensory competence, metathinking (cognitive-affective) and behavioral strategies [2].

The concept of *multisensory learning in a digital environment* affects all elements of the didactic system: defining goals, selecting content, organizing and implementing the learning process, diagnosing results, responding to social needs for successful realization.

Learning in a digital environment implies compliance with the following new versions of learning principles considered as hypothetical grounds for designing and implementing learning:

- Training is facilitated when solving real problems and tasks;
- Training is facilitated when new knowledge and skills are based on old ones;
- Training is facilitated when new knowledge and skills are demonstrated and affirmed by the students;
- Training is facilitated when new knowledge and skills are applied by the students;
- Training is facilitated when new knowledge and skills are integrated and transferred to new conditions;
- Multilateral support of intellect, interest, emotions and motivation;
- Reflection of learning;
- Balanced arrangement for the participation of teachers and students in the training;
- Optimization, efficiency and self-managed learning;
- Accessibility and response to expectations;
- Clarity, simplicity, flexibility and adaptability of the instructions;
- Complex learning environment for authentic activities [3].

The prospects for the development of educational technologies are associated with the possibilities of integrating the different media for presenting information, i.e. turning them into multimedia technologies in the context of multisensor learning in a dynamic, continually enriching educational digital environment. Electronic learning resources complement this perspective by making it realistic and synergistically possible in the conditions of a technologically enriched environment by deliberately ap-

plying multimedia technologies and integrating the different media for presenting information and provoking different senses and activities. This requires pedagogical specialists to adopt a different approach with respect to the planning and design of the educational environment and the realization of the training itself. Therefore, the digital competence of pedagogical specialists is an essential component of their overall professional profile considering the digital transformation in education. As a system of competencies, the digital competence of the pedagogical specialists integrates knowledge and skills to efficiently apply information and communication technologies, and work in a digital environment at different levels: basic, pedagogical, methodical, personal, which in turn ensure the realization of professional roles in technologically enriched environment. In the exercise of professional activity and in the context of the educational process, pedagogical specialists often face challenges related to the selection and combining of different electronic learning resources in traditional training or the creation of a technology-enriched learning environment. Therefore, the expertise in the selection of electronic educational resources appears to be a core component of the digital competence of pedagogical specialists.

## 2 Conceptual Framework for Evaluation

Electronic resources can perform and often perform integrated functions in the educational process: informational, cognitive, systematizing, forming, developing, exercising, reflexive, translating, transforming, prognostic, controlling-evaluative, sociocultural, etc.

The selection of electronic learning resources can be specified in the context of cognitive activities of the subjects – i.e., at the reproductive level, cognitively-productive level, coding, decoding or transcoding, reflexive level, self-knowledge level, etc. Although all these didactic and methodical projections of a full-fledged expertise deserve attention, the present study examines the technological and general-dimensional parameters (criteria and indicators) in the selection of electronic learning resources, which can be complemented in different directions in a private-didactic (methodical) context.

There are a number of publications offering frameworks for evaluating e-learning resources, some addressing the digital educational resources more generally [4, 5], while others focusing mainly on web-based resources [6, 7]. In most cases, the criteria are categorized in terms of functional, technical and aesthetic aspects, as well as pedagogical-didactic ones.

The conceptual framework proposed by the authors comprises six main points of view:

- Technical
- Functional
- Pedagogical
- Didactic
- Social
- Content and structure aspects

Which form the basis for specifying basic criteria and indicators for expert evaluation of the electronic educational resources in the context of their selection by the pedagogical specialists. Each of these aspects can be viewed as general or personal. The personal aspect is a projection of the instructors' personal perception of the characteristics of the digital resource. For example, while the technical parameters are common and display no variation in personal perception and evaluation, most of the functional parameters are perceived individually. On the other hand, each of these aspects cannot be considered on its own, since there are certain formal dependencies between them which determine the evaluation parameters. For example, the technological development determines the variations in functionality, which in turn affect the structure and content, etc.

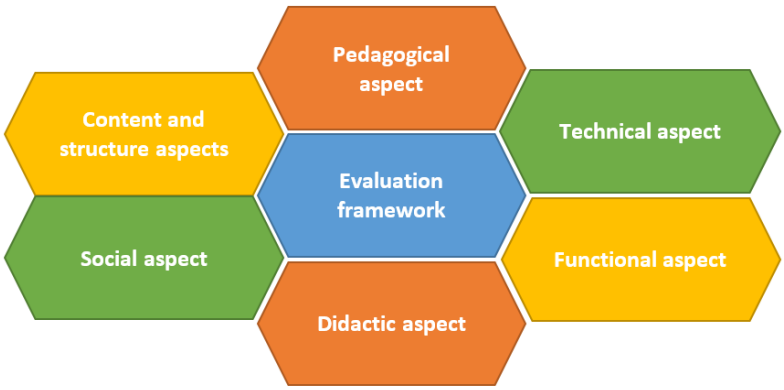


**Fig. 1.** Conceptual framework for evaluation

Content is the main element of the e-learning resource. It encompasses a set of ideas, messages, and knowledge that you pass on to learners. Structuring the content, *navigational accessibility*, *annotation (tagging)* and *indexing*, as well as the full coverage of content through *mechanisms for search* and discovery of individual elements of the content, are defining functional characteristics that influence its structural build-up. With regard to the content itself – its *relevance* and *timeliness* at the time of use, as well as the *reliability* and *credibility of the sources* on which it is based. There are four types of utilization of digital resources [5] – pure, pure/combined, adapted and dynamic. However, the use of digital resources must also be in line with the *license restrictions* imposed by their creators. Although educational resources are largely promoted as licensed with Creative Commons license[1], their modification and distribution is often limited. Paid digital resources are also license-limited, but for them, price-affordability is a determining parameter as well. Achieving maximum accessibility of education and the integration of learners with special educational needs imposes additional functional requirements on the digital educational resources – in terms of functional design, *interface*, *usability*, *intuitiveness*, etc.

1https://creativecommons.org/

The manipulation and interaction are key aspects of the effective learning resources: through interaction practitioners build their own understanding and use of resources; and by including digital assets or information objects in an interactive framework, practitioners ascribe educational goals and values to them by creating learning activities or projects [5].

Pedagogical aspects are related to the conceptual model (as a conceptual structure) and the approach to the design of electronic learning resources as pedagogically meaningful ones. Pedagogical aspects are seen from the position of approaches to the realization of the specific technological solution in the specific electronic educational resource and the possibilities for its categorization and standardization, namely:

- Goal-oriented
- Process-oriented
- Results-oriented
- Student-oriented (facilitated) - centered on learning
- Centered on teaching (coaching oriented)
- Oriented towards cooperative learning or interaction
- Hermeneutically-oriented (towards explanation, interpretation)
- Behavior-oriented
- Cognitively-oriented
- Constructivist-oriented
- Connectivistically-oriented, and so on

The didactic context of expertise generally comprises the complex of tools for the effective use of electronic educational resources in the following directions:

- Management-regulatory
- Intellectual-cognitive
- Informational-communicative
- Practical application
- Heuristic, research
- Social-cognitive
- Control/evaluative-resultant
- Situationally-constructive
- Intuitive-associative
- Problematic
- Adaptive, inclusive

The specification of the proposed aspects as basis for a conceptual framework for evaluation of the electronic educational resources is the reason for formulating a set of core criteria and indicators for their expert assessment, presented in Table 1.

**Table 1.** Conceptual framework for evaluation of the electronic educational resources as integrated multi-layer polyfunctional product.

| Criteria | Indicators for evaluation |
|---|---|
| Technical applicability | hardware and software compatibility<br>accessibility (remote, authentication-authorization, independent access)<br>required storage and maintenance infrastructure<br>access time<br>accessible to external users<br>platform/media dependency |
| Functionality and reliability | options for search and extraction of information<br>options for availability of export and download<br>options for annotation (tagging), sorting and classification<br>intuitiveness of the interface<br>suitable navigation<br>content licensing terms<br>degree of functional and technical personalization<br>relevance to people with SEN (special educational needs),<br>relevant level of gender, ethnic, cultural and social integration<br>use by embedding and interaction |
| Access to the electronic resource (options and transformations) | it is not online-offline<br>providing information only<br>unidirectional interaction<br>two-way interaction<br>transaction and integration of options<br>multi-channel access |
| Overall design of the electronic resource | usefulness of the content<br>degree of specification<br>degree of integration<br>constructive grouping<br>number of media integrated in the course |
| Design of learning via the electronic resource | predominant learning strategy (satisfying/minimizing; optimizing, maximizing, algorithmic, heuristic, perspective, situational)<br>stimuli<br>potential reaction options<br>support<br>level of personalization |
| Content design – organization | map of the resource<br>map of the content – static nature, dynamism, functionality, interactivity<br>use of quick links and metaphors<br>horizontal content correlation (within one cognitive level)<br>vertical content correlation (between different cognitive levels) |

The modernization of present-day education is directly related to its digital transformation. The digital children and students require new approaches and continuous search for opportunities to create an enriching and interactive digital environment. All this in the context of Europe's Digital Agenda[2] strengthens the interest towards a new

2Key Data on Learning and Innovation through ICT at School in Europe 2011, http://eacea.ec.europa.eu/education/eurydice/

vision for the continuous expansion of e-Skills upgraded to digital literacy and consequently to digital competence. All of these challenges related to digital, distant, mixed and mobile learning are the subject of author's searches [8, 9]. The digital environment is highly heterogeneous, resulting in problems with technological compatibility and platform constraints. These are also some of the elements of the technical category parameters for evaluation of digital educational resources.

All of this draws attention to the search for opportunities for comprehensive expertise on the part of the pedagogical specialists of electronic educational resources so as to ensure the fulfillment of their basic functions, namely informational, forming, developing, exercising, evaluating, self-assessing, reflexive, socio-cultural. This makes their vision for the assessment of electronic learning resources as part of their digital competence, particularly important for the full utilization of the latter in the educational activity with students in different educational degree programs and stages.

## 3 Criteria for Expertise in the Selection of Electronic Educational Resources – Pedagogical Specialists' Viewpoint

The study is directed towards examining the perspective of the pedagogical specialists with respect to the main criteria and indicators used to assess the expertise in the selection of the electronic educational resources. The subject of the study is the expertise in the selection of electronic educational resources. The objective of the study is to determine the significance of the criteria and indicators for evaluation and selection of electronic educational resources as elements of the summarized expertise.

The empirical study is conducted through an expert assessment where pedagogical specialists rank their preferences for the criteria and indicators for the expertise of the electronic educational resources in the context of their application in the educational practice. A contingent of the research are37 pedagogical specialists working in different stages and levels of school education.

The expert opinion of the subjects included in the empirical study focuses on the search for opportunities for better hardware and software compatibility, a top priority indicator (ranked first by 48% of the respondents) in terms of technical feasibility as evaluation criteria of e-learning resources. Accessibility of e-learning resources is a determinant (ranked second) for 45% of the experts and access time is for 33% of them. Particular attention is also paid to the necessary storage and maintenance infrastructure. The intuitiveness of the interface of the relevant electronic learning resource is highlighted by 41% of the surveyed experts, while 33% of them put the export and download capabilities as the most important functionality. For 30% of the experts, the possibility of annotation, sorting and classification, as well as the proper navigation in e-learning resource (26%) is the third priority.

Experts determine as most significant indicator in the access to e-resources (capabilities and transformations) criteria bidirectional interaction (41%) and multi-channel access (33%), followed by transaction and opportunity integration (30%).

The degree of integration is decisive for the overall design of the electronic resource and is related to the preference of 26% of the experts, whereas for 29% of

them the second place in the ranking is the degree of specification followed by the constructive grouping.

The predominant learning strategy predetermines the selection of the e-resource for 67% of the experts, while the potential response opportunities are ranked second by 30% of the respondents followed by the level of personalization. There is a clear trend of preference for the high degree of resource subjectivization and increased opportunities for personalization of activities in and through them. Content map evaluation determines the resource's relevance to the design and organization, followed by a resource map and the use of quick links and metaphors, in other words, more and more it relies on dynamic performance and rapid orientation.

With the highest factor weight (0.82), expert judgment to benchmark the criteria for evaluating electronic learning resources is access to the electronic resource, followed by its functionality, reliability and technical feasibility. Explained as significant is the possibility of designing learning, based on the relevant electronic learning resource - Figure 2.

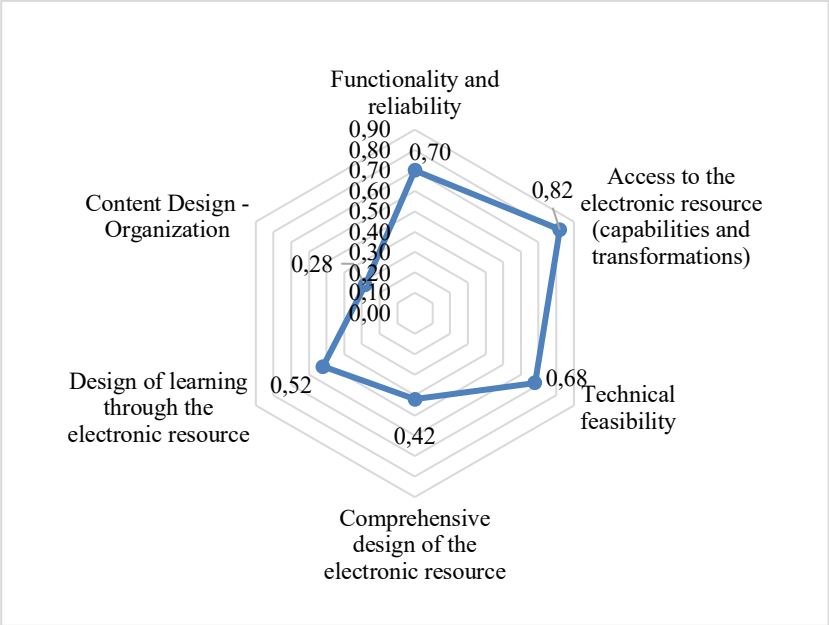


**Fig. 2.** Breakdown of factor weights

## 4 Conclusion

The overall study focuses on the search for ways to develop the expertise of pedagogical specialists regarding the selection and evaluation of electronic learning resources as an integral part of the didactic and methodical means of learning in different educational stages and grades. Given the degree of development of information

and communication technologies, this type of competence occupies an increasingly important place in the professional profile of the teacher and determines his success in the classroom and beyond in the overall educational process. Technological and content expertise is at the forefront, and it is becoming increasingly important to reflect and expand the opportunities to implement increasingly diverse learning strategies through the various electronic learning resources. Therefore, as technology advances, in addition to accessing e-resources and content design, navigational capabilities, levels of intuitive interface and personalization, degree of integration, caution and research prospects should focus on the design of learning. All this in the conditions of development of the competence of the pedagogical specialists regarding a complex expertise of the electronic educational resources will guarantee their more purposeful and systematic use in the educational process as well as their continuous improvement according to the applied learning strategies in their diversity.

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# Improving Cognitive Decision-Making into Adaptive Educational Systems through a Diagnosis Tool based on the Competency Approach

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**Abstract**—Adaptive Educational systems (AES) does not necessarily lead to a better learning. Several kinds of research reveal that the problem is due to, on the one hand, the accent is put mainly on the technological tools to the detriment of the pedagogical aspect. On the other hand, there is a lack of the importance given to the assessment which is an integral part of the learning-teaching process and the professional act of primary importance which gives the decisions and the consequences that result from it.In this paper, we propose a solution for the diagnostic evaluation based on competency approach especially on the pedagogy of integration. The proposed solution allows getting information about the available learners' knowledge level by presenting an assessment based on the common definition given to competencies by the majority of the authors of the domain. İn this context, the assessment process proposed is presented on two steps: the first step, we evaluate resources related to the competence to verify their acquisition degree and to remediate if necessary, the second step will evaluate the capacity of leaner to mobilize those resources in order to apprehend a situation and respond to it in a more or less relevant way. This research aims to present a new vision in the context of the assessment into adaptive educational systems.

**Keywords**—Assessment process, competencies, ontologies, the pedagogy of integration, adaptive educational systems, knowledge level, learning style.

## 1 Introduction

Adaptive Hypermedia Educational systems (AHES) inspect learners 'characteristics and make appropriate adjustments to support learning. The main goal of AHES is to flexible environment that supports learning for students with a range of abilities, disabilities, interests, backgrounds, and other characteristics. The challenge of accomplishing this goal depends largely on accurately identifying characteristics of a particular learner or group of learners – such as type and level of knowledge, skills, personality traits, affective states – and then determining how to leverage the information to improve student learning [6-8].

In AHES, the form of a user knowledge model is the scalar model, which estimates the level of user domain knowledge by a single value on some scale – quantitative (a number ranging from 0 to 5) or qualitative (good, average, poor, none).Scalar models, especially qualitative, are quite similar to stereotype models. The difference is that scalar knowledge models focus exclusively on user knowledge and are typically produced by user self-evaluation. Despite their simplicity, scalar models can be used effectively to support simple adaptation techniques in AHES. These systems divide their users into two or three classes according to their knowledge level of the subject (i.e., expert, intermediate, and novice) and serve different versions of the whole page content or page fragments to learners with different levels of knowledge. [8]

In other words ,the results of a diagnostic or formative assessment are translated by an affectation of a learner cognitive profile according to a score. Learners who had the same score have the same cognitive profile and also the same remedial activities. In this case, learners who have the same score, even if they have different learning deficiencies, get the same remediation since the score brings the same information; and it is here where resides the whole problem of the adaptation in terms of the remedial activities' content.

Although, Evaluation has to improve the learning process, by providing an efficient diagnostic, to identify learning difficulties, in order to precise the real knowledge level, and this latter is one of the several important factors to be considered by designers of adaptive educational systems; This article describes the design of an assessment process into an AHES which gives more importance in the specification of learners 'needs.

Our proposition is based on the competency approach and on the pedagogy of integration to specify - for an evaluated competency- the acquired & the non-acquired resources and then the capacity of their mobilization to apprehend a situation and to resolve it in a more or less relevant way.

This contribution presents a continuity of our previous work [9-11], and aims to define the knowledge level of learner in a reliable and valid way: It aims to diagnose effectively the learners' needs and use that information to build a dynamic profile for each learner and leverage an appropriate support.

## 2 Theoretical Foundation and Adopted Approaches

### 2.1 Presentation of a competency

Most authors today tend to agree on the definition of a competence as the spontaneous mobilization of a set of resources in order to apprehend a situation and respond to it in a more or less relevant way [12-17]. Based on this definition, we can present the competence as (figure1):

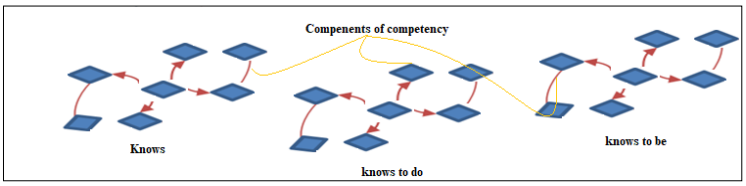



**Fig. 1.** Competency Components

## 2.2 The conception of learning activities according to the pedagogy of integration [18]

In the competency approach, there are essentially two moments in learning: -Specific learning of resources: resources are the subject of specific learning, and it is a priority to develop competency resources. -Integration activities and formative evaluation: The second part of learning time is reserved for what we call "integration activities", it is dedicated to teaching the learner to mobilize his resources in complex situations. This integration can be done gradually, or at once, in an important module, called "integration module".

As example, we represent a competency which requires the development of 7 specific objectives, or resources. Integration can be achieved in two ways.

**Progressively:** During the learning (table1)

**Table 1.** Progressive integration

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Obj1 | Obj2 | | Obj3 | Obj4 | | Obj5 | Obj6 | Obj7 | Integration Module |

Partial integration

At the end of learning (table2)

**Table 2.** Integration at the end of learning

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Obj1 | Obj2 | Obj3 | Obj4 | Obj5 | Obj6 | Obj7 | Integration Module |

The first way proceeds by progressive integration. It is richer, but it is not always possible.

The integration module is followed by a formative assessment module. To conduct the formative assessment, a family of complex situations related to a competency is presented to the learners.

## 2.3 Competency assessment

Whatever is their reference frame, anyone who inscribes their reflection, or their pedagogical practice, in the competency-based approach agree today that they are exercised when it is a question to solving problem situations requiring the

mobilization of several resources. Whether it is for the learning competencies or for their evaluation, it is thus advisable to place the learner in a complex environment and to require from him the mobilization of its various resources to solve a complex situation.

The purpose of a competency assessment is to assess the learner's ability to mobilize a set of internal and external resources through complex tasks called an assessment situation. This approach can be applied in the context of a summative evaluation which takes place at the end of a learning for certification purposes. If a learner does not succeed in this evaluation, the adoption of this approach does not allow to specify its difficulties, its strengths and even the component responsible for this failure.

To overcome this limitation, we opt in our diagnostic tool for a competency assessment on two phases as it's represented in figure2.

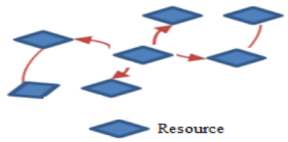
| | | |
|---|---|---|
| Phase1<br>Resources Assessment | Specific validation of the resources, phase which allows ensuring the acquisition of each resource |  |
| Phase2<br>Assessment of the capacity of resources' mobilization | after validation of the acquisition of the resources, the learner is led to mobilize his acquired resources |  |

**Fig. 2.** E-assessment based on competency approach

## 3 Proposed Diagnostic Tool

### 3.1 Pedagogical apport

In most educational systems, learners use tutoring sessions to prepare for exams or competitions. After completion of a learning module, either face-to-face or online, learners use tutoring sessions to overcome their difficulties or to consolidate their learning.

In order to achieve the objectives envisaged by the tutoring, our proposed tool is used to specify in an efficient manner the needs of each learner and select the appropriate content' remediation.

After determining the appropriate content of the remediation activity, in terms of resources and their mobilization, the activity will be presented according to its learning style (using a measuring instrument). With those characteristics, this tool allows to improve the learning-teaching process in different ways:

- **For the learner:** Being exposed to a content that suits his profile and that targets the knowledge he lacks, by using an optimal pedagogical approach that keeps the

learner in his proximal development zone (PDZ)[1],he is more likely to perceive his learning as relevant and challenged and he focuses on notions he does not master and he devotes all his energy to the learning he needs.

- **For the tutor/teacher:** The tool provides precious information that allows him to identify what knowledge and skills he would develop with his learners. Thanks to the collected data, this tool allows him to know if the invested efforts in training report as desired or it is necessary to adjust the shot.
- **The proposal diagnostic tool** is to use in the context of supporting at the tutoring session that means learners who use it are already did and finished their learning sessions, the objective is to support and respond to their specific needs:

### 3.2 Overview of assessment ontology

In the classical assessment approach, the questions cover the whole of a module, unit, chapter or lesson according to the object of assessment. But there are no links between the questions and specific concepts to evaluate. The presentation of relations between specific concepts allows having more indicators and information about their acquisition degree.

To represent the relationship between those elements, we adopt, in our approach, the semantic web ontologies by the advantages they offer in terms of complete and semantic formalization of information. For this, we have conceived a competency assessment ontology which aims to represent the evaluation of a competence under an interoperable form to guarantee its reuse and sharing between different learning platforms.

Our ontology describes relations between the competencies ‘component, questions and the objects to evaluate. So, to validate a specific concept, the learner must answer the questions related to this concept and concepts in relation with, which leads to a more relevant evaluation. (figure3)

Vygotsky introduce the PDZ as “the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance, or in collaboration with more capable peers”.

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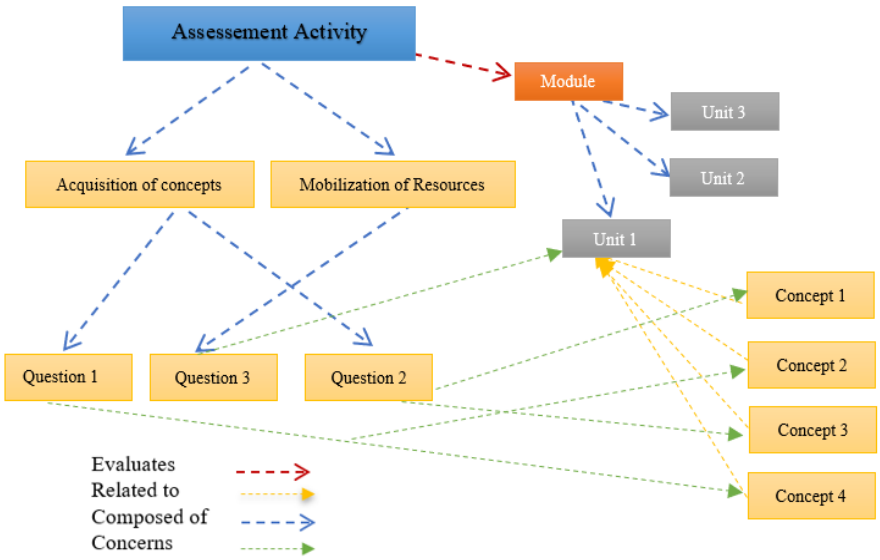



**Fig. 3.** E-Assessment Ontology

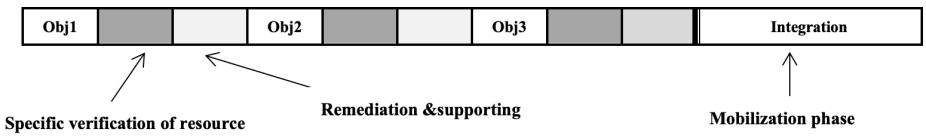
### 3.3 Algorithm for a specific competency assessment

By adopting the competency approach, there are essentially two moments in learning:

- **Specific learning of resources**: resources are the subject of specific learning, and it is a priority to develop competency resources.
- **Integration activities and formative evaluation:** The second part of learning time is reserved for what it calls "integration activities", it is dedicated to teaching the learner to mobilize his resources in complex situations. This integration can be done gradually, or at once, in an important module, called "integration module.

From this optic, our approach consists oDf treating each component of competence as a separate entity; each component is evaluated and supported if necessary. Then we go on to assess the mobilization of those components in an integration module as it represented in table 3.

**Table 3.** Assessment timeline



Based on what is already presened, the assessment process adopted in our approach is represented in figure 4.

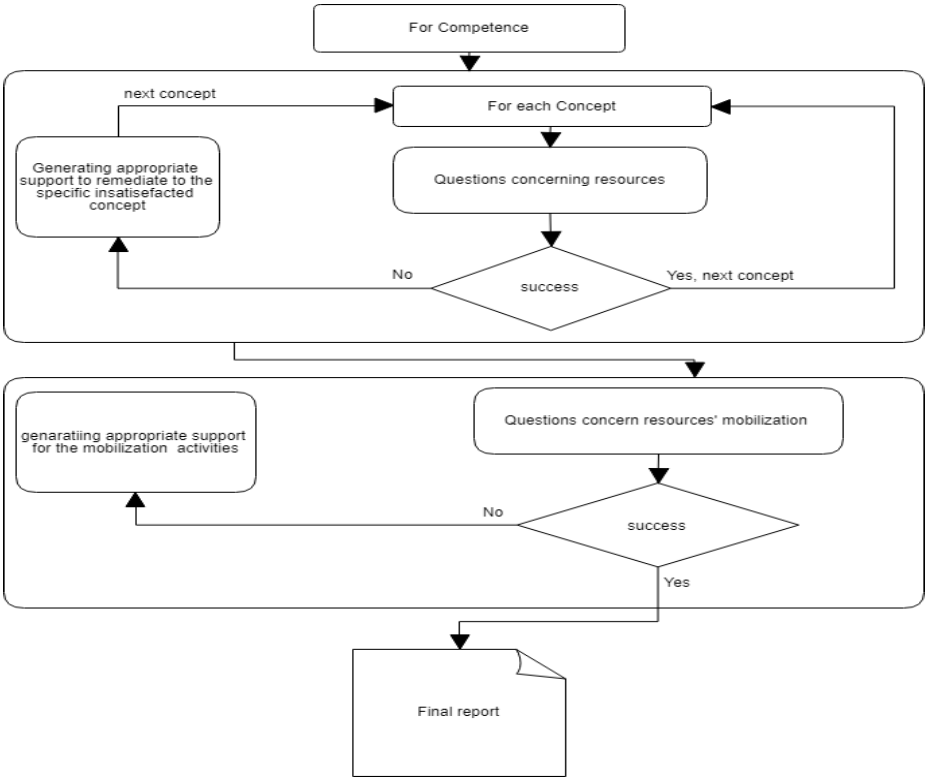



**Fig. 4.** E-Assessment Process

At the end of the process, a final report will be generated, containing information about the learner 'progression, learning2 path adopted and more relevant information which will be very useful for the learner, for the teacher and can be reused by the system for next users (to adopt same supporting for other learners with the same initial state).

## 4 Integration Into An AEHS

### 4.1 Architecture of AEHS

In general, the architecture of educational adaptive systems (AEHS) comprises two layers: the storage and execution layer.

**The storage layer** is the main engine that controls the adaptive process whose main tasks are:

- Initialization and update of the learner model
- The choice of domain model concepts, learning resources by applying specific rules.
- Storing the learning resources, domain ontologies, the model of the learner, etc.

**The execution layer** is responsible for the presentation of the adaptive learning material to the user and the observation of the user's actions so as to update the learner model.
Figure 4 represents the architecture of AEHS [19]

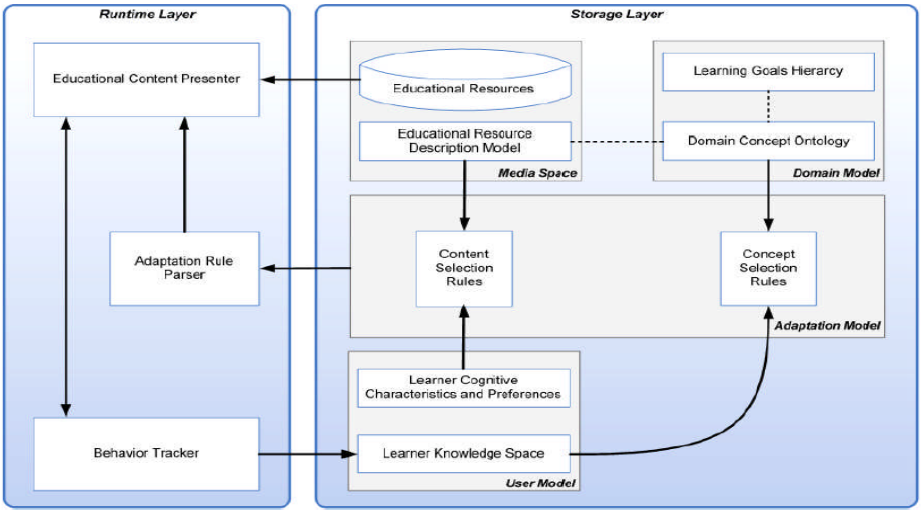



**Fig. 5.** Architecture of Adaptive Educational systems[19]

- **Domain model** structure of knowledge domain which is often referred to as a graph. Several researchers intend to build the domain model by using ontologies.
- **Media Model** contains learning resources and associated descriptive information (metadata).
- **Adaptation model** is the main component that gives effect to adaptation. It contains content and concepts selection rules. By applying these rules in content selection, it helps us choose the appropriate educational resources from the internal model. On the other hand, the concept selection rules are used to select the appropriate notions of the domain model. These rules must comply with a user model so that the selection becomes correct.
- **User Model** contains information and data about the user.

### 4.2 Integration module

Including interoperability and reusability characteristics, our diagnostic tool can be integrated into an AES and can improve its adaptation at the level of the learner knowledge level and its learning styles. (figure5)

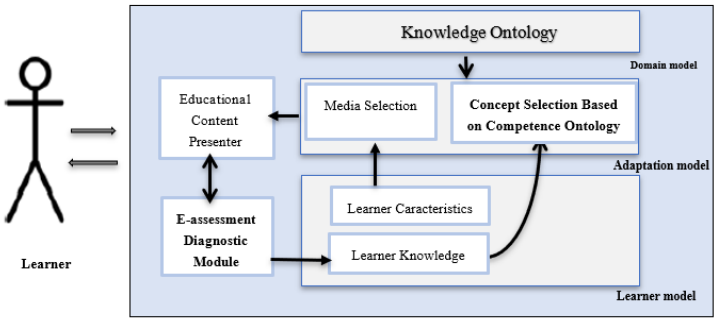



**Fig. 6.** Integration of our diagnostic module into AHES

## 5 Conclusion and Further Work

In a situation of formative evaluation, the specification of learner's source of errors and overcome their in a real time is the key of any adaptation: The adaptation must first take into account the content of the activity to present for the learner and then the way it will be presented (according to his learning style); we present in this article a novel view of assessment which could be exploited into adaptive educational systems and e-learning platforms in general. The proposed tool allows to specify for each learner the adapted content and then the way to present it according to their preferences and their learning styles.

Our working now is focused on the implementation of the tool, as future work, an experiment of our Assessment tool with learners in a real situation in a defined domain.

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