NEAR EAST UNIVERSITY
INSTITUTE OF GRADUATE STUDIES
COMPUTER EDUCATION AND INSTRUCTIONAL TECHNOLOGY
DOCTORAL PROGRAM

THE EFFECTS OF GAMIFIED FLIPPED LEARNING ENVIRONMENT ON STUDENT'S INNOVATION SKILLS, SELF- EFFICACY TOWARDS VIRTUAL PHYSICS LAB, AND PERCEPTIONS

PhD Thesis

Hana Dler AHMED

Nicosia, 2021

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Nicosia, 2021

Approval

We certify that we have read the thesis submitted by Hana Dler Ahmed titled "**The Effects of Gamified Flipped Learning Environment on Student's Innovation Skills, Self-Efficacy Towards Virtual Physics Lab, and Perceptions**" and that in our combined opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Doctor of Educational Sciences.

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Declaration

I hereby declare that all information, documents, analysis and results in this thesis have been collected and presented according to the academic rules and ethical guidelines of Institute of Graduate Studies, Near East University. I also declare that as required by these rules and conduct, I have fully cited and referenced information and data that are not original to this study.

Hana Dler AHMED

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Hana Dler Ahmed

Dedication

All praise to Allah for lighting up my path to reach where I'm standing now, for gifting me a wonderful parent who I'll forever be thankful for, leading my way to success and gave most of their time helping and advising me. Because of all these, I am proudly dedicated to this achievement and others with the support of my parents, lovely teachers, friends, and every person who helped, or shared my way. Thank you all, God bless you!

Abstract

The Effects of Gamified Flipped Learning Environment on Student's Innovation Skills, Self-Efficacy Towards Virtual Physics Lab, and Perceptions

Ahmed, Hana Dler

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The significance of university courses that consist of laboratory sessions cannot be over-emphasized. They have extreme importance in Physics education due to the fact that they hold the role of providing a detailed understanding of the theoretical course subjects which have been described in the class to the students. However, since the advent of the COVID-19 pandemic, various educational parastatals have altered their instructional approach, causing it to be carried out remotely and digitally globally. The effect of this challenge did not impact theoretical courses alone, rather, both practical and theoretical courses were moved to digital platforms.

Using a virtual physics lab course, this study investigated the effects of the Gamified Flipped Learning (GFL) method on students' physics self-efficacy and innovation skills. The study was carried out with true experimental design and the participants were a total of 70 first-year engineering students, which were randomly divided into two groups. The experimental group was trained using the GFL method, while the control group was trained using the Classical Flipped Learning (CFL) method. Using pre-test and post-test evaluation, data was collected through a physics self-efficacy questionnaire, innovative skills questionnaire, and through the conduction of semi-structured interviews. The research results showed that GFL method has a positive impact on the innovation skills of students although insignificant improvement was introduced by gamified-flipped learning on students' self-efficacy.

In addition, the interviews with the students revealed a positive perception of gamification, as they specifically identified crucial aspects of the implementation that were extremely beneficial to them.

Keywords: flipped learning, gamification, innovation skills, self-efficacy, virtual lab

Özet

Laboratuvar oturumlarından oluşan üniversite derslerinin önemi ne kadar vurgulansa azdır. Sınıfta anlatılan teorik ders konularının öğrencilere ayrıntılı olarak anlaşılmasını sağlama rolü üstlenmeleri nedeniyle Fizik eğitiminde son derece önemlidir. Bununla birlikte, COVID-19 pandemisinin ortaya çıkmasından bu yana, çeşitli eğitim kurumları öğretim yaklaşımlarını değiştirerek uzaktan ve dijital olarak küresel olarak yürütülmesine neden oldu. Bu zorluğun etkisi sadece teorik dersleri etkilememiş, hem pratik hem de teorik dersler dijital platformlara taşınmıştır.

Oyunlaştırılmış Ters Yüz Öğrenme (OTÖ) yönteminin öğrencilerin fizik öz-yeterliği ve yenilik becerileri üzerindeki etkilerini araştıran bu çalışma sanal bir fizik laboratuvarı dersinde uygulanmıştır. Gerçek deneysel desende yürütülen araştırmanın katılımcılarını rastgele iki gruba ayrılan toplam 70 mühendislik birinci sınıf öğrencisi oluşturmuştur. Deney grubu GFL yöntemiyle, kontrol grubu ise Klasik Ters Yüz Öğrenme (KTÖ) yöntemiyle eğitilmiştir. Çalışmanın verileri, ön test ve son test değerlendirmesini kullanarak, fizik öz yeterlik anketi, yenilikçi beceriler anketi ve yarı yapılandırılmış görüşmeler yoluyla toplanmıştır. Araştırma sonuçları, oyunlaştırılmış ters-yüz öğrenme ile öğrencilerin öz yeterlikleri üzerinde önemsiz bir gelişme sağlanmış olmasına rağmen, OTÖ yönteminin öğrencilerin yenilik becerileri üzerinde olumlu bir etkisi olduğunu göstermiştir.

Ayrıca, öğrencilerle yapılan görüşmelerde, uygulamanın kendileri için son derece faydalı olduğunu belirtmişler ve oyunlaştırmaya karşı olumlu yaklaşımları olduğu ortaya çıkmıştır.

Anahtar Kelimeler: ters yüz öğrenme, oyunlaştırma, inovasyon becerileri, öz-yeterlik, sanal laboratuvar.

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List of Abbreviations

CFL:	Classical Flipped Learning
FLM:	Flipped Learning Model
GFC:	Gamified Flipped Classroom
ICT:	Information and Communication Technology
LDH vLab:	Lactate Dehydrogenase Virtual Lab
LMS:	Learning Management System
SFL:	Simple Flipped Learning
SPSS:	Statistical Package for the Social Sciences
VEMA:	Virtual Electric Manual
VISIR:	Virtual Systems in Reality
VL:	Virtual Laboratory

CHAPTER I
Introduction

The traditional teaching approach has been significant to educators for an extensive period of time in which the present challenges that hinder the success of physical learning have been absent. Considering recent developments such as the ongoing COVID-19 pandemic, the challenges with the traditional approach to teaching has been a very concerning issue. In a bid to mitigate the challenges of the present time, researcher, instructors and academics globally have a duty to provide a solution to this challenge. The Gamified-Flipped classroom, a learning approach which operates by inverting the time and place in which activities are coordinated, and adds elements of games to make learning fun is a suitable candidate for such times as we are in.

In the Gamified-Flipped learning method, classroom learning activities and related in-class events are conducted at home through a video recording by the students, and a platform is created for the gamification elements. In it, students are chanced to peruse the learning material ahead of the class meeting, while problems are solved, knowledge is deepened and discussions are made during the class period with the help of the teacher, and students are evaluated in an interactive and interesting way (El Miedany, 2019).

Problem Statement

The traditional teaching method plays a crucial role in education and instruction with significant advantages. With it, instructors benefit from the possibilities associated with the availability of physical interaction and proximity with the students. In Dios and Charlo, (2021), the perceptions of the students was identified on face to face learning, as well as their individual learning patterns. The students identified that physical communication with the instructor is a significant benefit of face-to face learning. Regardless of its advantages, instances exist that demand alternative instruction approaches.

The era of COVID-19 drives home the needs to have such alternative approaches to learning that accommodate self-learning with minimal physical interaction, of which the gamified-flipped learning method is a crucial member.

Also, since the traditional instruction method is instructor-centric, less focus is placed on the students. This is due to the fact that it does not promote collaboration among students, neither does it encourage the students to direct their learning process as their focus on the instructor is of utmost importance during the learning period. The flipped classroom therefore provides the required recipe for a productive student-centric learning environment as it encourages collaboration, enables the students to pattern their learning appropriately and ask meaningful and academically significant questions due to the fact that learning material has been provided to them and studied ahead of the class. It also promotes critical thinking.

Flipped learning is an instruction technique that is capable of meeting this identified need, but when integrated into an established system for improving learning, a better approach is provided. Gamification, a learning improvement technique which makes use of game design approaches in which the learning process is converted into a gaming process in order to reduce the formality of the learning environment and improve the motivation of the learner is also applied. A combination of the two aforementioned techniques provide the necessary instructional technique discussed in this study.

Although several studies exist with results from independent but detailed studies conducted on gamification and on flipped learning. But it is essential to realize that studies that contain a mix of both gamification and flipped learning (gamified-flipped learning) are scarce, scarcer also are those that investigate the variables considered in this study. With a mix of the earlier described learning methods, we seek in this research to identify if the gamified flipped learning approach possesses the capability to improve learners' innovation skills as well as their self-efficacy in university level physics course. Also, we seek with the help of this study to measure the opinions of students on the integration of game elements into university-level physics course.

Research Questions

This research seeks to identify the significance of the gamified flipped learning on students' self-efficacy, perception, and innovation skills. In order to structure the research appropriately and measure the parameters of interest, it is important to identify the questions that it aims to answer.

For a thorough research, the following are the research questions that the study aims to answer:

1. Can the gamified flipped learning environment improve the students' innovation skills?
2. Can the gamified flipped learning environment increase the students' self-efficacy?
3. What are the students' opinions on the gamification?
   - **i.** What are the perceptions of students towards gamification according to their department?

Significance of the Study

Researchers have long sought to introduce other learning approaches that would improve students' learning. A familiar approach is the use of flipped learning as described by (Awidi & Paynter, 2019; Hew & Lo, 2018; Turan & Akdag-Cimen, 2020). Also gamification was employed in (Araya et al., 2019; Ramesh & Sadashiv, 2019). Even though several studies exist in these areas, there is a research gap in the investigation of the impact of both flipped learning and gamification on the innovation skill and self-efficacy of the students. Since innovation skill defines the capability of students to explore, collaborate and research independently in order to discover details or knowledge they were not taught in class, while self-efficacy promotes the belief of students in themselves, with an assurance that they have the ability to steer their lives, organize and sustain the course of action in order to achieve a desired result, we seek to investigate these 2 variables among others. In this thesis, we aim to cover the mentioned research gap by conducting required studies and detailing the scientific findings from them, including the perception of the students.

Limit of the Research Finding

Flipped learning can be perceived as a learning approach that is highly suitable for instructing engineering courses. Several techniques can be applied to it to make the best out of a learning session, techniques such as think-pair-share, and peer-instruction have been considered to prove effective in flipped learning and the attainment of several learning objectives.

Considering that scientific studies have a limitation to the applicability of their findings, the outcome of the several investigations conducted in this study also have their respective limitations. Even though the study offers detailed and in-depth information on the importance of the gamified-flipped learning to students' perception, self-efficacy, and innovation skills, yet, below are some of the identified limitations to the findings of the research.

Amongst others, the fact that finding from this study come from a Physics class, limits its applicability to such and related courses and as such, may not be directly applicable to other fields of learning. Extreme carefulness must be taken when applying the outcomes of this study to other fields of learning.

CHAPTER II

Theoretical Background and Relevant Studies

In this section, we provide thorough background information through existing literature on the current study. In order to justify our research, we present prior scientific findings made by other researchers such as those of (Hung et al., 2019; Jang & Kim, 2020) , which form the basis of our work. Succinctly, studies on flipped learning, gamification and the variables under investigation would be discussed.

Flipped Learning Model

Flipped learning is an instructional approach in which the educator or instructor flips students' time usage at home and school in order to more effectively introduce improved learning into the time spent by the students outside of the school, thereby creating more time for deeper, detailed learning within the school walls. Other researchers refer to it as an instructional approach that empowers teachers to introduce "school work at home and home work at school" to their students (Flipped Learning Network, 2014). Several benefits can be associated with this teaching approach. Since the regular formal teaching pattern is less required in this teaching method, students' discussions and interactions are more frequent and beneficial to the students as it provides a more student-centered learning environment, rather than the traditional teacher-centered environment. Also, the flipped learning system provides for a student-centered learning in which the students have a higher responsibility for their learning, and thus, creates an inverted traditional learning environment in which clarification for confusing topics are obtained during the classroom session (Comber & Brady-Van den Bos, 2018). To this effect, students bear the responsibility of preparing a suitable environment for their study, as well as deciding a productive time of the day and its frequency. Finally, the flipped learning system provides facilities for easy collaboration between fellow students as they have ample privilege to discuss the topics under consideration, consequently improving students' learning.

During the preliminary stages of the flipped classroom development, professionals were unconvinced by it and thus, left skeptical about the potential success of its implementation, even though in the current time, it has received a large reception so much that it is the choice approach in many learning environments and the only possible one in several other situations (Hung et al., 2019). In defense of their stance, the scholars emphasized on the increased workload of the instructors who would be laden with the burden of preparing the learning materials (Marti-Parreno et al., 2014). Also, the ability of students to maintain an atmosphere of discipline and self-restraints by themselves without supervision during the self-study period is an implementation challenge that bothers the professionals.

It is needful to know that this learning approach has some extra demands. Unlike in the traditional instruction mode where the instructor prepares only the lesson notes, the flipped learning mode requires that the instructor prepares videos of study materials which require added effort, time and technical skills. These nonetheless have not hampered the increased acceptability of the flipped classroom approach as it has seen wide reception from instructors due to the ease with which it switches the interest of students from being passive learners to active learners in their own learning environment (Hung et al., 2019). Studies have found out that the flipped learning approach exhibits an increased affective and interpersonal effect on students when compared with the cognitive impact (Jang & Kim, 2020).

Gamification in Education

On the other hand, gamification involves the application of game design elements and traits in an attempt to improve students' academic performance by the introduction of intriguing items such as games, due to the natural tendency that students love games (Rapp et al., 2019; Sanchez et al., 2020; Zainuddin et al., 2020). It is defined as the application of gaming items to such as leaderboards, avatars, ranks, levels and points to increase the interests of students competitively (Groening & Binnewies, 2019). Since it has been observed that learners and students are at the best learning level when they find the learning process fun, and there are goals and achievements to attain, also at the same time, an important desire of a teacher is to increase the motivation of their student to learn, thus, gamification is significant to both teacher and student as it introduces the appropriate technique essential to meet these needs.

Gamification can be summed up therefore as a teaching technique that employs the services of activities and rewards in order to promote the motivation of students in a game-free environment (Surendeleg et al., 2014). It encourages the motivation of students by introducing an enjoyability factor into the learning process, and as such, as students find the learning process enjoyable and return to it, there is a significant increase in their engagement and interest in the entire learning process. This in turn improves their willingness to continue to learning process by themselves (Nah et al., 2013). Landers & Armstrong, (2017) identified in their study that prior experiences like familiarity with video games have an influence on the effect of gamification. Several reasons such as the advancement of goal setting among the students, meeting the craving for recognition and the provision of an improved performance feedback have been recognized by (Bai et al., 2020) to promote the integration of gamification and improve its impact on the learning outcome of students.

Over various subject areas, gamification can be applied by instructors and parents with and without the use of computer technology. Without losing relevance, the following elements can be used for gamification in the basic sense; Instant feedback, scaffolded learning, progress bars, and social connection (*Gamification in Education: What is it & How Can You Use It?*, 2021).

For an effective implementation of gamification, several crucial elements play significant roles in the stimulation of students' interests for improved academic performance, such elements include avatars, levels, points, gifts and badge among others (Barata et al., 2017; Buckley & Doyle, 2017; Ding, 2019). Gamification in learning introduces among other things, the following benefits;

a. Improves students' learning motivation
b. Promotes active and participatory learning
c. Prevents the students from being stressed
d. Preserves the attention of students

Not only is gamification significant in educational institutions, it is in other fields. Some studies show the versatility of gamification by its applicability in several fields and disciplines such as in the marketing context (Thorpe & Roper, 2019), in production and logistics (Warmelink et al., 2020), and in motivational information system (Koivisto & Hamari, 2019).

Students' Innovation skill

Student Innovation skill, a measure of the encouragement received by a student to research, explore, study and integrate the use of available tools and resources in order to make novel findings is nothing new to education. It provides the willingness and drive to students to take alternative look at challenges and solve them from the new light, consequently encouraging students to ascend to uncommon levels of thinking and resourcefulness in order to solve complex challenges. Incorrectly, innovation has been paired with technology or technological inventions by many writers. Rather, it may be well correlated with the its usage and integration to empower students through collaboration and research (*Why Innovation Absolutely Matters in Education*, 2018). It is so significant to education and overall success of graduates that (Kershaw et al., 2014) termed it as key to the competitiveness of a country, and it, coupled with engineering creativity are considered as highly sought-after skills (Viswanathan & Linsey, 2009). They proceeded to investigate the engineering curriculum and its capacity to positively influence students' innovation skills, and if students' unique traits have a correlation with their innovation abilities.

In the studies of Brazdauskas, (2015), innovation among students can be seen to play an irreplaceable role in business and sustainability development. In order to equip students in business training to successfully establish a balance for their businesses and promote sustainability, it was realized that by improving their innovation inspired thinking, abilities to better understand how to establish such balance can be formed, thereby enabling them to form more sustainable business models. (Walsh & Powell, 2018) also found that it is important for students to be equipped with the capability to succeed in varying career paths, and in order to work out such preparation, the development of an independent mindset to which innovation is the core is crucial.

In this study, we seek to investigate among other measures, the significance of a gamified flipped learning system on the innovativeness of students.

Students' Physics Self-efficacy

Student's self-efficacy is a descriptor of a student's belief in themselves, producing a confidence in their capacity to be successful in an endeavor (Andrews, Borrego, et al., 2021). It is also defined by Bandura, (1978) as the internalized belief of an individual in their capacity to plan and execute courses of action in line with selected areas. It is an effective predictor of students' performance and persistence (Espinosa et al., 2019). Significant evidence exist of the important role self-efficacy plays in several educational outcomes, though it is needful to know that it is largely dependent on domain of interest or discipline, and not generalizable over several disciplines (Wang & Richarde, 1988). As such, self-efficacy is defined for decisions related to career as the career decider's belief in his/her own capability to engage and successfully execute the duties required of them in their professional undertaking (Betz & Taylor, 2012).

Therefore, in this thesis, we seek to examine the impact of a gamified and flipped Virtual Physics Lab on the physics self-efficacy of students, as it is identified to be crucial in the prediction of the persistency of students in a specific endeavor and career choice most specifically in the field of engineering. So significant is its role in the field of engineering that contrary to expected trend, self-efficacy of engineering students has been identified using longitudinal studies to wane, rather than increase over time (Andrews, Patrick, et al., 2021).

The construct of self-efficacy is important, and has seen relevance in several contexts such as career development (Ambiel & Noronha, 2016). Studies however have found that gender differences exist in self-efficacy, contributing massively to gendered academic and career outcomes. In confirmation, it was identified that female undergraduates with a resolve to continue in their field of study in engineering had considerably higher self-confidence than their counterparts in mathematics and related science courses. In Charkhabi et al., (2013), the impact of self-efficacy on academic burnout of undergraduate students was studied among students of Iranian origin. It was concluded from the study that self-efficacy has a positive correlation with the academic burnout of students. From (Bardach et al., 2019), it was also identified to be a significant factor in the mastery of student's goal structure, while (Kolil et al., 2020; Rabei et al., 2020) studied the effects of virtual learning on students' self-efficacy and anxiety.

Students' Perception

Perception can be defined as the process involved in perceiving. It is the awareness of an occurrence to which there is a connection to previous experiences or knowledge. Due to the presence of previous information, perception therefore produces the ability to learn information having a close relationship with prevailing thoughts and goals. Student' perception therefore is the belief and thoughts of students in line with a specific matter, it is a student's assessment or view on a subject matter (Morris, 2016). Even though perception plays a crucial role in education, its significance is found in several domains of life. It is significant in the domain of career such as aviation, where pilots perceive their location relative to ground markers, and also in the ability of humans to perceive emotional expressions and facial expressions.

As a significant role of perception in education, Köller, (2001) in a quest to identify the factors responsible for high school dropout, realized that the perception of students on the academic landscape available to them greatly impacts their academic behaviour and choices. It was identified that students who have a positive and supportive perception of school administration and teachers also tend to complete their education successfully. In the study of Ferreira & Santoso, (2008), a link between the perception and performance of students is investigated by the enrolment of both graduate and undergraduate students in an accounting course. From the study, the authors identified that negative perceptions by the students have a significant correlation with poor performance in the course, while on the flip side of their performance, high performing students were found to have maintained a significantly positive perception all through the academic semester.

Virtual Laboratory in Education

Virtual laboratories VL are interactive environments in which laboratory experiments can be created and carried out using simulations that closely mimics real phenomena. Other than closely providing a replica to the real-life facilities, virtual laboratories also provide additional features and capabilities that may be un-obtainable in a physical classroom. Researchers in (Alexiou et al., 2005) have proposed a virtual reality framework in which laboratories can be accessed and used by learners. In their work, they proposed a web-based system in which processes and actions similar to those occurring in a physical laboratory setting are simulated. Support available in this proposed system includes communication and collaboration.

Virtual laboratories tend to provide users with some rather significant amount of flexibility as it does no require a dedicated physical building for the conduction of experiments. Also, virtual laboratories are cost effective since the purchase, setup and maintenance of several expensive equipment is avoided. This is important since due to the high cost of setting up laboratories, several institutions have been unable to put together suitable ones. Also, virtual labs provide an invaluable level of safety to students and instructors by the absolute elimination of both non-fatal and fatal laboratory hazards (Larbi-Apau, 2020).

Kapilan et al. (2021) to further buttress the significance of virtual laboratory detailed the impacts of the COVID-19 on education in India as it caused a great problem in the ability of instructors to conduct laboratory experiments and train students with them. Due to this, the authors carried out a faculty development exercise in which instructors were trained on carrying out mechanical engineering laboratory experiments using an online environment. In the same way, students were also guided through virtual fluid mechanics laboratory experiment sessions using a designed environment. It was identified that the learning process of more than 90% of the participating students improved during the virtual laboratory activities, a finding consistent with that of (Estriegana et al., 2019).

Several implementations of the virtual lab have been described in the literature. In (Budai & Kuczmann, 2018), Weblab Deusto is described as a virtual lab environment with a web based interface, Virtual Systems in Reality (VISIR) provides facilities for remote connection of virtual electronic circuit components on virtual breadboards, it also has a web based interface. Other implementations are Virtual Electric Manual (VEMA), and LDH vLab.

Virtual Laboratory for Physics Teaching

Virtual laboratories have found significant usage in the sciences, and more specifically in the area of Physics course teaching as practical work has been proved to be highly important to it (Maulidah & Prima, 2018). Such a practical work has been defined by (Abrahams & Millar, 2008) as academic activities which requires the involvement of students in activities that require a manipulation and observation of real objects and materials. In Physics course, virtual laboratory can be setup in order to provide access to unavailable laboratory equipment and facilities, limitations to time allocation, and unsuitable or dangerous laboratory condition (Tüysüz, 2010). Also, the ability to store values and reuse them for the conduction of repeated experiments have made the use of virtual laboratories of tremendous importance. Virtual physics laboratory has been used to provide learning facilities to Physics students studying various topics such as waves and sounds measurement, precipitation formation and water-cycle, concept of electricity, direct current (DC) electric circuit, and magnetism.

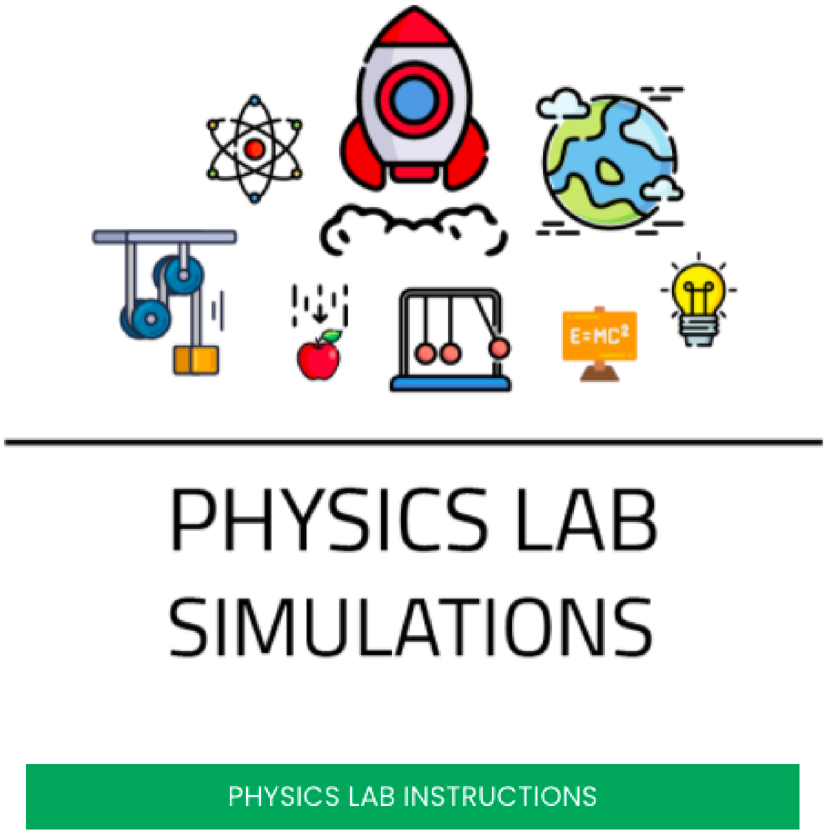

Figure 1. Virtual Physics Lab Welcome Page

Similarly, a virtual physics laboratory was designed and implemented in this research for the purpose of providing a quality platform for the conduction of physics experiments. The virtual lab makes use of a web-based interface in which several circuit elements and experiment resources are provided for the conduction of Ohms law experiment, Coulomb's law experiment, connection of resistors, charging and discharging of RC Circuit among others.

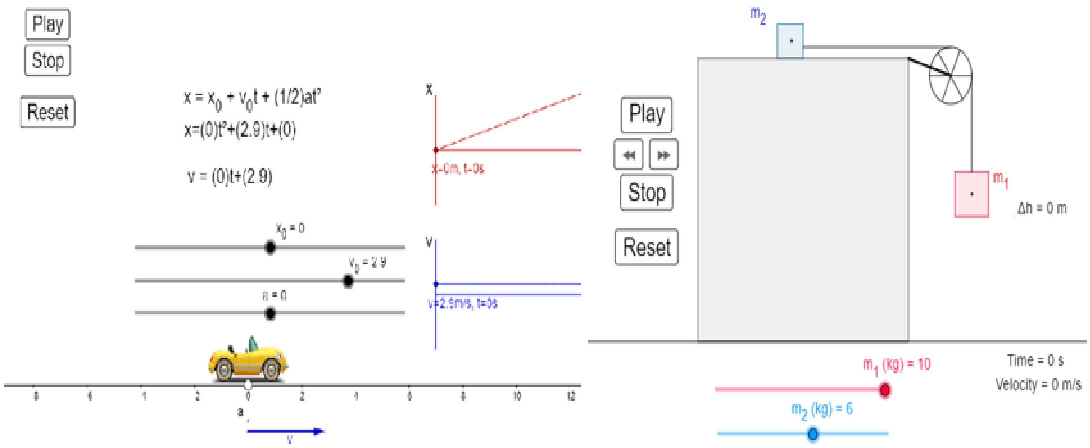

Figure 2. Virtual Lab experiment (Motion)

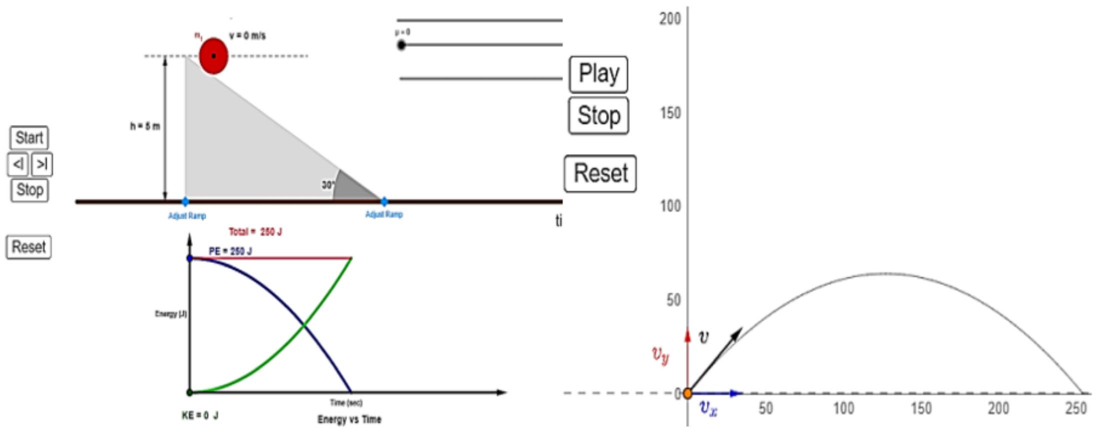

Figure 3. Physics Lab experiment

Online Learning

Online learning, also called electronic learning (e-learning) is a learning strategy or a process of acquisition of knowledge in which education is conducted virtually with the use of, and over the internet. Sarah Guri-Rosenbilt in her study (Guri-Rosenblit, 2005) defined it as the usage of electronic media for the purpose of learning which can range from supplementing traditional classroom to entirely replacing it. Clark, (2016) also defined online learning as the process of instruction delivery through the use of digital devices in order to achieve learning, while Arkorful & Abaidoo, (2015) defined it as the act of employing the availability of information and communication technologies (ICT) to provide access learning materials and online education.

Online learning is with a significant percentage the most common form of learning presently, and to facilitate its integration, learning management systems (LMS) are adopted since the learning sessions can be either asynchronous or synchronous; a mode of learning where the students are not online at the moment of the teaching or online respectively. It has tremendous advantages such as the availability of self-paced learning to students, ability of the students to select and manage their own learning environment, elimination of costly building procurement and maintenance, reduction of teacher scarcity, and the availability of platform analytics for proper management of students' learning progress and habits.

Online learning thus has experienced some unmistakable and remarkable growth in recent years. Global revenue from online learning has therefore been projected to increase by the year 2025 to $325B, an increase of $218B in a space of 10 years (McCue, 2014, 2018). Not only is it important in the university environment, online learning has seen usage across several sectors of the society such as adult education, corporate trainings, presentations and seminars, and others.

Since the minimum requirement for online learning is the availability of a computer or similar device with internet access, students and prospective students who may be unable to participate in physical classrooms or prefer to learn autonomously can take advantage of the system. Since there is little or no supervision or enforcement of rules, online learning students also need a motivation to succeed. Other than the few mentioned earlier, the following are other benefits of the online system that has enforced its relevance; convenience, improved learning, innovative teaching, and improved management.

Since this research was conducted during the COVID-19 pandemic, the researchers opted for the online education approach since academic environments were prohibited and universities closed. During this period, students were able to continue their learning processes by using the provided online platform.

Relevant Studies

From a number of existing studies, we have identified the significance of a few to this study, and these will be mentioned in this section. Relevant studies with direct interest on Flipped Learning Model, gamification in education and virtual laboratory for Physics teaching are the only ones discussed in this section.

Studies on the Flipped Learning Model

Flipped learning is not only applicable in the university settings to Physics course as (Y. H. Lee & Kim, 2018) demonstrated its use in the medical field. By instructing second-year medical students on Introduction to Medicine using flipped learning approach and evaluating them using questionnaires, it was discovered that their perception of students' centeredness of the flipped learning method increased significantly. Also, a sense of community of inquiry was perceived to have increased in both high-performing and low-performing students. Han & Klein, (2019) also in the study described how flipped learning is implemented in various pharmacy schools. They identified from the study that the students were sensitive to the structure and content of assignments such as clarity of objectives, availability of guidance and brevity.

In G. G. Lee et al. (2021), a study was conducted in which the effects of the flipped learning approach was compared to that of the traditional instruction method in the areas of student achievement and learning motivation through mixed-method design. By sub categorizing the flipped learning method to two, namely the cooperative flipped learning CFL and the simple flipped learning SFL, it was identified that students' motivation was improved by the CFL, while achievement was reduced. The opposite was identified in SFL, while (Widjaja et al., 2021) also investigated the effect of the flipped learning model on physics achievement test. Jdaitawi (2020) investigated the effect of flipped learning on the learning emotion of science students using a quasi-experimental design. From the study, students who were instructed were noticed to have obtained and maintained higher scores in their learning emotion tests.

In the sciences, (Bokosmaty et al., 2019) made use of a partially flipped learning approach while instructing chemistry students at the university of Sydney. Students indicated that they were tremendously satisfied with the learning process, a result similar to that of (Stratton et al., 2020) in which an evaluation was conducted, contrasting and comparing the flipped learning method and the traditional learning model. Also, a significant increase in the number of high performing students was observed in comparison with the performances obtained prior to the introduction of the flipped method.

Widjaja et al. (2021) covers a study of the impact of inquiry and mastery flipped learning on the achievement test of grade 10 physics students using a quasi-experimental research approach. In the study, students were grouped into 2 for the flipped classroom type while they responded to a scientific literacy test, the result of which would determine students with high scientific literacy and those without. It was established from the study that inquiry and mastery flipped learning has equal effect on the physics achievement test, while students with high scientific literacy bettered those who had low scientific literacy in the achievement test.

By investigating and interpreting results of available research, (Al-Samarraie et al., 2020) identified in their study that the application of flipped learning model in education is directed at promoting the engagement, cognition, performance, understanding, achievement, and attitude of students. While the main challenges were uniform across disciplines, there are difficulties involved in creating the study material, and the length of time required to productively consume it on the side of the instructor and student respectively. Cabi (2018) provided findings on the effects of the flipped learning model on the academic achievement of students, as well as the opinions of students about the model. Also, they identified three crucial problems involved in the application of the model as Content, Motivation and Learning. It was identified in the work of (Namaziandost & Çakmak, 2020) that gender has an active role in the effects of the flipped learning model on students. From their study, it was seen that female students who were in the experimental group had better self-efficacy than their male counterparts after the study.

Investigating the effects of the flipped learning model on classroom engagement of students in English teaching over four weeks, (Ayçiçek & Yelken, 2018) identified that the flipped learning model improved engagement in the experimental group students unlike those in the control group. The further proceeded to invite instructors to the use of flipped learning. Abdullah et al. (2019) also identified that the flipped learning model improved oral proficiency of students, while (Campillo-Ferrer & Miralles-Martínez, 2021) identified improved motivation and performance as characteristics of students in the experimental group who underwent the flipped learning experience. Also, students in the group had a positive perception of the learning model.

Studies on Gamification in Education

Several authors in this area of research have investigated the impacts gamification and flipped learning have on teaching. Yin & Chen, (2020) in their investigation realized that gamification mixed with flipped learning has a significant role on the engagement of students, promoting their optimism about learning a specific language. In the same way, Huang et al., (2019) while investigating the same measures on bachelor's degree students, realized that gamification and flipped learning improves students' engagement, and students who participated in the gamified flipped classes scored better than those who didn't in related tests. In the area of class participation and students' achievement, Gündüz & Akkoyunlu, (2020) identified that gamification promotes class participation and students' achievement, and even recommended that students with poor class participation could perform better in a gamified environment.

In R. Huang et al., (2020) researchers conducted a meta-analysis on the integration of gamification in education, with a focus on the learning outcomes of students. Examining several gamification design elements, it was noted that each gamification element possesses the capacity to trigger unique effects on students' learning outcomes. Biryukov et al. (2021) through a meta-analysis of experiences of gamified learning from several sources analyzed the significance and efficiency of gamifying the process of education. While students benefit from the face-to-face system of education, instances exist in which gamified applications are simultaneously used. Such possible aspects that influence the decision of selecting to use a supporting gamified application are mentioned in (Aguiar-Castillo et al., 2020). Díaz-Ramírez, (2020) also described the design and implementation of gamification in an engineering course's instruction process at a Mexican University. In the study, participants which are divided into 2 groups of which one is instructed using gamification, while the other employs the standard teaching method, are instructed in parallel. In an attempt to investigate the existing evidence that describe the effects of gamification on the motivation and academic performance of students over a period of 5 years, over several parameters, (Manzano-León et al., 2021) conducted a systematic review on three interdisciplinary databases. From the study, results corroborated the available evidences that gamification in education has the potential to greatly influence commitment, motivation and academic performance of students. Ofosu-Ampong, (2020) describes a similar study.

Toda et al. (2020) established the significance of several variables to the gamification-usage-intentions of students. Demographic and contextual variables were identified to play such an influential role in the intention of students to the use of gamification. Zahedi et al., (2021) in a study on the role of gender in gamification attempted to investigate how virtual points and leaderboard influence the identity development, self-efficacy and academic performance of computer science students. It was identified in the result that gamification process is gender agnostic as virtual points and leaderboards proved significant to an improved academic performance of students of both genders. Kalogiannakis et al., (2021) contains a systematic review of research work conducted on gamifying science education and its benefits.

Also, Zou, (2020) researched the perception of students and their instructors in academic settings using a gamified and flipped primary school environment, while other researchers (Zainuddin et al., 2019) gathered from their studies that students who were exposed to gamified flipped learning ended up with more motivation than their counterparts who were not, stemming from the fact that the psychological demands of the exposed students were met.

Several elements of the gamification environments play key roles in its overall effect on learners as identified in (Çakıroğlu et al., 2017; Hassan et al., 2019). They gathered that competitions have a positive significance on the engagement of the students based on their behavior, emotion and cognition. Although badges are significant elements of the gamification setup, (Kyewski & Krämer, 2018) showed that they did not necessarily improve the intrinsic motivation of the learners who encounter them. In (Putz et al., 2020), using gamified workshops, investigated the benefits of gamification to the ability of 537 students to retain the knowledge they just acquired. The activities covered the entire day in the form of field trips laced with an enrichment of several games. It was discovered that over an extended period of time, the students that participated in the gamified activities had better retention.

Not only is gamification significant in educational institutions, it is in other fields. Some studies show the versatility of gamification by its applicability in several fields and disciplines such as in the marketing context (Thorpe & Roper, 2019), in production and logistics (Warmelink et al., 2020), and in motivational information system (Koivisto & Hamari, 2019).

Studies on Virtual Laboratory for Physics Teaching

Virtual laboratories have greatly benefitted both instructors and their students, and as such, have found tremendous importance in several courses. Virtual laboratory has been designed and implemented by various researchers over different periods of time. In Indonesia, (Maulidah & Prima, 2018) described an implementation of virtual physics laboratory which was used for waves and sounds experiment in which grade 8 students were the participants. For this research, descriptive and methodological triangulation methods were used. In (Bogusevschi et al., 2020), a physics virtual laboratory was setup as part of a European Horizon project in order to teach the water cycle to students of ages 12 and 13. A virtual laboratory was also setup in (Gunawan et al., 2017) to investigate the problem-solving ability of students to the concept of electricity. Using true experimental design, it was identified that students from the experimental group improved in their capacity to plan and put into motion, several problem-solving approaches in Physics.

Also, in order to decide on the use of a virtual physics lab system, Mirçik and Saka (2018) conducted a study in which several virtual laboratory programs are investigated using content analysis, while comparisons are drawn such as strength and weaknesses, desired target audiences, design traits, experiment analysis abstraction, closeness to reality and friendliness of the interface. Other studies on physics virtual laboratory include, but are not limited to (Faour & Ayoubi, 2018; Gunawan et al., 2018).

CHAPTER III
Methodology

In this chapter of the research, we focus on the organizing principles behind the research, including all the other important approaches embraced during processes of data acquisition and analysis. Consequently, the work here will be tailored to describe essential components of the methodology ranging from the research method, the design of the research, study population, sampling and the sample size to the ethical issues.

Research Methodology

The study makes use of the mixed method of research by integrating both the qualitative research and the quantitative research approaches. Students who are available as participants in the research are divided into 2 groups namely the experimental and the control group in a true-experimental design approach, and students were randomly assigned to a group. In the experimental group, students were taught using a previously described instructional method called the gamified-flipped learning (GFL) approach, while the control group had their instruction in the classical flipped learning (CFL) approach.

Considering the impact of various learning approaches against their limitations, it is essential to investigate specific properties that determine the impact of the approach and the impact such approach has on the students who are at the receiving end of it. This research thus aims to investigate among others, the impact of the gamified flipped learning approach on the innovation skills of students, as well as their self-efficacy towards physics lab as a course.

Qualitative Research

Although various definitions exist for the qualitative research method, however, a striking definition is that proposed by (E. R. Babbie, 2017) defines it as a scientific method which is employed in observation in order to gather data which is in a non-numerical form. (Berg & Lune, 2012) informs that qualitative research provides the necessary description, definition, meaning, process and even characteristics of things which are not in numerical form, such that rather than providing the frequency of occurrence of an investigated event, it provides information which clarifies the purpose 'how', 'why' the investigated event occurred.

Qualitative research will be conducted in this study in the form of interviews. Semi-structured interviews will be carried out with the students in order to ensure that clear understanding of their knowledge of the gamified flipped classroom is ascertained and to measure their perception of it. In an attempt to provide validity of contents, existing studies were used during the preparation phase of the questions. Also, the prepared questions were handed in to experts in educational technology and training programme in order to validate the contents.

In order to measure their perception of the gamified flipped learning accurately, 6 questions were prepared and administered to the participants. These questions were subsequently analyzed after the collection process in order to arrive at a conclusion.

Quantitative Research

This has been described by (Given, 2008) as a systematic empirical inquiry of evident phenomena through the application of statistical, mathematical and computational techniques. Data obtained from a selected sample is evaluated using statistics or statistical methods with an expectation of the outcome being unbiased and applicable to a larger population.

Questionnaires will be employed in this study work to measure the impact of the GFL approach on the self-efficacy and innovation skills of the students involved in the experiment. A related questionnaire developed by (Butter & van Beest, 2017) will be used.

Research Design

Research design as defined by Bhat, (2020) is group of methods and techniques employed by a researcher in their bid to obtain efficient results by the synergy of several components during a research. True experimental design, a research approach which can be used to effectively quantify the cause and effect of a relationship was employed in this research work. An experimental group is setup with an accompanying control group, with students randomly assigned to either group. In the experimental group, teaching was carried out by the use of gamified flipped learning method (GFL), while the classical flipped classroom (CFC) is employed in the control group. Figure 4 presents the overall research design of the study.

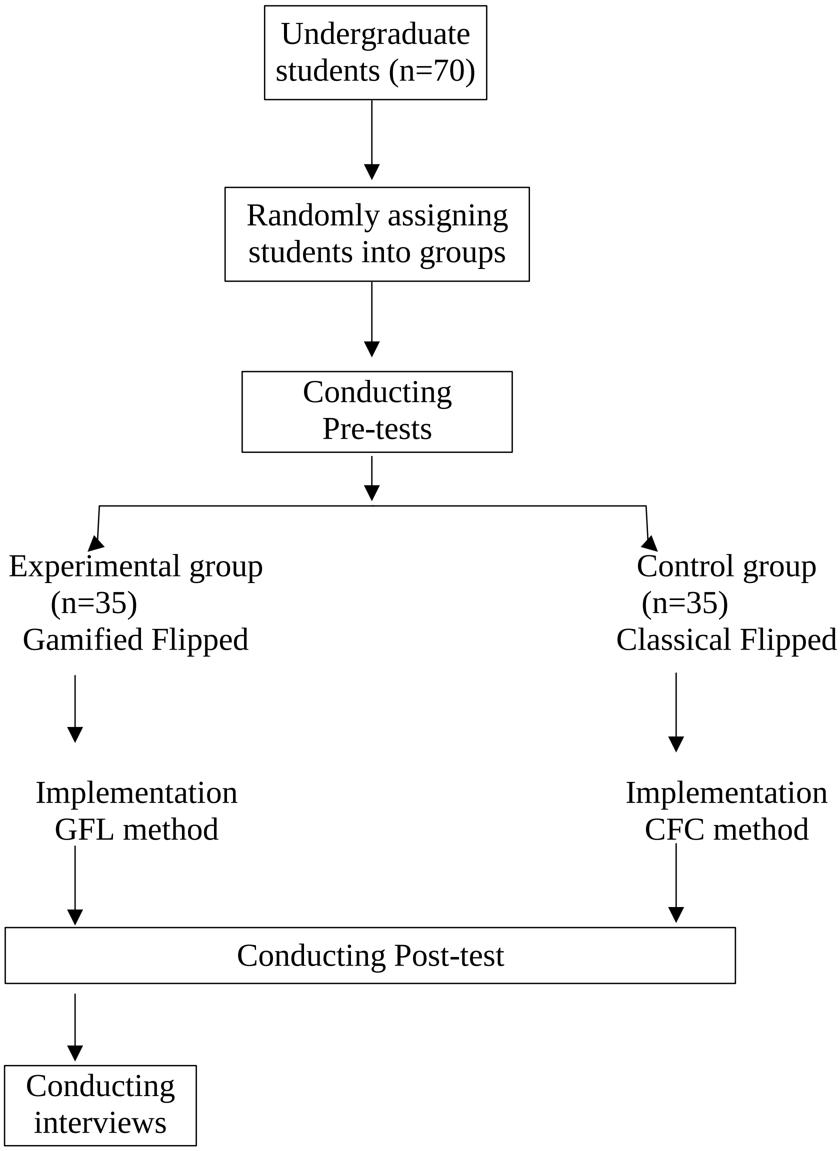

Figure 4. The Research Design

Participants

From the entire population of first year undergraduate physics students enrolled at the university during the 2020-2021 spring semester, a smaller group called the sample size consisting of 70 participants were involved in this study. The experimental group with 35 participants used the GFC method while the control group having 35 participants employed only the CFC method.

A single instructor taught both groups, comprising of young students with ages between 17 and 29, from which 58 were male, while 12 were females for a period of 10 weeks. The subsequent sections and tables contain the demographic distribution of students' in the study.

Participants' Age

Participants Students are aged between 17 and 29. Since the age range is not large, Table 1 shows the distribution. It can be seen from the table that 19 years old Physics Lab students are the most represented in the study with 24.3% involvement. Next to them are the 20, and 21 years old participants with 15.7% each, while the lowest ages are 24, 28, and 29 years old students having 1.4% each.

Table 1.

Age distribution of participants

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	17	2	2.9	2.9	2.9
	18	9	12.9	12.9	15.7
	19	17	24.3	24.3	40.0
	20	11	15.7	15.7	55.7
	21	11	15.7	15.7	71.4
	22	7	10.0	10.0	81.4
	23	8	11.4	11.4	92.9
	24	1	1.4	1.4	94.3
	25	2	2.9	2.9	97.1
	28	1	1.4	1.4	98.6
	29	1	1.4	1.4	100.0
	Total	70	100.0	100.0	

Department

Table 2 shows the distribution of students who participated in the study. It can be seen that the departmental distribution is severely skewed as engineering departments dominated. Out of the 70 students who participated in the study, 60 were from engineering departments, making a whopping 86% of the entire participants. The remaining 10 students were distributed over the remaining departments.

Table 2.

Distribution of participants by Department

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Automotive Engineering	2	2.8	2.8	2.8
	Biomedical Engineering	6	8.6	8.6	11.4
	Civil Engineering	12	17.1	17.1	28.5
	Computer Engineering	12	17.1	17.1	45.7
	Electrical Engineering	5	7.1	7.1	52.8
	Environmental Engineering	1	1.4	1.4	54.3
	Food Engineering	4	5.7	5.7	60.0
	Industrial Engineering	2	2.9	2.9	62.8
	Information System Engineering	1	1.4	1.4	64.3
	Molecular Biology & Genetics	7	10.0	10.0	74.3
	Mechanical Engineering	2	2.9	2.9	77.1
	Mechatronics Engineering	4	5.7	5.7	82.8
	Petroleum and Natural Gas	3	4.3	4.3	87.1
	Software Engineering	9	12.9	12.9	100.0
	Total	70	100.0	100.0	

Data Collection Tools

Physics Self-Efficacy Scale

Physics is generally considered to be a significant course in the sciences which heavily depends on experimental observations and quantitative measurement of physical phenomenon. In order for students to learn this course effectively, self-efficacy becomes of great importance as it is the measure of the belief of a learner in their competence to achieve the task (learning) at hand (Bandura et al., 1999). For the experimental studies and the measurement of the self-efficacy of the students as regards the physics course, the physics self-efficacy scale developed by Tezer & Asiksoy, (2015) was used. This 5-points Likert scale with options ranging from Strongly Agree, Agree, Neither Agree nor Disagree, Disagree and Strongly Disagree was used in this study for both pre-test and post-test experimental.

The Physics self-efficacy scale gathers data from the participants in two dimensions. There is a first dimension of the Level of Learning of the participants in which the ability of students to grasp contents and learn from the class is investigated. Also from the learning dimension, it is possible to detect if students can successfully put into use, through thorough understanding, the concepts learnt in the course. On the other hand is the problem solving dimension which seeks to investigate the ability of the students to make use of the learnt concepts to solve the problems that may arise or may be presented to them by the instructor in the course. This dimension seeks to evaluate among other things, if the participants can solve difficult physics problems, and be certain that their 'results' are actually correct.

University Students' Innovation Skill Questionnaire

The innovation skills of students who participated in the study was also measured. Since innovation is a skill which deals with the capacity of the students to put to implementation new ideas or processes, it becomes necessary to investigate it in a practical course like Physics. For the purpose of this study, the innovation scale provided by (Butter & van Beest, 2017) was applied. According to Butter & van Beest, (2017), 6 innovation dimensions were described as creativity, intrinsic motivation, freedom, autonomy, risk tolerance and proactive behaviour. A 5-point Likert scale ranging from 1 Strongly Disagree through Disagree a little, Neither Disagree nor Agree, Agree a little, to 5 Strongly Agree was used over the following three dimensions of innovation competency, creative thinking, intrinsic motivation and autonomy.

The creative thinking dimension evaluates in every participant, the capacity to improve ways in which problems are perceived and solved, while the intrinsic motivation dimension identifies how the participants perceive and react to difficult challenges. Participants could avoid difficult task when they are perceived as problems, but on the other hand, be highly motivated and determined to solve difficult tasks when they are perceived as interesting challenges. The autonomy dimension finally investigates the ability of participants to solve tasks related to their training independently and successfully. The described innovation skills scale was used during both the pre-test and post-test stages of the study.

Students' Perception Interviews

Among a number of volunteer students in the experimental group (28), semi-structured interviews were conducted in order to determine their perceptions towards the gamified flipped learning model and its mechanics. Six questions were asked from the students in this semi-structured interview. The first question in the interview asked about the benefit of gamification mechanics on the motivation of the students. The second question proceeded normally from the first question by asking if the student thought that the gamification mechanics can support their learning. In the third question, the students are asked if they think gamification is suitable for the just concluded physics lab, and why they think what they think. In the fourth question, the students are asked about the main advantages of the gamified virtual flipped physics lab, while the fifth question asks about the disadvantages of the gamified virtual flipped physics lab as observed by the student. Finally, the sixth question requests from the students, some suggestions on how to tackle the problems experienced in the newly introduced learning model, and how to improve the gamified virtual flipped physics lab generally.

Quizzes

Quizzes were conducted every 2 weeks as complements to the uploaded course video as a way of evaluating the understanding of the students/participants on the video content. As such, 4 quizzes were conducted during the study. Students were laden with the responsibility of preparing for the next quiz after the concepts required had been learn during the previous week. Students are usually pre-informed of the time duration for the quiz, which is enforced by the use of a timer, though late submissions are accepted and penalized. Scores obtained from these quizzes are essential in determining the achievement of the students in the course as well as determining their badges. The scores were based on the following criteria: full marks were obtained by students who got all questions right, and conversely, no mark was awarded to the students who got all the questions wrong, marks were reduced for students who got some questions wrong.

Validity and Reliability of Instruments

How empirical measurement closely represents the phenomenon under investigation is defined by (E. Babbie, 2010) as validity. Also, (E. Babbie, 2010) defined reliability as the ability of a chosen technique to provide reproducible results on a given dataset when applied repeatedly to it. It can be seen from this that while reliability seeks to establish that the measuring instrument is capable of producing accurate results, validity is concerned with the suitability of the instrument for the current study.

In order therefore to ensure validity and reliability, the key constructs in the study were obtained from existing literature and their Cronbach alpha coefficient was computed to verify the internal consistency.

Cronbach's Alpha

Cronbach alpha, conceived by Lee Cronbach in the 1950s is a measure used in the validity of the internal consistency (a measure of the relatedness of the elements in a test) of either a test or a scale (Cronbach, 1951). The internal consistency is measured on a scale of 0 to 1, with higher values denoting higher correlation and vice versa (Tavakol & Dennick, 2011). (Gliem, J.A., & Gliem, 2003) described a scale to have an acceptable internal consistency if its alpha value is greater than 0.7. Multiple Linkert scales will be used in this study, and as a result, Cronbach's alpha will be calculated for the questionnaires.

It is defined as:

$$\propto = \frac{k \times \bar{c}}{\bar{v} + (k-1)\bar{c}}$$

Where:

k is the number of items

$\bar{c}$ is the average covariance between items

$\bar{v}$ is the average variance

Data collection procedure

In order to obtain the data from the study, various tools were required. Due to the restrictions enforced by the government and institutions between 2020 and 2021 due to the COVID pandemic, prospective subjects could not be contacted in person/physically, and as such, online alternatives to data gathering were considered. Since online survey -a data collection approach in which structured questions are presented to, and filled by participants over the internet, is cheaper to implement than other approaches (paper, telephone, one-on-one), and easily conforms to governmental regulations as it can be self-administered, and has low error or invalid data rate, it was selected as the suitable data gathering approach. Google forms were used for this data gathering with a questionnaire containing multiple sections. The first section contains participant's demographic details, the second section seeks to gather participant's details as pertain to innovation, while the final section covers the self-efficacy questions.

As described earlier, data collection was done for both stages of the study. During the pre-class stage, data was collected using questionnaires to ascertain that both groups had equal gamification experiences and perceptions. Data gathered from the questionnaire was aimed at identifying the impacts of the gamified flipped learning procedure on the physics self-efficacy and innovative skills of the students. Specifically, innovation was measured using a 5-point Likert scale that ranged from Strongly disagree, through Neither Disagree nor Agree to Strongly Agree, while physics self-efficacy was measured on a 5-points Likert scale also, ranging from Strongly Agree through Neither Agree nor Disagree to Strongly Disagree. After the online lab/gamification phase of the study, an interview was conducted with the experimental group of students in order to identify how they perceived the gamification process. In addition, Log files were used for students' quiz submission data. Several indicators were used in the measurement of the research variable.

Data from the activities occurring prior to the class were also collated for both groups such as the time spent online by each participant, whether they watched the lesson video or not and their completion of related weekly quizzes.

Data Analysis

Statistical Package for Social Sciences (SPSS) version 21 was used for the analysis of the questionnaire in which both descriptive and inferential analysis were done. frequency, percentage, mean and standard deviation are some of the descriptive analysis that were conducted. The standard deviation and mean of data obtained from constructs aimed at the research questions would be considered in answering the research questions. Shapiro-Wilk test was used for normality testing, and independent sample t-test was computed for the data. Homogeneity is also assumed since equal sample sizes were used. They are all significant at the 0.05 level.

Pre-test Evaluation:

As a pre-test, a questionnaire of innovation skill and physics self-efficacy was administered to the students in order to determine if both groups considered in the study (Experimental and Control) had similar innovation skill and self-efficacy prior to the start of the study. As a result of this, data was gathered, analyzed, and independent sample t-test results according to the innovation skill pre-test results are available in Table 5, and for self-efficacy are available in Table 8 in the results section.

It can be seen from Table 5 and Table 8 that prior to the study, students in both groups has similar innovation and self-efficacy as indicated by the means value, and as such, an acceptable basis for the experiment was met.

Post-test Evaluation:

Upon completion of the experiment, we sought to identify the effects of the gamified flipped learning on students who were in the experimental group, this process also showed to us the differences between both groups after the experiments. As such, the same questionnaire of innovation skill and physics self-efficacy was administered to the students after the study. The resulting data was gathered and analyzed, while independent sample t-test were also conducted on them.

Instructional Design

In the Moodle learning management structure, pages associated with each group were created for different courses, and students were required to access the courses by entering a unique username and password. For each group, the Moodle was thoroughly loaded with essential resources among which are chat messaging, feedback, quizzes among others, but additionally, the experimental group had gamification functions which were added through the use of gamification plug-in.

Liberty was given to the participants to decide whether to or not to complete the out-of-class activities.

Prior to the start of the experiment, all the students according to their groups were informed of the learning procedure to be expected. The students in the experimental group were informed that they would be instructed using the gamified flipped learning method while the students in the control group were told to expect something different, as they would be instructed using only the flipped method.

For both groups, the course content (detailed in Table 3) remained the same for the entire period of the experiment, while the classes were organized for a period of 30 minutes weekly, and it lasted for 10 weeks. The study complied with the required ethical standards and related approvals were duly obtained from the university before conducting the research.

Table 3.

Teaching schedule for both experimental and control group students

Week	Topic
Week 1	Explain course outline, give online survey
Week 2	Experiment 1: Ohm's Law
Week 3	Quiz no.1
Week 4	Experiment 2: Resistances in Series and Parallel
Week 5	Quiz no.2
Week 6	Experiment 3: Charging and Discharging of RC Circuit
Week 7	Quiz no.3
Week 8	Experiment 4: Coulomb's Law
Week 9	Quiz no.4
Week 10	Makeup Exams

Control group

As earlier intimated, the 35 students in the control group will be taught using the traditional flipped classroom method. Details on the process were made available online for the consumption of the participants. Figure 5**Error! Reference source not found.** contains the structure adhered to:

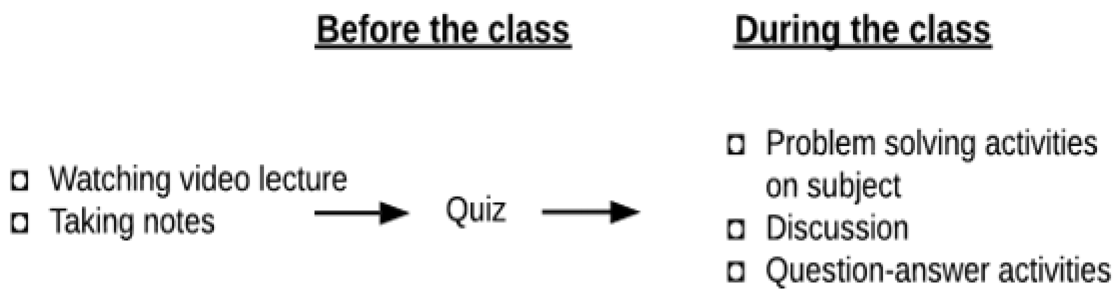

Figure 5. Study design of the control group

Pre-class:

2 days before the class for the control group, the researcher prepares a video with the minimum length of 15mins and a maximum length of 20mins. Also, a related set of quiz questions were provided and uploaded to the available Moodle page. Subsequently, the students do the following:

i. Watch the uploaded video
ii. Solved the quiz questions
iii. Prepared questions regarded the contents they could not understand

During class:

In continuation of the activity done out-of-class, discussion was made during the class about contents that were unclear or not understood by the students in the video with the guidance of the instructor. Also, the instructor paid rapt attention to the discussions in order to identify and prevent false learning. It is needful to know that gamification was not used in the control group.

Experimental group

For the experimental group, the students were given a clear description of what to expect throughout the experiment process (Marczewski, 2015). Description of the gamified flipped classroom thus was given to them. Conversely, in order to maintain a clear focus, and deter the participants from wrongfully aiming at high scores only, the grading criteria was not included in the disclosed contents. A summary of needed information was made into a guideline and made available on the Moodle. Below in Figure 6 is the structure of the group.

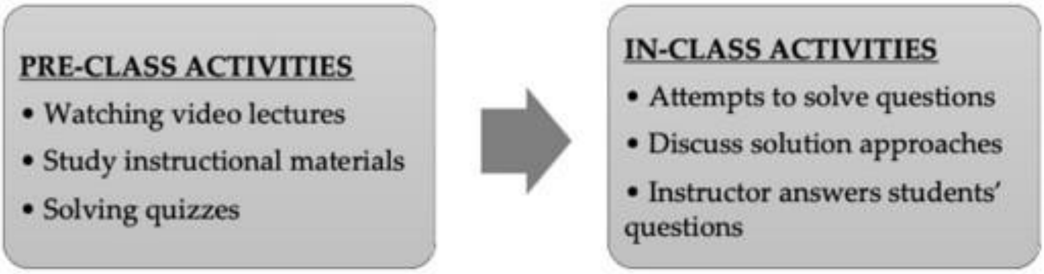

Figure 6. Study design of the experimental group

Flipped Learning Model

Students in the both control and experimental groups were instructed using the flipped learning approach, with the experimental group students having an additional gamified environment for better learning.

Using the website provided by the university, the instructor uploads a video material for the students to watch in order for them to obtain the knowledge required to gain mastery of the subject matter and prepare for a subsequent quiz. The students were able to download the video in order to watch them on their devices, and answer the related questions in the quiz. A link was provided to the students for answering questions during the quiz.

Gamified Environment

A gamified environment was provided for the experimental group in contrast to the classical flipped classroom approach implemented in the control group. In order to measure the effectiveness of the implemented approach, the design of the environment required several extra elements which provided the gamification. They are badges, leaderboards, levels, experience points, timers and feedback. They are discussed in details subsequently.

Timers

These gamification environment elements are essential in learning applications where time is crucial in the success or failure of a learner. They provide the needed reality of time-constrained real-world activities in the gamified environment.

In our study, they were used in order to determine and control the duration of the online quizzes. The timer started with a countdown at the beginning of a scheduled quiz and ended at the end of the quiz period or terminates for a student when they completed the quiz prior to the pre-defined end time (a period of 20 min). Prior to the start of the quiz, the students were informed of the quiz details including start and end time, and related instructions. During the period of this study, a total of 4 quizzes were conducted every two weeks, ensuring that the timer was used 4 times. It was necessary to determine the time spent in the Moodle for the purpose of viewing video contents and answering questions. This recorded the start and stop times of participants' activities on the platform, which in turn was reduced to time spent in seconds. A comparison was made of the online activity time of both groups (experimental and control) for the purpose of the study. As an indicator of online participation, online time of participants in other studies was considered.

Badge

Badges are essential indicators of participant's achievement and success in that they provide a much-needed reward of effort to the gamification participants (Lo & Hew, 2020). They promote social validation as they provide a platform through which users show their conformity to an expected behavior (Hamari, 2017). It is also described as a tool of rank recognition among participants which is used as a measure of student achievement since they represent their success. Though they could also be implemented as rewards, medals or trophies, they all represent an acknowledgement of the commitment put in place by the student in order to achieve the aim(s) of the task (Marczewski, 2015). They are popular among users as means of returning feedback to the students.

A single badge (Lab Genius) was used in this study. It is attained when a student obtains a maximum score in all quizzes, it is seen in Figure 7.

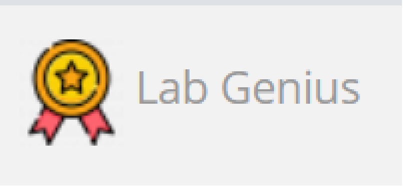

Figure 7. Lab genius badge (obtained after scoring full marks in all quizzes).

Leaderboard

Being a crucial tool for the encouragement of participants, the leaderboard was used for the gamified study (G. Zichermann; C. Cunningham, 2011). It shows to participants their rank in the gamified study compared with other students or participants. It was populated by the students based on their points, which is used as a basis to compare their performances with those of other students and maintain a healthy competition as they seek to obtain more badges and achievements (Seaborn & Fels, 2015). The names of the best 3 students based on this ranking is placed on the leaderboard on a weekly basis.

Level

Since feedback can easily show the progress of the students, we have implemented a feedback mechanism into the gamified system. It helps them to track their progress and the experience they have acquired through the process (G. Zichermann; C. Cunningham, 2011). Consequently, levels which are crucial elements of the gamification environments were decided based on the scores obtained from the bi-weekly quizzes (Prakasa & Emanuel, 2019). Whenever a new level was attained, the students were notified with a message. All students were considered to be level one candidates at enrolment (which required zero points) and subsequently were promoted to level two upon accumulating a minimum of 120 points. They subsequently work their way up the levels as iterated in Figure 8.

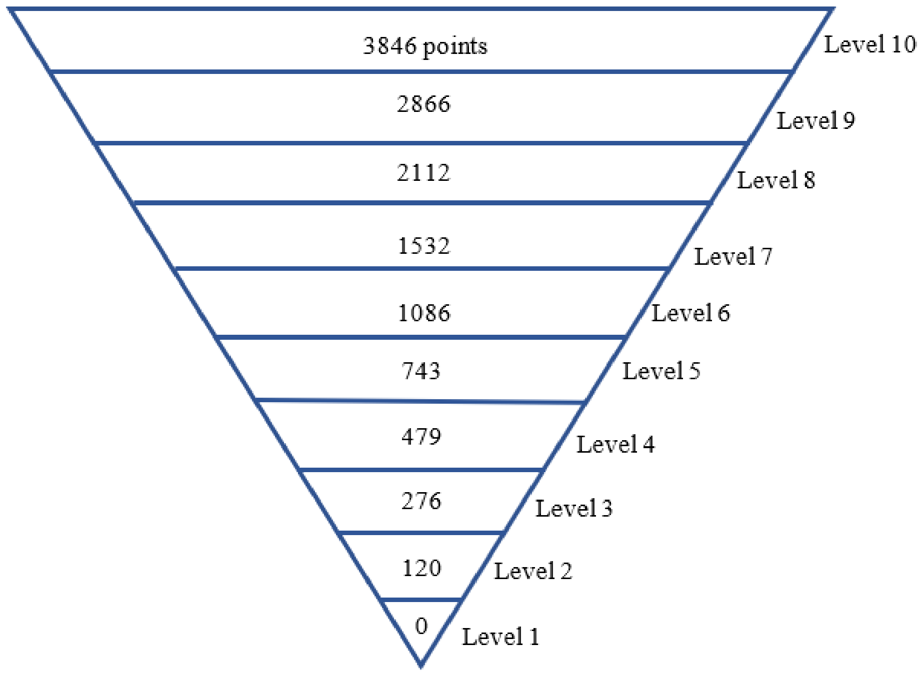

Figure 8. Level hierarchy and required experience points

Experience Points

These were computed based on participants' activities, and in turn, were used for the determination of user levels. Starting from zero points at enrolment, students through a selection between their quiz performance and questionnaire responses earn experience points. For the purpose of this study, it was decided that 200 experience points were awarded to each student after a successful submission of their quiz solutions or after a successful submission of a questionnaire among other points awarding criteria. Several actions and events such as repeated actions, administrators' actions were ignored in order to enforce a fair points-awarding system. Figure 9 shows the experience points and its relationship with level.

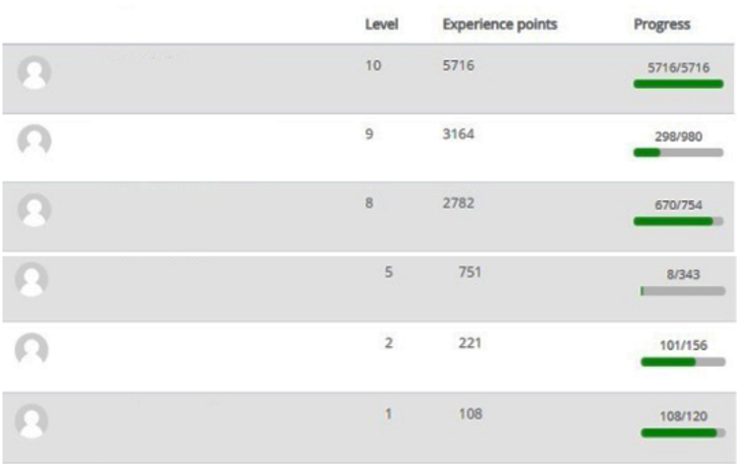

Figure 9. Snapshot of Experience point, showing level ranking

Feedback

This crucial element of gamification serves the roles of both notifying participants of mistakes and encouraging them to proceed to subsequent activities (Furdu et al., 2017). They are usually employed to tailor users activities towards a goal (Mazarakis, 2015). Due to its enormous significance, feedback has been added to our gamification environment to provide distance-to-goal transparency to students.

CHAPTER IV
Results

In this chapter, we present the result of our data analysis and the findings from them based on the study's research questions. We make use of the Percentage, Mean value, Frequency and Standard Deviation as metrics for the measurement of statistical data. Results and tables obtained from Statistical Package for the Social Sciences (SPSS) are also provided. Using Levene's tests for the equality of means, homogeneity of variance was computed for the data, as well as a Shapiro-Wilk test (Table 4) for normality which are all significant at the $p > 0.05$ level.

Table 4.

Shapiro-Wilk Normality test

	Shapiro-Wilk		
	Statistic	df	Sig.
I like to think about a new project approach	.856	35	.129
I like to find new challenging to develop new products in my own discipline	.929	35	.233
I like to think about how work can be improved	.927	35	.128
I see complex problems as challenging	.901	35	.203
I like to find a new solution to an existing problem	.858	35	.207
I am good at combining different disciplines	.863	35	.100
I can link new ideas to existing ideas (of others).	.858	35	.093
I see my assignment/project as challenging	.894	35	.054
I find my assignment /project field interesting	.929	35	.140
I am is good at my work	.866	35	.238
I can do my core tasks in a routine manner	.876	35	.110
I can understand the important concepts in the physics lab book	.864	35	.086
I can design examples about the content of the physics lab book	.885	35	.213
I can use my physics knowledge to understand the problem discussions in the physics lab book	.862	35	.069
I can write a simple example about any physics subject I have learned.	.857	35	.112
I can understand physics lab terms	.916	35	.088
I can make an effective use of my knowledge while solving physics lab problems.	.897	35	.093

I can make connections between recently learned subjects and my physics lab knowledge.	.899	35	.054
I can discover little things by using physics theorems.	.876	35	.220
I can make connections between physics lab terms.	.853	35	.200
I can interpret a physics lab subject I have seen for the first time with my previous knowledge.	.936	35	.149
I can identify the important physics lab points of a physics lab subject I read about.	.928	35	.230
I know how to behave when I encounter a new challenge in physics lab.	.871	35	.058
I believe that I have the ability to learn physics lab.	.920	35	.223
I know how I can make an effective use of my previous knowledge when I encounter a new challenge in physics lab.	.912	35	.237
I can use my physics lab knowledge to learn similar concepts in other lessons.	.915	35	.190
I can find clues in physics lab problems.	.859	35	.131
I can solve physics lab problems by using self-specific solutions.	.858	35	.195
I can concentrate in physics lab sessions.	.888	35	.112
I strongly believe that I can solve a difficult physics lab problem.	.866	35	.101
I can guarantee the accuracy of a result I find for a physics lab problem.	.918	35	.101
I can get compliments for my physics lab homework.	.875	35	.075
I always have a feeling that I solve a physics lab problem correctly.	.889	35	.095
I can get good marks in physics lab exams.	.865	35	.200
I can solve physics lab problems by concretizing them.	.861	35	.180
I can make a good solution plan for physics lab problems.	.901	35	.082
I have my own ideas about questions related to physics lab.	.858	35	.212
I can analyze the event in a physics problem.	.926	35	.150
I study alone to solve problems in the learning step.	.918	35	.071
I think with a physics lab mentality when planning daily life events.	.928	35	.134

Results About the Effect of Gamified Flipped Learning Model on Students' Innovation Skills

The first research question is aimed at investigating the effects of implementing the gamified flipped learning model on the innovation skills of students in a virtual physics lab. By conducting an independent-samples t-test significant at the 0.05 level prior to the start of the experiments, it was established that there was no statistical difference observed between the Innovation skill of the Experimental group and those of the students in the control group before the experiment. Responses were obtained from the participants about their innovation skill before and after the study. Upon analyzing the survey data on Innovation skills, Table 5, Table 6 and Table 7 contain the outcomes. Considering that $p \geq 0.05$ for the innovation skills survey items as seen in Table 5, it can be said that the difference between the innovation skill of students in the experimental group and control group was not significant before the start of the experiment.

Table 5.
Pre-test scores of Innovation Skill Survey

	Group	N	Mean	Std. Deviation	Std. Error Mean	*t*	*p*
I like to think about a new project approach	Experiment	35	2.4286	.91670	.15495	.770	.742
	Control	35	2.6000	.94558	.15983		
I like to find new challenging to develop new products in my own discipline	Experiment	35	2.2000	.93305	.15771	1.881	.923
	Control	35	2.6286	.97274	.16442		
I like to think about how work can be improved	Experiment	35	2.5429	.91853	.15526	.392	.751
	Control	35	2.6286	.91026	.15386		
I see complex problems as challenging	Experiment	35	2.5429	.91853	.15526	.256	.960
	Control	35	2.4857	.95090	.16073		
I like to find a new solution to an existing problem	Experiment	35	2.5714	.81478	.13772	.813	.461
	Control	35	2.4000	.94558	.15983		
I am good at combining different disciplines	Experiment	35	2.7429	.65722	.11109	.140	.042
	Control	35	2.7143	1.01667	.17185		
I can link new ideas to existing ideas (of others).	Experiment	35	2.5429	.98048	.16573	.669	.214
	Control	35	2.6857	.79600	.13455		
I see my assignment/project as challenging	Experiment	35	2.6857	.96319	.16281	.889	.794
	Control	35	2.6000	1.14275	.19316		
I find my assignment /project field interesting	Experiment	35	2.5429	.91853	.15526	.231	. 102
	Control	35	2.5143	1.03955	.17572		
I am is good at my work	Experiment	35	2.4286	1.00837	.17045	2.001	. 173
	Control	35	2.9714	1.24819	.21098		
I can do my core tasks in a routine manner	Experiment	35	2.4286	.91670	.15495	.770	. 345
	Control	35	2.6000	.94558	.15983		

Also, it can be observed from the results of the pre-test Innovation skill survey for both the experimental group and the control group in Table 5 that except for the question “I am good at combining different disciplines” for which the differences were significant ($p < .043$) prior to the start of the experiment, participants’ responses to other questions showed that they had similar Innovation skills ($p > 0.05$) before the start of the study.

Table 6.

Scores of innovation skill questionnaire (experimental group)

	Group	N	Mean	Std. Deviation	Std. Error Mean	*t*	*p*
I like to think about a new project approach	Pre-test	35	2.4286	0.91670	0.15495	6.529	0.023214
	Post-test	35	3.6857	0.67612	0.11429		
I like to find new challenging to develop new products in my own discipline	Pre-test	35	2.2000	0.93305	0.15771	6.809	0.042510
	Post-test	35	3.5429	0.70054	0.11841		
I like to think about how work can be improved	Pre-test	35	2.5429	0.91853	0.15526	5.758	0.016031
	Post-test	35	3.6571	0.68354	0.11554		
I see complex problems as challenging	Pre-test	35	2.5429	0.91853	0.15526	5.431	0.019105
	Post-test	35	3.6000	0.69452	0.11739		
I like to find a new solution to an existing problem	Pre-test	35	2.5714	0.81478	0.13772	5.473	0.007361
	Post-test	35	3.5143	0.61220	0.10348		
I am good at combining different disciplines	Pre-test	35	2.7429	0.65722	0.11109	4.176	0.000013
	Post-test	35	3.3429	0.53922	0.09114		
I can link new ideas to existing ideas (of others).	Pre-test	35	2.5429	0.98048	0.16573	4.489	0.013147
	Post-test	35	3.4571	0.70054	0.11841		
I see my assignment/project as challenging	Pre-test	35	2.4857	0.91944	0.15541	4.802	0.033127
	Post-test	35	3.4000	0.65079	0.11000		
I find my assignment /project field interesting	Pre-test	35	2.6000	1.14275	0.19316	4.115	0.021576
	Post-test	35	3.4857	0.56211	0.09501		
I am is good at my work	Pre-test	35	2.5143	1.03955	0.17572	5.455	0.042134
	Post-test	35	3.6000	0.55307	0.09349		
I can do my core tasks in a routine manner	Pre-test	35	2.4286	1.00837	0.17045	5.691	0.001821
	Post-test	35	3.5143	0.50709	0.08571		

From the experimental group, it was observed after the experiment that there was a significant difference ($p < 0.05$) between the pre-test and post-test performance of the students for each investigated variable. We can thus comfortably conclude that the innovation skills of the students who participated in the study was improved by the use of gamifications mechanics employed in the study.

Table 7.

Scores of Innovation Skill Questionnaire (Control Group)

	Group	N	Mean	Std. Deviation	Std. Error Mean	*t*	*p*
I like to think about a new project approach	Pre-test	35	2.6000	0.94558	0.15983	1.523	0.132326214
	Post-test	35	2.9429	0.93755	0.15847		
I like to find new challenging to develop new products in my own discipline	Pre-test	35	2.6286	0.97274	0.16442	1.465	0.147423234
	Post-test	35	2.9714	0.98476	0.16645		
I like to think about how work can be improved	Pre-test	35	2.6286	0.91026	0.15386	1.21	0.23034345
	Post-test	35	2.8857	0.86675	0.14651		
I see complex problems as challenging	Pre-test	35	2.4857	0.95090	0.16073	0.86	0.392542379
	Post-test	35	2.6857	0.99325	0.16789		
I like to find a new solution to an existing problem	Pre-test	35	2.4000	0.94558	0.15983	1.048	0.298199693
	Post-test	35	2.6286	0.87735	0.14830		
I am good at combining different disciplines	Pre-test	35	2.7143	1.01667	0.17185	1.221	0.226243151
	Post-test	35	3.0000	0.93934	0.15878		
I can link new ideas to existing ideas (of others).	Pre-test	35	2.6857	0.79600	0.13455	0.587	0.559298529
	Post-test	35	2.8000	0.83314	0.14083		
I see my assignment/project as challenging	Pre-test	35	2.6857	0.96319	0.16281	1.09	0.279366019
	Post-test	35	2.9143	0.78108	0.13203		
I find my assignment /project field interesting	Pre-test	35	2.5429	0.91853	0.15526	1.276	0.206272517
	Post-test	35	2.8286	0.95442	0.16133		
I am is good at my work	Pre-test	35	2.9429	0.96841	0.16369	0.794	0.429778596
	Post-test	35	3.1143	0.83213	0.14066		
I can do my core tasks in a routine manner	Pre-test	35	2.9714	1.24819	0.21098	1.029	0.306897293
	Post-test	35	3.2571	1.06668	0.18030		

Table 7 contains the control group's result from which it was observed after the experiment that there was no significant difference ($p > 0.05$) between the pre-test and post-test performance of the students for each investigated variable. This is in contrast to the observed performance improvement noticed in the students who were present in the experimental group as contained in Table 6. We can thus comfortably conclude that the innovation skills of the students who participated in the study was improved by the use of gamifications mechanics employed in the study.

Results About the Effect of Gamified Flipped Learning Model on Students' Physics Self-Efficacy

Also, we present the results of analysis done on self-efficacy of the students. Before the study, pre-test survey was conducted on participants in both groups previously defined in the study. Results to this can be found in Table 8.

Table 8.

Pre-test scores of Physics self-efficacy Survey

	Group	N	Mean	Std. Deviation	Std. Error Mean	*t*	*p*
I can understand the important concepts in the physics lab book	Experiment	35	3.6286	1.11370	.18825	1.413	.377
	Control	35	4.0000	1.08465	.18334		
I can design examples about the content of the physics lab book	Experiment	35	3.7429	1.14642	.19378	.525	.594
	Control	35	3.8857	1.13167	.19129		
I can use my physics knowledge to understand the problem discussions in the physics lab book	Experiment	35	3.7714	.84316	.14252	.000	.386
	Control	35	3.7714	.94202	.15923		
I can write a simple example about any physics subject I have learned.	Experiment	35	3.7429	1.09391	.18490	.788	.839
	Control	35	3.9429	1.02736	.17366		
I can understand physics lab terms	Experiment	35	3.6571	1.05560	.17843	.675	.880
	Control	35	3.8286	1.07062	.18097		
I can make an effective use of my knowledge while solving physics lab problems.	Experiment	35	3.6571	1.02736	.17366	.812	.817
	Control	35	3.8571	1.03307	.17462		

I can make connections between recently learned subjects and my physics lab knowledge.	Experiment	35	3.9714	.95442	.16133	.637	.981
	Control	35	3.8286	.92309	.15603		
I can discover little things by using physics theorems.	Experiment	35	3.8286	1.07062	.18097	.354	.178
	Control	35	3.9143	.95090	.16073		
I can make connections between physics lab terms.	Experiment	35	3.9429	1.10992	.18761	.678	.886
	Control	35	3.7714	1.00252	.16946		
I can interpret a physics lab subject I have seen for the first time with my previous knowledge.	Experiment	35	3.6286	1.05957	.17910	.497	.178
	Control	35	3.7429	.85209	.14403		
I can identify the important physics lab points of a physics lab subject I read about.	Experiment	35	3.8286	1.01419	.17143	.222	.236
	Control	35	3.7714	1.13981	.19266		
I know how to behave when I encounter a new challenge in physics lab.	Experiment	35	3.5429	.95001	.16058	2.351	.990
	Control	35	4.0857	.98134	.16588		
I believe that I have the ability to learn physics lab.	Experiment	35	4.0286	.98476	.16645	.481	.780
	Control	35	4.1429	1.00419	.16974		
I know how I can make an effective use of my previous knowledge when I encounter a new challenge in physics lab.	Experiment	35	3.6857	1.07844	.18229	1.580	.465
	Control	35	4.0857	1.03955	.17572		
I can use my physics lab knowledge to learn similar concepts in other lessons.	Experiment	35	3.6286	1.23873	.20938	1.070	.125
	Control	35	3.9143	.98134	.16588		
I can find clues in physics lab problems.	Experiment	35	3.6857	1.13167	.19129	.595	.044
	Control	35	3.8286	.85700	.14486		
I can solve physics lab problems by using self specific solutions.	Experiment	35	3.6000	1.09006	.18425	.119	.464
	Control	35	3.5714	.91670	.15495		
I can concentrate in physics lab sessions.	Experiment	35	3.7714	1.11370	.18825	1.037	.334
	Control	35	4.0286	.95442	.16133		

I strongly believe that I can solve a difficult physics lab problem.	Experiment	35	3.9429	1.10992	.18761	.211	.288
	Control	35	3.8000	1.20782	.20416		
I can guarantee the accuracy of a result I find for a physics lab problem.	Experiment	35	3.8571	1.03307	.17462	.213	.730
	Control	35	3.8857	1.02244	.17282		
I can get compliments for my physics lab homework.	Experiment	35	3.8857	1.05081	.17762	.108	.609
	Control	35	3.8000	1.07922	.18242		
I always have a feeling that I solve a physics lab problem correctly.	Experiment	35	3.7714	1.13981	.19266	.108	.751
	Control	35	3.9429	1.16171	.19637		
I can get good marks in physics lab exams.	Experiment	35	3.9429	1.02736	.17366	1.746	.534
	Control	35	3.5714	1.14496	.19353		
I can solve physics lab problems by concretizing them.	Experiment	35	4.0286	1.04278	.17626	1.746	.177
	Control	35	3.4857	.98134	.16588		
I can make a good solution plan for physics lab problems.	Experiment	35	4.0000	.87447	.14781	2.315	.706
	Control	35	3.7714	1.03144	.17434		
I have my own ideas about questions related to physics lab.	Experiment	35	3.8571	1.11521	.18851	.334	.744
	Control	35	3.7429	1.01003	.17073		
I can analyze the event in a physics problem.	Experiment	35	3.7714	1.00252	.16946	.119	.917
	Control	35	3.8571	1.08852	.18399		
I study alone to solve problems in the learning step.	Experiment	35	3.8571	1.03307	.17462	.000	.784
	Control	35	3.8824	1.12181	.19239		
I think with a physics lab mentality when planning daily life events.	Experiment	35	3.7429	1.01003	.17073	.542	.377
	Control	35	3.6286	1.11370	.18825		

The second research question is aimed at investigating the effects of implementing the gamified flipped learning model on the self-efficacy of students in a virtual physics lab. By conducting an independent-samples t-test significant at the 0.05 level prior to the start of the experiments, it was established that there was no statistical difference observed between the self-efficacy of the Experimental group and those of the students in the control group before the experiment. Responses were obtained from the participants about their self-efficacy before and after the study.

Upon analyzing the survey data on self-efficacy, Table 8 and Table 9 contain the outcomes. Considering that $p \geq 0.05$ for the self-efficacy survey items as seen in Table 8, it can be said that the difference between the self-efficacy of students in the experimental group and control group was not significant before the start of the experiment.

In line with the test conducted to verify the Innovation skill equivalence of participants in both groups earlier, another test was conducted in order to ascertain that both groups had similar self-efficacy. But considering the mean of values and p at a significance of less than or equal to $.05$, it can be observed from Table 8 which contains the outcome of this investigation that prior to the study, participants in both groups had similar self-efficacy.

Table 9.

Post-test scores of Physics self-efficacy Survey

	Group	N	Mean	Std. Deviation	Std. Error Mean	*t*	*p*
I can understand the important concepts in the physics lab book	Experiment	35	2.9429	.90563	.15308	1.413476	0.162077
	Control	35	3.3143	1.07844	.18229		
I can design examples about the content of the physics lab book	Experiment	35	2.8286	.70651	.11942	0.524651	0.601532
	Control	35	3.5143	1.14716	.19390		
I can use my physics knowledge to understand the problem discussions in the physics lab book	Experiment	35	2.8000	.58410	.09873	0	1
	Control	35	3.4286	1.03713	.17531		
I can write a simple example about any physics subject I have learned.	Experiment	35	2.6857	1.02244	.17282	0.788443	0.433178
	Control	35	3.6000	1.00587	.17002		
I can understand physics lab terms	Experiment	35	2.9429	.93755	.15847	0.674551	0.502248
	Control	35	3.6000	1.11672	.18876		
I can make an effective use of my knowledge while solving physics lab problems.	Experiment	35	2.9429	.76477	.12927	0.812121	0.419556
	Control	35	3.6571	1.10992	.18761		
I can make connections between recently learned subjects and my physics lab knowledge.	Experiment	35	3.0857	.95090	.16073	0.636512	0.52658
	Control	35	3.5429	1.06668	.18030		

I can discover little things by using physics theorems.	Experiment	35	2.9143	.85307	.14420	0.354133	0.724335
	Control	35	3.6571	.96841	.16369		
I can make connections between physics lab terms.	Experiment	35	2.9143	.85307	.14420	0.678089	0.500016
	Control	35	3.5429	.98048	.16573		
I can interpret a physics lab subject I have seen for the first time with my previous knowledge.	Experiment	35	2.8571	.84515	.14286	0.497265	0.620606
	Control	35	3.5429	.81684	.13807		
I can identify the important physics lab points of a physics lab subject I read about.	Experiment	35	2.8857	.79600	.13455	0.221579	0.825305
	Control	35	3.6000	1.14275	.19316		
I know how to behave when I encounter a new challenge in physics lab.	Experiment	35	2.7714	.80753	.13650	2.351346	0.021611
	Control	35	3.7143	1.10004	.18594		
I believe that I have the ability to learn physics lab.	Experiment	35	2.9143	.74247	.12550	0.480724	0.632255
	Control	35	3.8571	1.14128	.19291		
I know how I can make an effective use of my previous knowledge when I encounter a new challenge in physics lab.	Experiment	35	2.9429	.76477	.12927	1.579835	0.118785
	Control	35	3.8571	1.16677	.19722		
I can use my physics lab knowledge to learn similar concepts in other lessons.	Experiment	35	2.8857	.90005	.15214	1.069584	0.288588
	Control	35	3.6286	1.08697	.18373		
I can find clues in physics lab problems.	Experiment	35	2.9429	.99832	.16875	0.595367	0.553719
	Control	35	3.5714	.94824	.16028		
I can solve physics lab problems by using self-specific solutions.	Experiment	35	2.8286	.92309	.15603	0.118678	0.90588
	Control	35	3.4000	.94558	.15983		
I can concentrate in physics lab sessions.	Experiment	35	2.7714	.80753	.13650	1.037199	0.303318
	Control	35	3.8000	1.05161	.17775		
I strongly believe that I can solve a difficult physics lab problem.	Experiment	35	3.0857	1.01087	.17087	0.210819	0.833659
	Control	35	3.6571	1.16171	.19637		

I can guarantee the accuracy of a result I find for a physics lab problem.	Experiment	35	2.8286	.89066	.15055	0.212704	0.832194
	Control	35	3.5714	1.14496	.19353		
I can get compliments for my physics lab homework.	Experiment	35	3.0571	.96841	.16369	0	1
	Control	35	3.6857	1.15737	.19563		
I always have a feeling that I solve a physics lab problem correctly.	Experiment	35	2.9429	.90563	.15308	0.107686	0.914562
	Control	35	3.6286	1.11370	.18825		
I can get good marks in physics lab exams.	Experiment	35	3.0286	1.09774	.18555	0	1
	Control	35	3.7714	1.00252	.16946		
I can solve physics lab problems by concretizing them.	Experiment	35	2.8286	.82197	.13894	1.746355	0.085265
	Control	35	4.0286	1.04278	.17626		
I can make a good solution plan for physics lab problems.	Experiment	35	2.9143	.81787	.13824	2.31473	0.023654
	Control	35	4.0000	.87447	.14781		
I have my own ideas about questions related to physics lab.	Experiment	35	3.1143	.90005	.15214	0.333819	0.739544
	Control	35	3.8571	1.11521	.18851		
I can analyze the event in a physics problem.	Experiment	35	3.2286	1.00252	.16946	0.118777	0.905803
	Control	35	3.7714	1.00252	.16946		
I study alone to solve problems in the learning step.	Experiment	35	3.2000	1.05161	.17775	0	1
	Control	35	3.8571	1.03307	.17462		
I think with a physics lab mentality when planning daily life events.	Experiment	35	3.2571	1.03875	.17558	0.543159	0.588823
	Control	35	3.7429	1.01003	.17073		

Contrary to the observations for innovation skill, Table 9 shows the results of the physics self-efficacy survey, which indicates that gamification process did not improve the physics self-efficacy of the students.

Results of Interviews

The aim of the third research question is to identify the opinions of students in the experimental group about gamification. We conducted semi-structured interviews with 28 volunteer students from the experimental group in order to determine their perceptions towards the gamified flipped learning model. A total of six questions were asked from them. The first question in the interview asked about the benefit of gamification mechanics on the motivation of the students. The second question proceeded normally from the first question by asking if the student thought that the gamification mechanics can support their learning. In the third question, the students are asked if they think gamification is suitable for the just concluded physics lab, and why they think what they think. In the fourth question, the students are asked about the main advantages of the gamified virtual flipped physics lab, while the fifth questions asks about the disadvantages of the gamified virtual flipped physics lab as observed by the student. Finally, the sixth question requests from the students, some suggestions on how to tackle the problems experienced in the newly introduced learning model, and how to improve the gamified virtual flipped physics lab generally. Codings were done, and several themes were deduced after examining the qualitative data gathered from the students' answers. The frequencies of these codings have been presented in Table 10.

Table 10.

Themes Related to Gamified Flipped Learning

Context	Themes	Frequency
Perceptions of students about the gamification mechanics on their motivation.	Positive	28
	Negative	0
	Did not affect	0
Perceptions of students about the gamification mechanics on their learning.	Positive	27
	Negative	0
	Did not affect	1
Perceptions of Students about the gamified flipped learning for virtual physics lab.	Positive	22
	Negative	6
Advantage of the gamified flipped learning	Made learning fun.	10
	Developed my self-learning skills.	8

	Increased my social interaction.	0
Disadvantage of the gamified flipped learning	I did not like the method	0
	It worried me	0
Suggestions	Mechanics should be used more often.	4
	It should be applied in other courses as well.	4

Considering the codes under the context of Perceptions of students about the gamification mechanics on their motivation, all the students (f = 28) indicated that the gamification mechanics (such as levels, badges, leaderboards, points) increased their motivation for the course, some went further to provide details such as;

Student: Seeing my achievements made me happy

Since they all had positive perceptions about the gamification mechanics on their motivation, no student had a negative perception of gamification on their motivation.

Similarly, from the codes under the context of Perceptions of students about the gamification mechanics on their learning, a majority of the participants (f = 27) had perception that gamification mechanics have positive impact on their learning. Under this context, students provided details such as;

Student: It can create a competitive environment and this can be useful for our learning.

Also, another student responded to the interview question this way;

Student: I understand better by visualizing

Out of the 28 students who participated in the interview, only 1 student responded that the gamification mechanics had no effect on their learning. No student reported a negative effect from the usage of gamification mechanics (such as levels, badges, leaderboards, points) on their learning.

From the codes under the context of Perceptions of Students about the gamified flipped learning for virtual physics lab, most of the students had positive responses (f=22), claiming that the gamified flipped learning was an appropriate learning approach to the virtual physics lab. Referring to the gamified flipped virtual physics lab, a student has the following response under the understudied context, describing the enjoyment received from its application;

Student: The best thing that can be done for the physics class has been done. Physics lesson was more enjoyable for me

In the same context of Perceptions of Students about the gamified flipped learning for virtual physics lab, a few students (f= 6) responded negatively. From a perspective of class control, a student in this category gave the following response;

Student: No, in a real classroom, teachers have control over the classroom and there is discipline amongst the students.

From the codes in the next context, the context of Advantage of the gamified flipped learning, a number of the students (f= 10) answered that the main advantage to the gamified flipped learning approach is the fun it introduces to the learning process. On the other hand, other students (f= 8) agreed that the system helped develop their self-learning skills. A student gave the following response;

Student: The main advantage was that it is really easy to follow. It is very convenient for taking different readings in a quick manner. I highly recommend this version of Labs as it is a fun way to study the physics Lab.

From the codes in the next context, the context of Disadvantage of the gamified flipped learning, a number of the students (f= 15) answered that they could not identify a disadvantage of the gamified flipped learning approach. A student who participated in the interview had the following to say;

Student: I do not see anything disadvantage with it. Everything is okay

Finally, from the codes in the context of suggestions to improve learning in the gamified virtual flipped physics lab, while some students did not have suggestions for the improvement of the gamified virtual flipped physics lab because they believed that there was no need for such, a number of the students (f= 4) were of the opinion that gamification should be applied to other courses also, while some other students (f= 4) expect that the mechanics of it be applied more often. Among the students, a student had this to say;

Student: This kind of practice can be done on all subjects

Summarily, as seen in Table 10, using thematic analysis, interview responses/transcripts were thoroughly and repeatedly perused to identify patterns in participants' descriptions of their experiences. Several recurring patterns were observed in the study. All the students agreed that the gamification mechanics employed in the research (such as levels, badges, leaderboards, points) increased their motivation for the course, some went further to provide details such as "Seeing my achievements made me happy". In like manner, the students collectively agreed that the provided game mechanics can greatly support their learning.

When asked if the students think that the gamified flipped learning approach is suitable for virtual physics class, most (79%) of the students perceived that it was, leaving only a handful of students with contrasting opinions which is open to consideration. Among these remaining 21% with contrasting views, some requested for better "class control", claiming that instructors' physical absence may play a positive role in students' participation.

When asked to know the main advantages of the gamified flipped class they had, the participants unusually provided divergent reasons, but all agreed that there were certain advantages. Their responses varied from "Instant feedback" through "faster result" to "ease of results' reproducibility". The latter 2 responses show clear benefits of a simulated laboratory experiment which need to be explored further by researchers. Due to the complexity in the process of setting up a physical laboratory experiment session, time required and the difficulty of subsequently reproducing exact results due to several uncontrollable phenomenon, the ease of reproducibility and experiment setup in the gamified flipped approach appeals to students. On the flip side, when asked about the disadvantages of the gamified flipped laboratory sessions, even though more than half (54%) of the participants didn't notice a disadvantage, the prevalent challenge among the 46% remaining responses seems to be "technical issues", as students complained of a few technical challenges they faced in joining and maintaining productive sessions.

While some students perceived the system as perfect or could not figure out a necessary improvement it needs, some others recommended that periodically, it should be mixed with traditional classroom while an interviewee requested for "more games".

Students' Perception by Department

Since we have students from various departments within the university, their perception based on department was also evaluated. Students who participated in the interview process were from 6 departments namely; Computer Engineering, Software Engineering, Mechatronics Engineering, Biomedical Engineering, Food Engineering, and Environmental Engineering. Table 11 contains the frequency distribution of the students who volunteered to participate in the interview according to their respective departments.

Table 11.

Frequency Distribution of Interviewed Students according to Departments

Department	**Frequency**
Computer Engineering	16
Biomedical Engineering	6
Food engineering	3
Environmental Engineering	1
Software Engineering	1
Mechatronics Engineering	1

Figure 10 shows the pictorial ratio representation of students who participated in the interview according to their departments. We had 16 Computer Engineering, 1 Software Engineering, 1 Mechatronics Engineering, 6 Biomedical Engineering, 3 Food Engineering, and 1 Environmental Engineering students who participated in the semi-structured interview that was conducted.

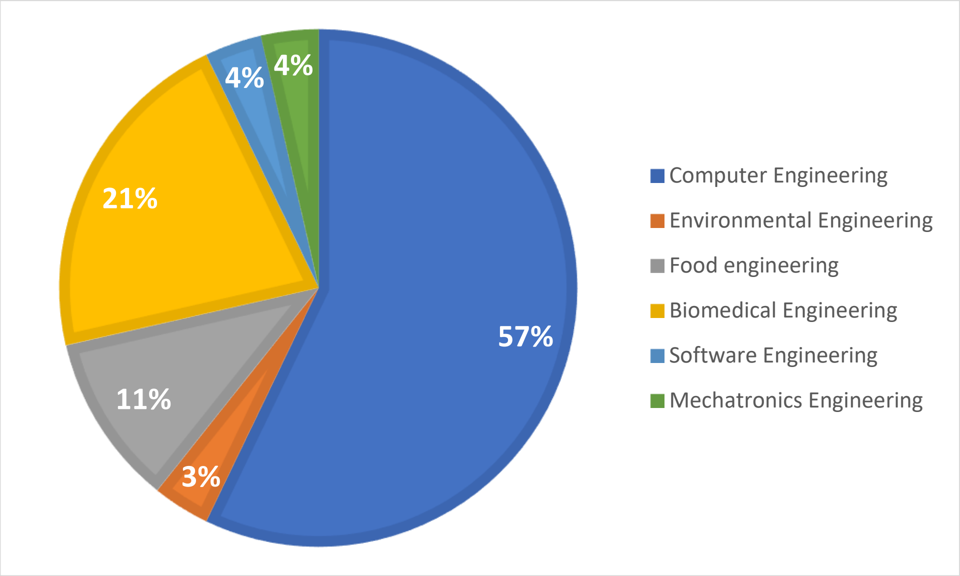

Figure 10. Interview Respondents According to Department

Perceptions of Students about the Gamification Mechanics on their Motivation.

From the codes under the context of Perceptions of students about the gamification mechanics on their motivation, irrespective of departments, all the students had positive responses. It was observed that all the Computer Engineering students (f= 16), Software Engineering students (f= 1), Mechatronics Engineering (f= 1), Biomedical Engineering (f= 6), Food Engineering (f= 3), and Environmental Engineering student (f=1) who participated in the interview had positive perception of gamification mechanics (such as levels, badges, leaderboards, points) on their motivation. It could be seen that department did not play any role in their perception of gamification mechanics on their motivation.

Perceptions of Students about the Gamification Mechanics on their Learning.

From the codes under the context of Perceptions of students about the gamification mechanics on their learning, little disparity was observed. All the students except for one in the department of Computer Engineering had positive perceptions on the impact of gamification mechanics on their learning. The students of Computer Engineering students (f= 15), Software Engineering students (f= 1), Mechatronics Engineering (f= 1), Biomedical Engineering (f= 6), Food Engineering (f= 3), and Environmental Engineering student (f=1) who participated in the interview had positive perception of the gamification mechanics on their learning.

No student from any department perceived that the gamification mechanics had a negative impact on their learning.

Perceptions of Students about the Gamified Flipped Learning for Virtual Physics Lab.

From the codes under the context of Perceptions of Students about the gamified flipped learning for virtual physics lab, it was observed that the gamified flipped virtual physics lab was unpopular among mechatronics engineering students as it received a negative response (f= 1) from the representing student. (f= 3) also gave a negative response among the Biomedical engineering students available in the interview, this equals to a negative response from 50% of the students from this department. All the students in both software engineering (f=1) and food engineering (f= 1) found the virtual physics lab highly compatible with the gamified flipped learning. From the department of computer engineering, it was observed that (f= 13) students perceived that gamified flipped learning is very suitable for virtual physics lab.

A Computer Engineering student responded;

Computer Engineering Student: Yes, because it helps you return to the experiment to be sure again and more than once. The student is not required to repeat the experiment in order to obtain the results of the interactions and write them down

Similarly, a Biomedical Engineering student had this response;

Biomedical Engineering Student: Yes, because it's fun and educational

Advantage of the Gamified Flipped Learning.

From the codes in the context of Advantage of the gamified flipped learning, several advantages were presented by the students. It was also easy to note that a few students could not identify the advantages of the learning model. (f= 2) students, who also are from the Department of Computer Engineering were in this category. A student from this department said this;

Computer Engineering Student: Main advantage is that it is much easier for us to learn

Also, a student from Biomedical Engineering department (f= 1) had the following to say about the advantage of the gamified flipped learning;

Biomedical Engineering Student: we can experiment live and see the results faster

A Food Engineering student reported this advantage;

Food Engineering Student: Improved motivation and Interest

Disadvantage of the Gamified Flipped Learning.

From the codes in the next context, the context of Disadvantage of the gamified flipped learning, a large percentage of Biomedical Engineering students (f= 5) answered that they could not identify a disadvantage of the gamified flipped learning approach, while (f= 1) Biomedical Engineering student had a reservation about the teaching model. From the department of Computer Engineering, (f= 5) students had varying disadvantages that were recognized from the study. A student said the following;

Computer Engineering Student: One of the biggest shortcomings with gamified is the focus on short-term gains vs. long-term. As we look at some of the engagement elements of gamification points, badges and leaderboards — it is clear they can provide an increase in short-term engagement when implemented into an enablement program.

Also, an Environmental Engineering student identified the following disadvantage when asked about the gamified flipped learning;

Environmental Engineering Student: It might decrease some students' attention span.

A Food Engineering student also responded about the effect of the physical absence of the teacher with the students, giving them the chance to get out of control while studying. The student said the following;

Food Engineering Student: For me there is no any disadvantage, but one of the disadvantages could be student not concentrating on the labs just doing it for fun.

Suggestions to Improve Learning in the Gamified Virtual Flipped Physics Lab.

Finally, from the codes in the context of suggestions to improve learning in the gamified virtual flipped physics lab, some students (f= 9) from the department of Computer Engineering did not have suggestions for the improvement of the gamified virtual flipped physics lab because they believed that there was no need for such. From other departments, a Food Engineering student who was contented with the gamified flipped virtual physics lab had little to no suggestion, they said;

> *Computer Engineering Student: I don't have any suggestions as I think everything was done well so I wouldn't like to change anything in it.*

In like manner, a Computer Engineering student who seemed to have experience a technical challenge during the lab sessions had the following suggestion, here is it;

> *Computer Engineering Student: Optimizing the audio system just nothing else.*

CHAPTER V

Discussion and Conclusion

In this section, we provide discussions on the findings obtained from collected data. Data from the qualitative and quantitative research is discussed. Also, suggestions for future research are provided.

Discussion

In this study, we have investigated the impacts introduced by gamification and its elements on the innovation and self-efficacy of first year university physics students. The results of the study have made crucial attempts to provide clarifications on the impacts of gamified flipped classroom on recipients in an academic environment (students) within the scope of perception, innovation skills and self-efficacy of students.

Results About the Effect of Gamified Flipped Learning Model on Students' Innovation Skills

The results of the survey carried out to measure the Innovation skill of the students showed that the experimental group improved in their Innovation skills at the end of the experiment, it was observed that there was a significant difference $(p < 0.05)$ between the pre-test and post-test performance of the students for each investigated variable. Conversely, among the control group students after the experiment, it was identified that the innovation skills of the students did not improve. It can be concluded that due to the gamification mechanics, the innovation skills of the students who participated in the study was improved by the use of gamifications mechanics employed in the study. The reason for the improvement in Innovation skills can be narrowed down to the improved engagement and motivation to learn by the students, as the students perceived that through it, leaning was fun.

The result obtained about innovation in this work is in conformity with the results of (Ionica & Leba, 2015) in which improvement to students' innovation was practically marked by their ability to develop a detailed software system. The presence of several elements applied with the experimental group of the study, such as badges and levels were considered to have played significant roles in student's improved innovation skill. Students were able to conduct experiments on their own without external interference or involvements, and also, integrate their creativity in the process of conducting the required experiments.

Participants in the study showed a positive perception of the learning approach, specifically mentioning some key aspects of the process that were outstandingly beneficial. A participant found the “ability to reproduce experiment results without setting up the experiment environment all-over” as an unparalleled benefit of the gamified-flipped lab environment because it provides a research environment which is currently unavailable in the conventional laboratory. This unique environment enables studies on varying research parameters to be conducted in a short period as time-wasting, repetitive initializations are eliminated from the research process. Several participants indicated that they look forward to gamified-flipped learning experiences in other future courses, as 58% of the participants recommended that its scope be expanded to other courses. The result of this study was found to corroborate the findings of (Lu et al., 2021).

Considering that the innovation skill of the participants in the experimental group increased at the end of the study when compared with those of the control group, it is important to consider that gamification has a role it can play in improving innovativeness of students. Students in the experimental group can better perceive complex problems since the now “see them as challenging” rather than complex as described by their response to the questionnaire.

Results About the Effect of Gamified Flipped Learning Model on Students' Physics Self-Efficacy

In line with the findings in the studies of (Ortiz-Rojas et al., 2017; Rachels & Rockinson-Szapkiw, 2018), the study identified that no significant improvement was introduced by gamified-flipped learning on students’ self-efficacy, this could be a result of the prevailing COVID-19 situation and its psychological effects on the students. Contrary to the observations in Table 6 for innovation skill, Table 9 shows the results of the physics self-efficacy survey, which indicates that gamification process did not improve the physics self-efficacy of the students. The reason for this can be seen in the light of the work of Bandura, (1995) as they identified physiological and emotional states as one of four mandatory factors in the development of self-efficacy. Due to the prevalence of COVID-19, its accompanying concerns, and other individual physiological challenges such as an unanticipated mandate on students by their respective institutions to adapt to the online academic system, we believe that the development of students' self-efficacy suffered. Similarly, physiological and emotional states was identified in (Rachels & Rockinson-Szapkiw, 2018) as the main deterrents to the improvement of students' self-efficacy.

Results of Interviews

The third research question sought to identify the impact gamification and its mechanics on the perception of students on gamification. It was observed from the responses of the students that gamification mechanics (such as levels, badges, leaderboards, points, timers and feedback) improved their learning and consequently, promoted their perception of the learning method.

Analysis was done based on the perception of gamification and its mechanics by the students based on their departments. From the 6 represented departments, it was observed that students in the department of Computer Engineering who were highly represented in the study also had more positive responses concerning the advantages of the gamified flipped virtual physics lab on their learning. Though it cannot be established that gamification mechanics had more impact on their learning due to the distribution disparity, it is quite worthwhile to note that a significant number of the students had a positive perspective of the method. It can thus be interpreted that students in computing and computer related fields tend to appreciate the gamified learning approach possibly due to their familiarity with computers which makes their learning curve probably gentler than those from contrasting departments who have little to no computing background.

Limitations of the Study

Even though the study provides an insight to the significance of the gamified-flipped learning to students' perception, self-efficacy, and innovation skills, yet, its findings are not without limits.

It must be understood that the findings in the study were obtained from, and are related to the undergraduate Physics class, and as such, may not be directly applicable to other fields of learning. Any form of generalization of the study to other fields must be considered cautiously. Similarly, through this study, perception of students concerning the flipped classroom was collected, involving the conduction of interviews with the participants. The responses and analysis done in this section described those of the students, while those of the instructors were not considered. It is essential to consider such an evaluation in future studies.

Also, in this study, 3 variables were identified and measured to investigate the impact of the gamified-flipped classroom on participating students, they are innovation skills, self-efficacy and perception. While the measurement of these variables provides us with required information about their roles in the effectiveness of the afore-mentioned teaching approach, it is needful to know that the list of 3 variables is far from exhaustive in the investigation of students' relationship with the gamified-flipped learning approach. Due to this, several other measures are to be identified and investigated in order to identify their roles and their impacts in the gamified flipped learning context.

Similarly, the time span in which the study was conducted may be of great importance to the outcome of the study. The study was conducted in just 10 weeks, while the normal length of an academic semester in Near East University exceeds this. Also, the study investigates the impacts of gamified flipped learning by using the regular (non-gamified) flipped learning as a control study. This is crucial, yet, a study comparing the gamified flipped learning with the traditional classroom learning method needs to be conducted, as well as a study on non-experimental based classes in order to balance the study.

Implications of the Study

The potentials of the gamified flipped learning have been seen from the study considering perception, self-efficacy and Innovation as investigated variables. It is needful then to note the scientific significance of the findings from each variable. Considering perception, it is important that researchers and other scientific stakeholders take advantage of the positive perception of the students by introducing more gamified flipped learning courses to their syllabus. Researchers also can further investigate the perception of participating students about GFL in other non-engineering related courses.

It has been observed from the study that self-efficacy was not improved by the application of the GFL, with a possible cause being the prevailing Covid-19 pandemic and its effects on participating students. Since the panic and fear ascribed to Covid-19 is expected to wane in coming years as several medical solutions are obtained and the pandemic declines, researchers and educational experts need to seek out new findings in this area. In the short while, self-efficacy improvement of students need to be sought from other means, or through other methods while the pandemic is still ongoing.

It was also observed that Innovation was improved by the application of the gamified flipped learning GFL on the study syllabus of the students. This offers an essential benefit to researchers and instructors as the innovation skills of students can be targeted for a boost using this means. Instructors are thus advised to ensure that students are subject to this innovation improving learning technique, while researchers investigate more ways to improve it.

Recommendations from the Study

The results of this study provide a practical guide to instructors, managers and stakeholders in the learning environments. It is recommended that they establish and maintain frameworks that can promote gamified flipped learning in their respective establishments considering its benefits as identified by the study.

This system can be setup either by existing units in the institution of learning, or by the creation of a specialized for the design and implementation of gamified flipped learning environments, initially for various engineering courses, and subsequently expanded to other applicable fields of study. By establishing such student-centric learning systems, better environments are provided to the students in which collaboration and detailed approach to complex problems can be made, which in turn provide novel findings and better learners.

Conclusion

The findings obtained from this thesis provides several contributions to the body of existing knowledge. From our research, we identified that gamifying the flipped classroom is tremendously beneficial to the improvement of students' innovation skill and perception of the learning environment. Since innovation skill, a measure of the encouragement received by a student to research, explore, study and integrate the use of available tools and resources in order to make novel findings plays a pivotal role in the ability of students to formulate new solutions to problems and henceforth, succeed academically, then the introduction of gamification to the learning environment promises better innovation skills among university students.

Also significant is the role perception plays in the success of students. Since it produces the propensity to learn new information due to their relationship with existing ones (Morris, 2016), it becomes important to ensure that students are equipped with such information that will promote their desire to learn new information. Also, the findings in this research about innovation is very important in helping students attain their academic potential, and not dropout in severe cases (Kershaw et al., 2014; Köller, 2001; Viswanathan & Linsey, 2009).

From the data obtained in the study, we can come to a conclusion that students approve of, and enjoy the flipped learning method and are satisfied with it. With it, they realize that they can have full control over their own learning speed and environment as well as engage in very productive interaction with their colleagues during the period of learning. An opportunity they never had in the traditional classroom since it is Instructor-centric. Considering the results of the study, it is safe then to conclude that the gamified flipped learning technique is an effective learning approach for engineering students and engineering courses.

Suggestions for Further Studies

Considering the study limitations described earlier in the study, in further studies we can investigate the perception of instructors as gamification is concerned. Even though students have tremendously positive perception of the instruction approach, this does not directly translate to those of the instructors who have the responsibility of providing both the learning environment and the resources.

While the variables; innovation skill, self-efficacy and students’ perception were measured in this research, it would be important to measure other essential variables such as motivation and academic performance can be investigated subsequently for the duration of a complete academic semester, treating the traditional classroom learning method as a control study in a true-experimental research.

Also, by altering the geographical region of the study, the significance of these variables on the results obtained can be identified in other localities, making sure that applicable data is available for each region.

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APPENDICES

Appendix A: Ethics Approval

YAKIN DOĞU ÜNİVERSİTESİ

BİLİMSEL ARAŞTIRMALAR ETİK KURULU

17.12.2019

Dear Hana Dler Ahmed

Your application titled **"The Effects of of Gamified Flipped Learning Environment on Student Innovation Ability, Self-efficacy towards Physics course and perceptions"** with the application number YDÜ/EB/2019/397 has been evaluated by the Scientific Research Ethics Committee and granted approval. You can start your research on the condition that you will abide by the information provided in your application form.

Assoc. Prof. Dr. Direnç Kanol

Rapporteur of the Scientific Research Ethics Committee

Note: If you need to provide an official letter to an institution with the signature of the Head of NEU Scientific Research Ethics Committee, please apply to the secretariat of the ethics committee by showing this document.

Appendix B: Questionnaire

Dear Students,

The purpose of this questionnaire is to collect data about "The Effects of Gamified Flipped Learning Environment on Student's innovation skills, self- efficacy towards virtual physics lab course and perceptions".

As a researcher, I would appreciate if you could fill in the questionnaire, which will only take 15 minutes.

This is completely confidential and will not be used for any other purpose except this research.

I would kindly appreciate your invaluable contributions to my research.

Hana Dler Ahmed

PhD in Computer and Instructional Technology in Education

Hana.majeed90@yahoo.com

General personal information:

Nickname:

Age:

Department:

Gender:

TO BENEFIT INNOVATION, HOW DO YOU CONSIDER YOUR ABILITY TO:

Creative thinking dimension	Strongly Disagree	Disagree a little	Neither disagree nor agree	Agree a little	Strongly agree

1. I like to think about a new project approach.					
2. I like to find new challenging to develop new products in my own discipline					
3. I like to think about how work can be improved					
4. I see complex problems as challenging					
5. I like to find a new solution to an existing problem					
6. I am good at combining different disciplines					
7. I can link new ideas to existing ideas (of others).					
Intrinsic motivation dimension					
1. I see my assignment/project as challenging					
2. I find my assignment /project field interesting					
Autonomy dimension					
1. I am is good at my work					
2. I can do my core tasks in a routine manner					

PHYSICS LAB SELF-EFFICACY QUESTIONNAIRE

This questionnaire is used for a research and aimed at investigating students' Self-efficacy toward physics Lab course.

QUESTIONNAIRE OF PHYSICS LAB SELF-EFFICACY **Sub-dimension 1: Learning Level**	Strongly Agree	Agree	Neither Agree Nor Disagree	Disagree	Strongly Disagree
1. I can understand the important concepts in the physics lab book					
2. I can design examples about the content of the physics lab book.					
3. I can use my physics knowledge to understand					

the problem discussions in the physics lab book.					
4. I can write a simple example about any physics subject I have learned.					
5. I can understand physics lab terms.					
6. I can make an effective use of my knowledge while solving physics lab problems.					
7. I can make connections between recently learned subjects and my physics lab knowledge.					
8. I can discover little things by using physics theorems.					
9. I can make connections between physics lab terms.					
10. I can interpret a physics lab subject I have seen for the first time with my previous knowledge.					
11. I can identify the important physics lab points of a physics lab subject I read about.					
12. I know how to behave when I encounter a new challenge in physics lab.					
13. I believe that I have the ability to learn physics lab.					
14. I know how I can make an effective use of my previous knowledge when I encounter a new challenge in physics lab.					
15. I can use my physics lab knowledge to learn similar concepts in other lessons.					
16. I can find clues in physics lab problems.					
17. I can solve physics lab problems by using self-specific solutions.					
18. I can concentrate in physics lab sessions.					

Sub-dimension 2: Problem Solving

1. I strongly believe that I can solve a difficult physics lab problem.					
2. I can guarantee the accuracy of a result I find for a physics lab problem.					

3. I can get compliments for my physics lab homework.					
4. I always have a feeling that I solve a physics lab problem correctly.					
5. I can get good marks in physics lab exams.					
6. I can solve physics lab problems by concretizing them.					
7. I can make a good solution plan for physics lab problems.					
8. I have my own ideas about questions related to physics lab.					
9. I can analyze the event in a physics problem.					
10. I study alone to solve problems in the learning step.					
11. I think with a physics lab mentality when planning daily life events.					

Appendix C: Interview Questions

1. Did the gamification mechanics (points, badges and leader board) increase your motivation? How?

2. Do you think game mechanics (points, badges and leader board) can support your learning? Why?

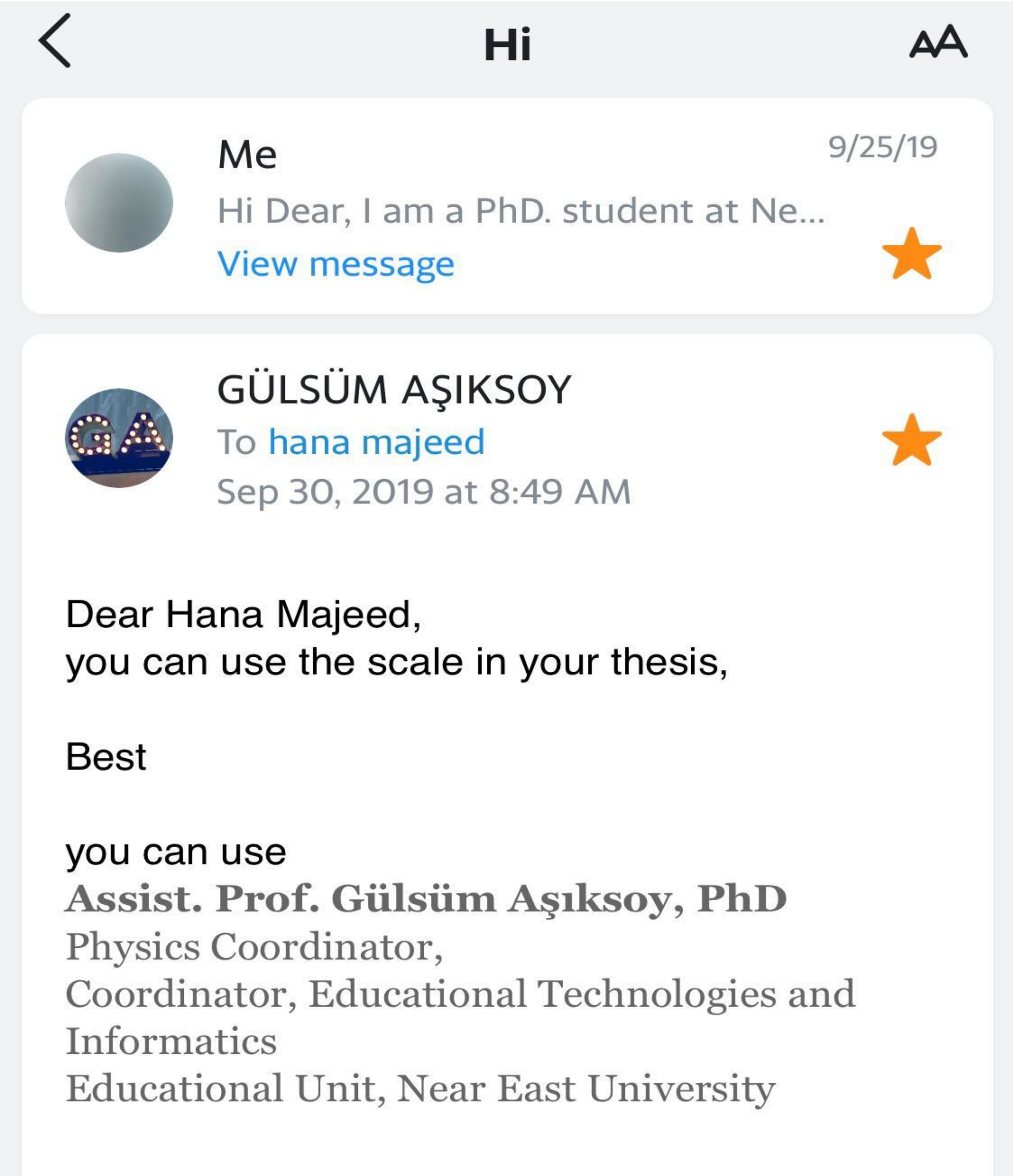
3. Do you think gamified flipped learning method is suitable for virtual physics lab? Why?

4. What are the main advantage of the gamified virtual flipped physic lab?

5. What are the disadvantages of the gamified virtual flipped physic lab?

6. What are your suggestions to improve learning in the gamified virtual flipped physic lab?

Appendix D: Permission to use Scale



Hi

Me 9/25/19

Hi Dear, I am a PhD. student at Ne...

View message

GÜLSÜM AŞIKSOY

To hana majeed

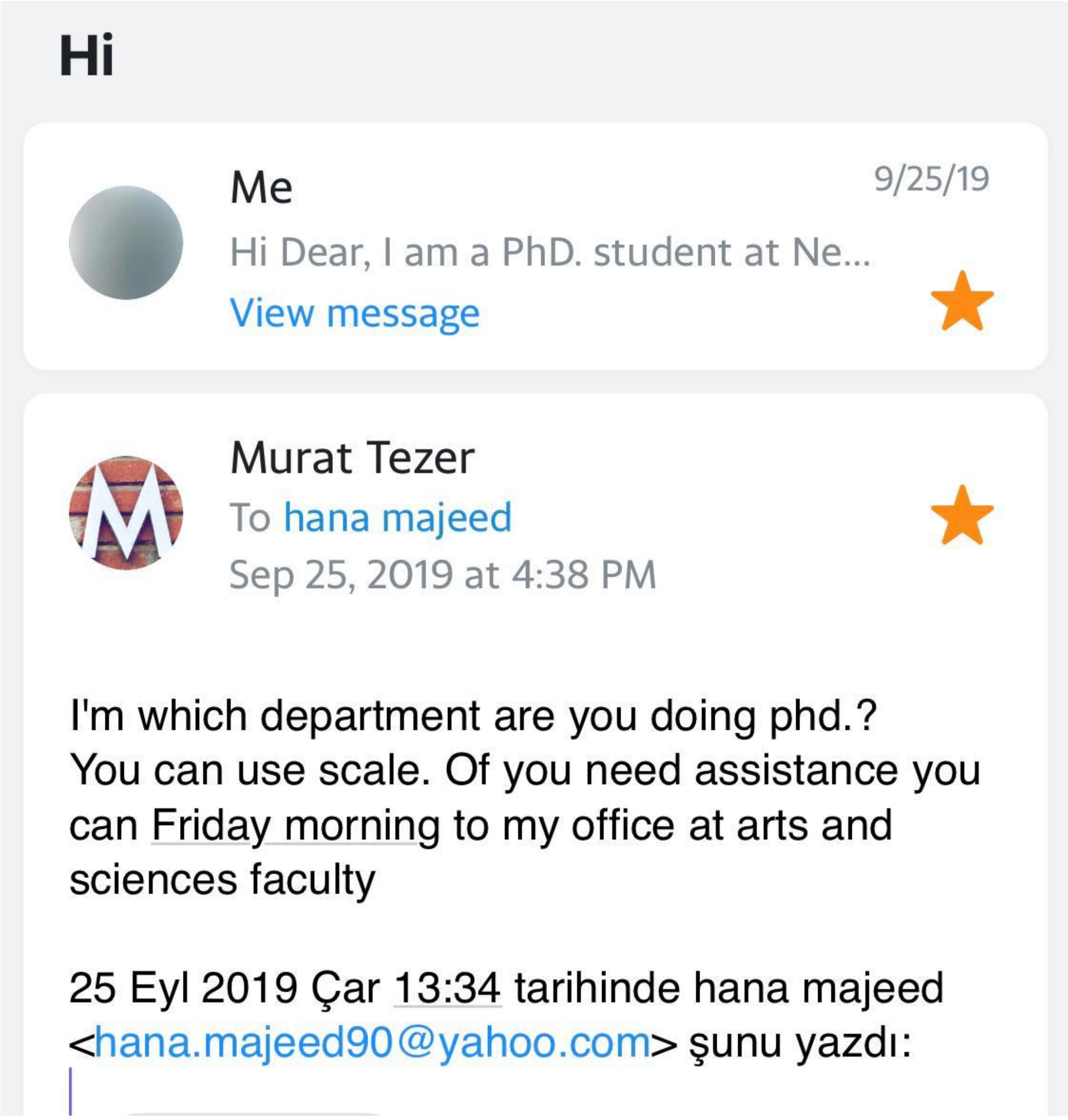
Sep 30, 2019 at 8:49 AM

Dear Hana Majeed,
you can use the scale in your thesis,

Best

you can use

Assist. Prof. Gülsüm Aşıksoy, PhD
Physics Coordinator,
Coordinator, Educational Technologies and Informatics
Educational Unit, Near East University



Hi

Me 9/25/19

Hi Dear, I am a PhD. student at Ne...

View message

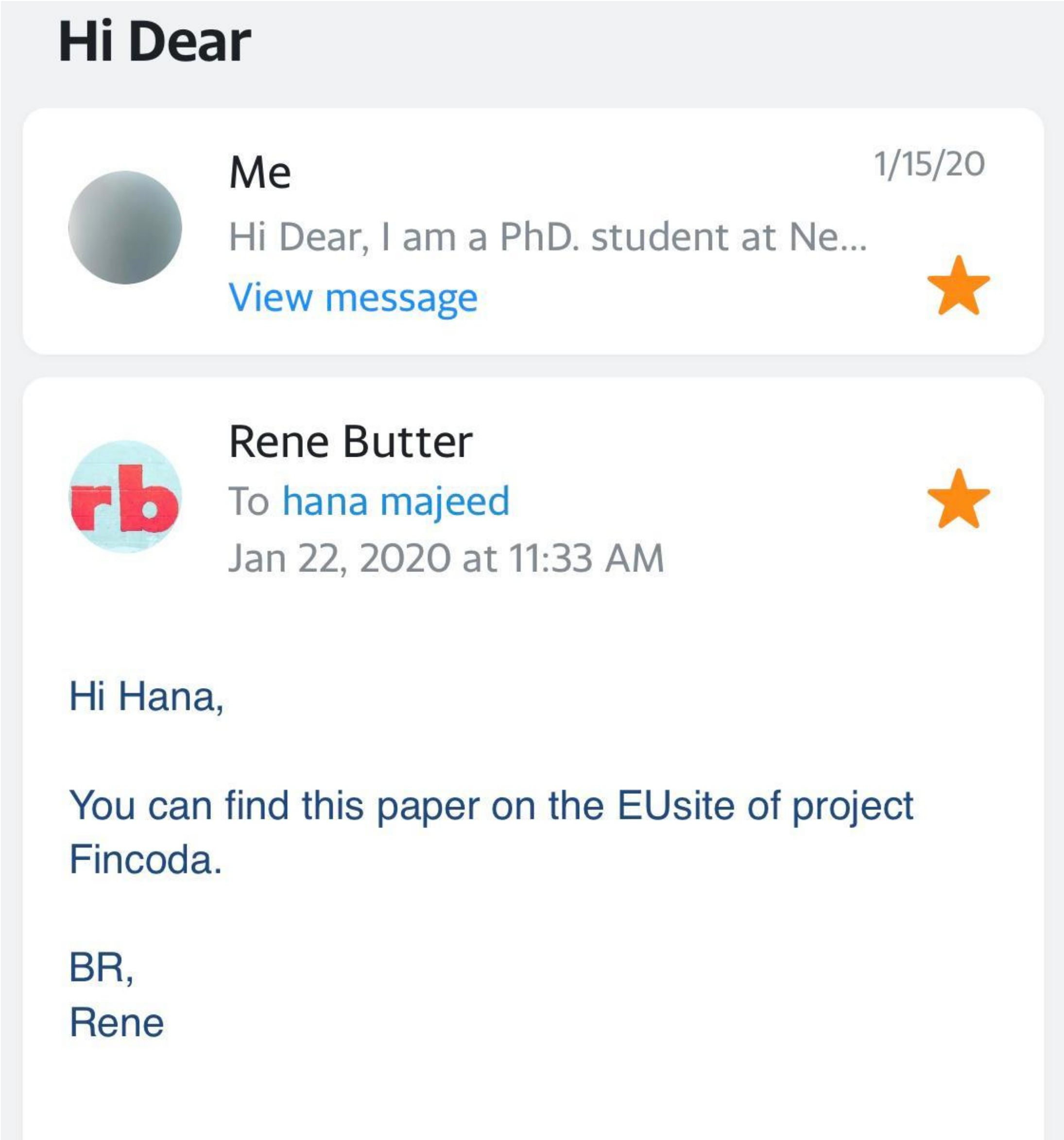
Murat Tezer

To hana majeed

Sep 25, 2019 at 4:38 PM

I'm which department are you doing phd.?
You can use scale. Of you need assistance you can Friday morning to my office at arts and sciences faculty

25 Eyl 2019 Çar 13:34 tarihinde hana majeed <hana.majeed90@yahoo.com> şunu yazdı:



Hi Dear

Me 1/15/20

Hi Dear, I am a PhD. student at Ne...

View message

Rene Butter

To hana majeed

Jan 22, 2020 at 11:33 AM

Hi Hana,

You can find this paper on the EUsite of project Fincoda.

BR,

Rene

Appendix E: Turnitin Similarity Report

Doküman Görüntüleyici

Turnitin Orijinallik Raporu

Işleme kondu: 27-Oca-2022 21:38 EET
NUMARA: 1749467389
Kelime Sayısı: 20089
Gönderildi: 1

Tez Hana Ahmed Dler tarafından

Benzerlik Endeksi	Kaynağa göre Benzerlik	
%13	Internet Sources:	%12
	Yayınlar:	%3
	Öğrenci Ödevleri:	N/A

alıntıları çıkar bibliyografyayı çıkar küçük eşleşmeleri çıkar mod: raporu hızlı görüntüle (klasik) Change mode yazdır yenile İndir

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Appendix F: Expert Opinions on Interview Questions

First Expert:

FAHRİYE ALTINAY

Dear Hana,

I would like to congratulate you on your research focus. You need to apply for ethical procedures in order to conduct your research. After getting the approval, if students are graduate students, I can support to collect data. If they are undergraduate students, you need to bring ethical approval to the Faculty of Education for collecting data to the students.

I hope it works

Best regards
Fahriye Altinay

Second Expert:

DİDEM İŞLEK

Semi-structured interview questions:

1. Did the gamification mechanics (points, badges and leader board) increase your motivation? Why?

2. Do you think game mechanics (points, badges and leader board) can support your learning? Why?

3. Do you think gamified flipped classroom method is suitable for physics course? Why?

4. What are the main advantage of the gamified flipped classroom?

5. What are the disadvantages of the gamified flipped classroom?

6. What are your suggestions to improve learning in the gamified flipped classroom?

7. What are the challenges that you faced during the application?

Third Expert:

HÜSEYİN BİCEN

Semi-structured interview questions:

1. Did the gamification mechanics (points, badges and leader board) increase your motivation? Why?

2. Do you think game mechanics (points, badges and leader board) can support your learning? Why?

3. Do you think gamified flipped classroom method is suitable for physics course? Why?

4. What are the main advantage of the gamified flipped classroom?

5. What are the disadvantages of the gamified flipped classroom?

6. What are your suggestions to improve learning in the gamified flipped classroom?

7. What are the challenges that you faced during the application?

Forth Expert:

Sezer KANBUL

Dear Hana,

First of all, I congratulate your supervisor and you. The subject of your work is very effective.

When adding the form to the thesis, the sample "qualitative interview form" format can be used. examples are found in qualitative research books.

The writing of the questions is appropriate.

The number and quality of the questions are appropriate.

Best wishes

Sezer.

CURRICULUM VITAE

PERSONAL INFORMATION

Name: Hana Ahmed Majeed

Gender: Female

Marital Status: Single

Date of Birth: 10.2.1990

Nationality: Iraq (Sulaimaniyah)

Email address: hana.majeed90@yahoo.com

Mobile Contact: +90(542)8753031

EDUCATION

1. BSc. Computer Science. Cihan University. 2010-2014.

2. MSc. Information and Communication Technologies in Education (ICTE). Eastern Mediterranean University. 2016-2017

3. Ph.D. in Computer Education and Technology. Near East University. 2017-2021.

PAST TRAININGS

1. Five courses of English in “AUIS” at Iraq-Sulaimaniyah.

2. IELTS lessons in institute at Sulaimaniyah.

SKILLS

-Language skills

Kurdish: Native

Arabic: Native

English: Advance -IELTS Academic (15th of July, 2017)

-Computing

Microsoft Office