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The Impact of Gamification on Learning Basic Biology Scientific Concepts in a Foreign Language at a Public High School

A thesis submitted to obtain the master's degree

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Dedication

To all my family.

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Abstract

Students who tend to engage in traditional classroom settings have been a persistent concern in science education (Pascarella & Terenzini, 2005). Some studies indicate that having low engagement can lead to negative consequences such as decreased academic performance, higher dropout rates, and reduced motivation (Fredricks et al., 2004). Furthermore, traditional teaching methods often face several challenges that can hinder student learning, motivation, and engagement despite giving basic foundations.

These methods typically rely on passive learning techniques and may not be adequate to engage students (Prensky, 2001). However, gamification, which is defined as the integration of game design elements into non-game contexts (Deterding et al., 2001), offers a potential solution to increase motivation and improve learning (Sailer et al., 2017). This study aims to identify whether a gamified approach can enhance students understanding of scientific concepts and promote a positive attitude towards science.

To achieve this goal, a mixed-method approach was employed with a sample of high school L2 biology students. Quantitative data focused on performance and qualitative data concentrated on the assessment of student attitudes. A group underwent pre- and post-tests to measure their biology knowledge and skills and their perceptions of the gamified course were conducted through a questionnaire and an interview.

The findings demonstrate a significant positive impact between the implementation of the gamified course and improvement in students learning dynamics. Students

who were exposed to this course showed substantially higher levels of motivation as well as the ability to solve tasks.

All in all, even though this research provides some evidence that gamification is not only a supplementary tool, it may improve pedagogical frameworks in order to meet educational objectives while providing essential skills for the modern workforce.

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CHAPTER I: INTRODUCTION

1.1 Introduction

In the latest years, learning that incorporates game-like elements is gaining a lot of attention in the education system because this approach is playful, and it attracts students to feel more motivated about any topic. It also allows students to work in a cooperative way and it provides higher social experience (Vindergor, 2021).

Furthermore, according to Samala et al. (2024), game-based learning is becoming more and more common in society today since it promotes 21st century skills such as critical- thinking, problem-solving, and teamwork. For example, this type of learning can be integrated into lessons where students need to use logical thinking and appeal to multiple feelings at the same time in order to solve a problem (Wiemker et al., 2015). In some video games, students are required to use different skills and abilities to solve tasks, puzzles, or make progress in the game in order to end up getting a reward for having completed it successfully (Adams et al., 2018). In addition to that, gamification, which is defined as the application of game design principles in non-game contexts by Yanes and Bououd (2019), has proven to be beneficial for educators if it is implemented correctly. Some of these features presented in students focus on meeting educational goals, learning more about students' weak and strong skills, improving their learning, motivating them toward learning and engaging pupils to educational processes (Alzahrani & Alhalafawy, 2022).

Nevertheless, it is fundamental for educators to have some knowledge about technology so that they can use it more efficiently while implementing game-

like mechanics in the classroom. For example, a study done by Jan (2017) reveals that technology is a requirement for teachers who want to provide quality education. Additionally, the author highlights the importance of integrating it to fulfil the demands of students so that technology can be useful for them. However, teachers must be up-to-date when it comes to technological tools because they develop continuously and what is new for beginners it can also be new for experienced teachers.

In the context of second language acquisition, there have been some studies that have shown that learning a second language along with academic content simultaneously is better than doing separately (Met, 1991; Swain, 2001; Tedick & Wesely, 2015). According to Dong (2002), learning subjects such as math, social studies, or biology in the target language and in real-life situations is an optimal way to learn them since language that is used in context stimulates motivation and thinking.

All in all, this study investigates gamification's potential to develop high school students' abstract knowledge about biology. More specifically, the study aims to explore techno pedagogical design perspectives as well as the perception of both students and teachers on the use of gamification in biology lessons. bridge the disconnect between theoretical language instruction and practical application. Using a well-designed gamified techno pedagogical course that incorporates real-world scenarios into the learning experience, this research can provide learners and educators with opportunities to utilize their language skills in a more authentic and engaging manner.

In Mexico, gamification has been proven to be an effective tool for improving student learning and motivation (Arufe et al., 2023). Furthermore, a large body of research across different educational settings suggests that gamification can be a powerful tool for transformation because the creation of gamified environments leads students to become more engaged, thus, developing a natural desire to learn more. In addition, English language learning, with its emphasis on constant exposure and interactive practice, presents a particularly fertile ground for gamification's potential to boost engagement and proficiency. Gamified language learning platforms such as Quizizz, Pear Deck, or Baamboozle offer a dynamic solution by seamlessly integrating these crucial components since they create an immersive and vibrant linguistic environment where students can fully engage with the language.

1.2 Introduction to the Problem

Students who engage in traditional classroom settings have been a persistent concern in education (Pascarella & Terenzini, 2005). Furthermore, traditional teaching methods can hinder student learning, motivation, and engagement despite giving basic foundations. These methods typically rely on passive learning techniques such as boring lectures, limited knowledge, and rote memorization, which may not engage students (Prensky, 2001). Some studies indicate that low engagement can lead to negative consequences such as decreased academic performance, higher dropout rates, and reduced motivation (Fredricks et al., 2004). Teachers struggle with maintaining student interest and motivation, especially in subjects perceived as difficult or less engaging, such as biology. Moreover, traditional methods may not provide enough opportunities for

active learning, critical thinking, and real-time feedback, which are crucial for deeper understanding and retention of knowledge (Prince, 2004)

Since traditional methods do not always offer opportunities to practice in real contexts where biology is taught, they have created difficulties such as the style that teachers adopt in lessons, the poor management skills that students have for studying, the negative attitudes that learners have toward the topics, and the absence of resources (Cimer, 2012). In addition, Allen & Tanner (2003) states that experiencing difficulty in learning biology concepts leads students to negative effects such as lack of motivation or no sense of achievement. Wai and Khine (2020) also noted that this complication of learning biology is due to insufficient knowledge about materials from teachers and the stress students can suffer from learning such difficult topics.

The nature of biology itself and its teaching methods are some aspects of this difficulty in learning abstract concepts. However, some researchers have investigated the benefits of using game-like elements in different fields of science, getting successful results (Alt, 2023; Forndran & Zacharias, 2019; Ibanez, 2014; Mellor et al., 2018). In biology, Drace (2013) discusses how the implementation of these interactive tools connects the information seen in lectures and laboratories to real world situations.

Moreover, Udeani and Akhigbe (2020) suggest that using gamification is a powerful pedagogical tool that helps learners construct knowledge in biology as well as a better attitude towards learning because of the implementation of gamification elements such as leaderboards, points, and badges.

Since the use of ludic activities has shown potential in learning biology concepts, gamification is an approach that can benefit educators in the field of biology. According to Yanes and Bououd (2019), gamification is the application of game design principles in non-game contexts. Since this approach incorporates engaging and interactive elements, it has the potential to revolutionize education, making it not just informative but also inspiring.

1.3 Significance of the Study

The significance of this study lies in its potential to contribute to practical issues in terms of teaching biology through the use of gamification because it will provide a new way to teach biology in L2 with the aid of an innovative techno pedagogical design. This research will expand the existing body of knowledge on gamification in education, particularly within the context of high school biology instruction since it is heavily focused on the construction of scientific concepts using gamification. While numerous studies have explored the effects of gamification on language learning (Flores, 2015; Dehghanzadeh et al., 2021; Pinto et al., 2021; Wulantari et al., 2023; Yanes & Bououd, 2019), there is little research that focuses on its application in learning biology in a second language.

Since there is a lack of studies related to learning scientific concepts through L2, it is vital to address this problem immediately. The importance of teaching biology in a second language (L2) environment has been a topic of interest because the increasing use of technology has facilitated language learning. Ahmadi (2018) highlights how technology is being used to improve language learning and its growing importance as a tool to facilitate it. This perspective emphasizes that the integration of technology can enhance the teaching and

learning of biology in an L2 environment. Furthermore, it has been argued that biology is important to teach in an L2 environment because humans are neurobiologically prepared for sharing attention with other humans, which may provide the basis for a wide variety of uniquely human social and cultural learning processes (Drubin & Kellogg, 2012). This strongly emphasizes the biological basis for language learning and the importance of integrating biology into L2 education. In the context of biology, Pitura and Chmielarz (2017) discovered that gamification in learning resulted in an improvement in educational and emotional gains, suggesting that it leads to motivational effects. Moreover, according to Jameson and Kolawole (2024), the incorporation of game design elements such as rewards and challenges can make biology lessons more dynamic and effective. The authors also stated that gamification can increase comprehension, retention, and motivation among students. Additionally, Abykanova et al. (2016) mention that the use of interactive learning tools helps students in their cognitive potential such as the obtention, analysis, and application of information from different sources as well as an increase in knowledge assimilation. However, he also found out that there can be some negative aspects that need to be addressed such as the time required to study a lot of information from a given topic, the lack of pedagogical experience in teachers implementing these tools, and the deficiency in instructional materials.

Gamification has been used as a promising tool to increase both students' motivation and outcomes (Gamboa, 2023). In this study, a gamification tool called Dream Scape was developed to enhance cognitive functions related to recognition and language. He also conducted an experimental study with 66 third-grade

students who showed an increase in motivation and stimulation due to gamification, improving academic performance and student participation.

Although the resulting findings focus only on a local context, it may be beneficial to international contexts where educators have found difficulty in areas of science such as biology education. Hence, it is hoped that findings from this research may contribute to new techno pedagogical designs with gamification elements for teaching biology in a second language. It is also expected that this information may increase interest in using games as a new means of teaching and learning.

1.4 Research Context

This research is conducted in Preparatoria Enrique Cabrera Barroso, which is a high school located in Tecamachalco, Puebla, Puebla. The school serves a diverse population of students with varying levels of academic achievement and socio-economic backgrounds. The biology curriculum emphasizes the understanding of fundamental biological concepts, scientific inquiry, and the application of knowledge to real-world problems. In addition, classrooms are equipped with technological equipment that allows students to interact with others. Also, students have access to computers, and cellphones. The school's administration is supportive of integrating innovative teaching methods and is interested in exploring the potential benefits of gamification in the curriculum.

1.5 Research Questions

In this study, the primary emphasis was on identifying which elements of gamification are advantageous and how these insights can be applied to learning

scientific concepts in L2. Consequently, the study is guided by the following research questions:

1) To what extent does a gamified techno pedagogical course improve the construction of scientific concepts of high school students in a biology class?
2) How do high school students perceive the gamified techno pedagogical biology course?

1.6 Justification

The continuous use of traditional methods in biology has led to a low level of student engagement and motivation (Chen & Lien, 2021; Rice et al., 2018). Despite the fact that these methods can be useful to some extent when it comes to understanding basic abstract concepts, they do not always incite learners to develop critical-thinking or problem-solving skills. Hence, designing a course with gamification elements seems like a promising method to overcome these obstacles (Uchenna & Akhigbe, 2020).

For example, Hwang and Wu (2014) highlighted the potential of using gamification to address these issues by implementing mobile technology in the learning process. Furthermore, Kalogiannakis et al. (2021) did a systematic review of the literature on gamification where they found positive effects on students learning experiences.

Gamification has also been applied across different educational contexts with promising results. In one study conducted by Deterding et al. (2011), there were positive benefits in language learning after implementing elements such as points, badges, and leaderboards, resulting in having improved vocabulary and

language proficiency. However, the lack of study in biology in L2 students remains underexplored since existing research focuses on general ideas about gamification with little attention to L2 learners in a biology context. This research project aims to learn more about gamification in techno pedagogical designs and the positive impact it may have in the improvement of abstract concepts as well as the possible positive factors such as motivation, engagement, or academic performance in students. It is also expected that this study may contribute to the creation of more effective approaches for biology learners in L2.

1.7 Contents and Organization of the Thesis

This research investigated the impact of gamifying a high school biology course on students' knowledge in order to see if there was a positive effect while learning scientific concepts. This chapter began with an introduction to the problem, highlighting the need for innovative teaching methods such as gamification to address the limitations of traditional educational approaches. Then, the significance of the study, including its potential contributions to educational theory and practice, was then discussed. The research context as well as the research questions guiding this investigation were presented, followed by a justification of the study’s relevance to the educational field. After that, the overall content and organization of the thesis was shown as well as a summary of chapter one.

In the subsequent chapters, Chapter II presents the theoretical framework underpinning the study, including key concepts related to learning sciences in L2 education as well as the concept of gamification and its application in education. In addition, it covers various topics such as the theoretical foundations of biology

education, the role of technology in learning sciences, and educational modalities. It also provides an in-depth discussion on gamification elements, dynamics, mechanics, and the benefits of techno pedagogical models in the classroom. Finally, it delves into characteristics of virtual education, motivation, learner autonomy, and the historical evolution of gamification in language teaching.

Chapter III includes an introduction to methodology, a declaration of the epistemological stance, a description of the research design, the context, participants, data collection procedures, and the instruments used (pre-test, post-test, and the techno pedagogical course as the treatment). Additionally, it covers the methods used for data analysis. Chapter IV describes the data collection process and the analytical methods employed as well as the results of both the pre-test and the post-test. Additionally, it includes the description of the activities implemented on the techno pedagogical design along with the results of the questionnaire and the interview. Finally, Chapter V discusses the key findings, accomplishment of the aims, and contributions of the study. Moreover, recommendations for future research are also provided to enhance the understanding and application of gamification in education.

CHAPTER II: LITERATURE REVIEW

2.1 Introduction

Back in the past, games were created to entertain people during their free time. However, as time goes by, games have taken a bigger role. A few years ago, many people realized that games could motivate people in different ways rather than just having fun with them. For example, some researchers believe that including characteristics found in games can improve engagement in the classroom, thus leading to better academic performance (Arufe Giráldez et al., 2022; Jaramillo-Mediavilla et al., 2024). This leads to the question of whether these elements can be applied in education, where students struggle to learn in subjects where abstract knowledge is required, for instance, biology. Hence, to understand the concept of game-like elements in other contexts, a literature review is necessary to comprehend what this means in a deeper manner. It is also required to know the elements and mechanics used in gamified environments. Additionally, the role of both students and teachers in gamified learning environments is also pointed out here. Most importantly, the role of technology in teaching as well as the characteristics of teachers and students in virtual modalities, are mentioned.

2.2 Learning Biology

When it comes to teaching and learning biology concepts, some researchers have tried to implement new frameworks with better organization. For example, Khodor et al. (2004) came up with the creation of an approach called the Biology Concept Framework (BCF) which is a hierarchical model that provides a relationship between context and concepts in biology. This model was of big help with inexperienced students who struggle to understand complex terms in biology

because it contains the real-life aspect that students need in order to better comprehend these abstract ideas.

Another way to grasp the content of biology courses was proposed by Derting and Ebert-May (2010). They implemented a learner-centered approach with inquiry- based characteristics in basic biology courses. In this course, the approach focused on both critical thinking and collaborative work since these features supply students with more long-term achievements in comparison to those who are taking lessons in a traditional format. In addition, this course equipped students with a deeper understanding of biology concepts because they participated actively in it.

The use of technology is another crucial feature that has been taken into consideration since it has been useful to move toward more effective teaching strategies in biology. For instance, Muhamad et al. (2012) integrated virtual technologies into a biology course where they used a virtual laboratory that students used to explore as it was a real one. This was quite useful since schools usually have difficulties in conducting physical experiments because of safety concerns or cost constraints. The use of these labs, where students use virtual simulations, highlights the importance of using technology to increase the learning and teaching experience in the classroom.

Other studies conducted by Egamberdiyeva (2024) emphasized the importance of using interactive teaching methods while teaching biology. The authors mentioned that teachers can create better learning environments if they implement group discussions, hand-on experiments or technology because these characteristics can stimulate critical thinking, curiosity, and long-lasting retention of

biology concepts. As long as educators include them, they can improve students' engagement in any biological knowledge.

Creating textbooks is another area that has changed the way educators address the complexities of teaching and learning biology. A study conducted by Gacheva (2023) demonstrated that new academic standards in biology require the incorporation of diverse teaching methods as well as innovative assessment tools. This has highly improved the quality and relevance of biology education since it encourages students to think in a critical way where they can apply this knowledge in real-life situations.

The COVID-19 pandemic in 2020 prompted significant changes in education, leading to a reevaluation of curricula. Roberts (2021) suggests that educators should prioritize two key aspects: maintaining a strong emphasis on biological concepts over contemporary issues, and recognizing that effective educational strategies are essential for understanding these concepts, as knowledge alone is insufficient.

One more way to promote critical thinking in biology is by integrating metacognitive technologies since they improve the acquisition of abstract concepts. Imomaliyeva (2023) argues that these technologies develop problem-solving by understanding what the real problem is. The author also points out that these tools can increase student engagement by making them more aware of their own thinking processes while conducting experiments.

In sum, this overview of biology education reveals a complex field that has reinvented itself to meet 21st -century demands. From the implementation of frameworks with new teaching methods to the integration of technology using

virtual laboratories as well as metacognitive tools, biology education continues to transform for a better future for education. As long as these curriculum features are addressed, the development of essential skills in biology education will equip students with the critical abilities for success in the modern world.

2.3 Technology in Learning Sciences

Even though technology has shown some benefits for students who study biology, it continues to grow rapidly in recent years. In order to increase the learning experience, it is essential that educators familiarize themselves with the possible challenges that students face while learning biology in a language that is not theirs (Flores-González, 2022).

Academic achievement is one of the most important trends in biology education where technology should be integrated. According to Teoh et al. (2022), the incorporation of technology in the learning process has a positive impact on the academic life of students since the features of technology enhance the learning experience of biology education because they provide the ability to focus on the students' needs and their ability to be involved with these concepts.

In addition to that, the use of interactive teaching methods that involve the use of devices such as laptops, tablets, or cellphones is mentioned in the literature. For example, a study conducted by Egamberdiyeva (2024) found out that these methods create dynamic classes that encourage students to participate more. Furthermore, another study done by Duisenbek et al. (2020) indicates that educators must include cooperative activities to increase motivation in students so that they can feel more motivated and find biology concepts more relevant in their

lives. The author also points out that the correct implementation of cooperative tasks increases the intensity of training activities that develop mastery in the field.

Another role that has been explored is the use of virtual simulations in biology, especially in distance learning and online learning. For example, Ayega and Khan (2020) illustrate the effectiveness of virtual labs in comparison to those used in face-to-face learning.

This study highlighted the positive and negative effects of these tools as well as students' perceptions of their effectiveness. It is also suggested that the use of virtual labs may provide other means of conducting activities that are done in laboratories, thus representing a real-life situation.

In the context of biology education, technology can be used along with complex and abstract concepts to improve comprehension. For instance, Ruado and Cortez (2024) strongly believe that Pear Deck and Nearpod, two interactive slide presentations apps, are useful since they have shown significant improvements in students' achievements during biology lessons. Furthermore, according to Yapici and Karakoyun (2017), teachers who used Kahoot! increased their motivation levels and made the lessons more enjoyable. This app also proved to expand active participation and more permanence on students.

All in all, the role of technology in biology education has diverse applications and the potential to improve teaching and learning. These resources offer a dynamic experience where virtual labs and other interactive apps can be implemented in the class while making the lessons more entertaining. As technology continues making progress in different fields, it is important to be

updated in new platforms that offer these innovative opportunities in education in order to increase students learning outcomes.

2.4 Virtual Modalities

Teaching biology with traditional methods can be difficult since it requires students to generate abstract knowledge without being exposed to real-life situations. In this case, it is advisable that teachers implement virtual modalities in their teaching practices (Flores-González, 2020). There have been some studies that have focused on the use of these modalities from different perspectives. For example, a study conducted by Teoh et al. (2022) found that learning that uses technology can increase student academic achievement. In this study, the authors mentioned that using technology while teaching provides this diversity that some students need to learn biology. In addition, the implementation of technology provides additional support along with instructional strategies for teachers (Flores-González, 2023).

This model is not only present in face-to-face lessons, but it is also found in distance learning. Végh et al (2017) believe in the optimal use of Information and Communication Technology (ICT) in the lessons since they think these tools can be used for meta learning because they make students aware of how to learn and how to make cognitive tasks in a more efficient way. In addition to that, multimedia is another feature that has shown improvement in the learning outcomes in biology. For instance, Kareem (2018) investigated the effectiveness of instructions that use multimedia to teach, and they discovered that groups who were exposed to this tool did significantly better to those who did not use them. These studies show that there are a lot of advantages to those educators who are willing to use these tools.

A similar tool that has proven to be effective is the use of gamified virtual labs to increase students' engagement. A study that focused on chemistry education conducted by Sanzana et al. (2023) discovered that students increased their involvement in the lessons as well as an improvement in their knowledge. Furthermore, in the field of anatomy, researchers found that the use of augmented reality brought a lot of positive benefits to students in the learning performance because of the virtual interaction that they provide (Arslan et al., 2020).

An outstanding feature that excels in the use of virtual education is the possibility of using them whenever students or teachers want. For instance, Inoue (2009) highlighted that virtual education offers flexibility because learners can access course materials and interact with them at any moment. He also mentioned that this is beneficial for students who are not traditional or those who have family obligations or duties at work. This balance that virtual modalities offer can be combined with other responsibilities without interfering with their regular lives.

Additionally, Scherer et al. (2018) noted that virtual education nature allows institutions to reach learners who are beyond borders. Because of this online system, student populations are more diverse in terms of culture, which can improve the learning experience since they are continuously exposed to different ideas, perspectives, and cultural backgrounds. Another benefit of online learning is the various assessment methods employed. For instance, Vezne (2022) thinks that timely feedback through the use of quizzes or peer evaluations can increase the learners' perspectives and outcomes because they are told what areas need to be improved.

However, in order to implement these technologies effectively, it is necessary to have technological foundation in the use of them as well as internet access to use Learning Management Systems (LMS) since they help teachers to deliver courses more efficiently and students to engage more effectively (Davies & West, 2014).

It is also of vital importance that teachers take a role in the effective use of virtual modalities. In this line, Ally (2019) emphasized that educators must be trained in using platforms and digital tools in order to deliver content in an effective way. The author also mentions that these skills must cover technical mastery in using devices and a clear understanding of how technology can be used to improve learners' outcomes. He also believes that teachers must be knowledgeable about instructional design since some students require diverse activities.

Another feature to consider is adaptability in teaching and learning. For example, Minea- Pic (2020) reveals that teachers must adjust their strategies based on specific needs where they take feedback into consideration. This is a great aid since appropriate virtual settings are good for students with diverse ways of learning.

Learners also must possess certain skills while using virtual modalities because these will define their experience in education and their outcomes either in a positive or negative way. Akram (2021) noted that learners who are exposed to virtual education, exhibit strong self-motivation and discipline because these models require them to become autonomous in their learning process.

In addition, Guillén et al. (2021) suggested that students who are involved in virtual education show more participation in discussions and group work. The authors mentioned that this involvement is fundamental for creating a sense of belonging and thus, increasing the learning experience. In addition to that, digital literacy is a skill that students must have. According to Vezne (2022), students must possess it in order to use online courses. This includes the ability to use them for collaboration, research, and communication. Besides, virtual education can be adaptable for different learning preferences where students can learn more about their weaknesses and strengths.

2.5 Gamification in Teaching

Despite the fact that gamification has been used for a long time, it is a concept that has had multiple definitions throughout the time (Seaborn & Fels, 2015). However, different authors have tried to provide the concept in different ways but always maintaining its essence. One of the most common definitions used in literature is the one provided by Deterding et al. (2011), who describe gamification as the integration of game design elements into non-game contexts. Mora et al. (2017) believe that gamification is a strategy to increase the user experience by incorporating game-like elements into practice. One more definition of gamification is proposed by Jakubowski (2014) who depicts it as a process of transforming interfaces in order to make them more interactive, similar to those used in video games. For the purpose of this research, the definition of Deterding et al. (2011) will be the one used.

Based on different studies about gamification, some researchers have tried to explain the benefits of it in educational contexts. For example, Nah et al. (2013)

highlighted the core characteristics of gamification: leaderboards, badges, a system of points, and immediate feedback mechanisms. The authors believe that the incorporation of these elements in education can improve instructional designs to improve learners' outcomes.

As there was an increasing interest in gamification, Ofosu-Ampong (2020) contributed to key areas of development and application where themes and trends related to technology were used to transform education. This research led to more investigation into how gamification could be applied to different disciplines related to science. For example, Alhammad and Moreno (2018) done a study on the unique use of gamification in software engineering where they found that this application is closely related to improving students' engagement and knowledge. Similarly, Kalogiannakis et al (2021) provided information of where and how gamification should be applied in scientific contexts as well as the potential to increase data collection from researchers in studies that try to incorporate new assessment tools. The authors also mentioned that gamification can result in more information in the learners' process because of the data it provides within its tasks.

In order to create more sophisticated approaches that focus on different types of learning needs, it is important to learn how to tailor game elements to each learner (Hallifax et al., 2019). These elements must focus on the personalization of each learner to reflect their outcomes using more responsive experiences. More contributions related to gamification elements can be tracked down from previous years. For instance, Urh et al. (2015) introduced new concepts between techniques and methods of game- mechanics to show how they can be used in the classroom.

Additionally, the authors believe that if educators define the objectives clearly, students can significantly increase their satisfaction, motivation, and engagement.

In spite of the fact that gamification research looks promising, there are still challenges that need to be addressed. Studies presented have shown how educators can take advantage of gamification in order to make their lessons more interesting. However, there is a need for more empirical studies that focus on long-term effects in other educational contexts. For example, Cassel et al. (2019) noted that studies conducted so far only focus on short-term impacts. This may be an indicator that more research is needed in order to establish stronger evidence to back up the benefits of gamification.

2.5.1 Gamification Elements

Some elements that can be used in gamification environments are those who function as quantifiable measures for students' achievements as well as their progression. These elements are based on a system of points that create leaderboards and provide either rewards or badges after completing a task. They provide a sense of competition among students by showing the rank where they are at that time, thus motivating them through health social comparison and competition (Morschheuser et al., 2019).

Challenges and Quests are also other features that appeared in gamification. These characteristics are designed to be solved in a progressive way that becomes harder and harder as the student continues to do the task. These types of quest-based activities, where students are part of a virtual journey, are good for completing goals presented in the lessons. They also promote engagement and encouragement among students to improve their critical thinking

skills as well as their problem-solving skills (Flores & Pinto, 2023; Romero-Rodríguez et al., 2018; Flores-González, 2024).

In environments where gamification is used, feedback is also presented in an immediate and continuous form since these technologies allow educators to show students results in real time as soon as they complete a task. Because of this, students are able to identify areas where they have difficulties and areas for improvement. They also help students reinforce positive behaviors in the class since they get ongoing feedback. In addition to that, this feedback can be found in different forms such as scores, sound effects, verbal comments, or indicators that show how good or bad the student is making progress (Llorens-Largo et al., 2016; Puritat, 2019).

It does not matter the age, listening to stories is something that catches students' attention. This type of narrative element is also used in gamification as a way of engagement. As long as the story is well-written, students are immediately immersed in the learning process. They make the stories relatable, and they feel amused and joyful. Storytelling is a strong tool that is utilized as a bridge between context and learning objectives, thus increasing the most relevant points of the materials being taught (Mattock, 2023).

Gamification also includes elements of social interaction and collaboration among students. In most cases, there are tasks or challenges that students can only complete working with another partner. These collaborative tasks can create a sense of belonging among students since they are always trying to be part of a community that is similar to their likes. This social interaction is also great since it

incorporates team-based competitions, which enrich the learning experience for all the participants (Flores & Pinto, 2023; Ivanova & Georgiev, 2019).

Customization and personalization also appear in gamification as challenges based on individual needs. For example, gamification allows teachers to personalize students' goals within any activity no matter students' style. Since these tasks feel familiar to learners, they are more motivated and satisfied with the content seen (Rahman et al., 2018; Wirani et al., 2021).

2.6 The Role of Students in Gamified Learning

While the implementation of gamification can be sometimes difficult to do, there are other characteristics to consider such as the role that students play. For example, research has shown that using gamification provides more active and motivated learners through stimulation of curiosity (Huseinovi, 2023; Kaya & Era, 2023). These tasks that use gamification elements such as leaderboards or rewards often create competitive atmosphere that encourages students to participate more in classes (Huei, 2020). Another study conducted by Kaban (2021) states that this motivation may lead to more engagement with the materials creating a positive attitude towards the content taught in schools.

Besides the increase in motivation, gamification also includes technologies to make lessons more interactive and increase students' involvement. For example, Hilary et al. (2024) found that the correct use of interactive tools and platforms increases student engagement. Furthermore, a study done by Sanosi (2018) demonstrated that educational apps and interactive quizzes provide more opportunities to practice in a fun and engaging way. Since students work

collaboratively with others in these types of environments, they create a more active learning experience (Berns et al., 2016; Doumanis et al., 2018).

In terms of understanding students' progress, they are provided with continuous feedback that can be self-regulated. Students are able to self-assessment since they immediately get the results in real-time (Auvinen, 2015). For instance, two famous interactive platforms that are used nowadays, Quizziz and Kahoot, allow students to track their progress as soon as they finish the task where they can see the reports and identify areas that need to be improved (Bicen & Kocakoyun, 2018). Since this feature gives students the power to know the answers, it can lead to ownership of their learning process, which may be useful when it comes to developing better learning habits (Panmei & Waluyo, 2022).

Even though gamification can improve self-regulated learning because immediate feedback is provided, it is also beneficial in other ways such as the adaptation of students' needs. According to Behl et al. (2021), environments where gamification is used can tailor students' demands by focusing on learning tendencies that cover these requirements. For instance, learning preferences and adaptations of game mechanics can be modified to tackle students' weaknesses through the use of tools like the Felder- Silverman Style Model (FSM). Behl et al. (2021) also stated that this personalization improves students' effectiveness, resulting in a more supportive and inclusive learning atmosphere.

2.7 The Role of Teachers in Gamified Learning

Maximizing the benefits of gamification requires teachers to know how to design, implement, and facilitate these tools to students. It also needs a clear understanding of pedagogy, gamification, and students' demands to take the best

of these technological resources. According to Huseinnovi (2023), teachers are the ones responsible for developing gamification elements into the curriculum in a meaningful way. For example, Hilary et al. (2024) and Lim and Yunus (2021) mention that teachers must be in charge of selecting the appropriate platforms to design engaging activities that align with the objectives of the classroom. Moreover, Ishaq (2022) maintains that teachers also need to consider specific skills according to the level of students while designing gamified tasks.

During students' learning journey, it is also necessary to provide ongoing support through the course. Since this cannot be done without the help of teachers, Heseinovi (2023) believes that they must act as facilitators and guides in these environments because they must provide this guidance to students in order to ensure that they understand all the game mechanics, thus participating in the activities more effectively. In addition, Kaya and Era (2023) argue that teachers must monitor students' progress while providing feedback because this will ensure that students are engaged in learning.

Not only should teachers act as facilitators, but they should also be equipped with skills and resources to integrate this type of technology into gamification environments. A study conducted by Azar and Tan (2020) found out that teachers must be comfortable while using technology in their teaching practices because this promotes a better understanding of how these tools are used. Also, Lee and Hwang (2022) state that schools provide teachers with training and support in technology in order to ensure a successful implementation of gamification strategies. For example, in assessment, teachers must take into consideration on the way they evaluate students' performance which has to align

with both the learning objectives and the gamification tools used (Manzano-León, 2021).

According to Bereczki and Kárpáti (2021) and Yu (2022), collaboration and communication between teachers and students are key aspects in the role of teachers in gamification. Additionally, teachers must be open to discussion and willing to adjust their strategies based on students' demands and preferences (Kim et al, 2022). They also need to promote communication among students in order to provide support during the learning process (Berns et al., 2016; Doumanis et al., 2018).

Finally, teachers must use technological tools to enhance student comprehension as well as vocabulary to create more enjoyable and stimulating learning experiences that promote participation among students (Panmei & Walayu, 2022; Sanosi, 2018; Flores-González, 2023).

According to Auvinen (2015), autonomy is another feature that teachers can promote through the use of gamification elements since students have the opportunity to practice independently in an asynchronous way.

2.8 Conclusions

The literature presented reveals that there have been some significant changes in pedagogical approaches across various domains. First and foremost, biology education has evolved from traditional to learner-centered approaches. These new approaches now implement technological tools such as virtual labs, game-like features, or platforms in order to address the complexity of scientific concepts. Secondly, the use of technology has proven to be a vital tool for enhancing student engagement, self-regulated learning, and diversity in the learning process. Thirdly,

the role of students and teachers while using technology is one of the key factors to consider. For students, it gives a personalized and engaging learning experience. For teachers, it enhances their pedagogical practices and makes classes more efficient, relevant, and impactful. Finally, the growing body of research on gamification clearly has the potential to improve all these benefits. This implementation of game mechanics, such as badges, rewards, leaderboards, and feedback, is a strong strategy for boosting both motivation and participation. Therefore, this research specifically addresses this by testing the efficacy of a Quizizz-based techno pedagogical design.

CHAPTER III: METHODOLOGY

3.1 Introduction

This chapter describes the methodology used to gather, analyze, and present data for this research. It provides the reader with an explanation of epistemological and ontological stance, research design, sample, data collection methods, instruments, data analysis methods, ethical considerations, and conclusions. First, the epistemological and ontological stance, research design, and sample are described. Then, data collection methods and instruments used are presented. After that, the description of data analysis methods from both quantitative and qualitative as well as ethical considerations are stated. Finally, the last section provides a brief conclusion for this chapter.

The purpose of this research is to explore the potential of gamified techno pedagogical courses to increase the learning outcomes of high school L2 biology students. It also aims to determine if gamification can enhance student engagement, motivation, and understanding of scientific concepts. The research focused on two questions:

1. To what extent does a gamified techno pedagogical course improve the construction of scientific concepts of high school students in a biology class?
2. How do high school students perceive the gamified techno pedagogical biology course?

3.2 Declaration of Epistemological and Ontological Stance

In the last years, a combination of quantitative and qualitative research has been promoted in the area of humanities (Teddlie & Tashakkori, 2009). According to Cresswell (2009), this method involves two stages where the researchers collect

quantitative data in the first phase, analyze this data, and then, in the second phase, collect qualitative data, analyze it and explain the reason behind the quantitative results.

This research utilizes a mixed method approach due to its strength in providing a more complete picture of the phenomenon. An explanatory sequential design was used in this research because it provides researchers with a more comprehensive and in-depth understanding of the research topic. This approach allows researchers to first collect and analyze either qualitative or quantitative data, which is then used to inform the design of quantitative or qualitative data collection and analysis. This integration increases the validity and reliability of the findings because the information from different sources of data can be analyzed using triangulation. Furthermore, this design allows for a more comprehensive analysis of complex phenomena that cannot be adequately captured by either qualitative or quantitative methods alone (Fetters et al., 2013).

Additionally, this methodology has quasi-experimental elements in order to explore the cause and the effect of a gamified techno pedagogical course on teenagers where a standardized test was used, and this offered a quantitative measure of teenagers' biology knowledge before and after the treatment. Moreover, standardized tests are a widely accepted method for measuring knowledge since they provide a reliable baseline. However, this quantitative data alone might not capture the why behind the learning outcomes.

Furthermore, in order to obtain additional information regarding the results from the pre-test and the post-test, a fifteen-question questionnaire was conducted. It was divided into three categories (emotional, behavioral, and cognitive

engagement) and it was done in order to gain better understanding of how students learn through the implementation of gamification using the platform Quizizz.

Besides, an interview was also conducted so that students would elaborate on their experiences and perspectives related to factors that influence the gamified learning environment. This interview consisted of 5 questions to elicit rich qualitative data.

The treatment for this research consisted of a designed gamified techno pedagogical course for a designated period of time (around four months), where a group of high school students participated. This course covered various topics in biology such as body systems, cell types, tissues, nucleic acids, etc. Through engaging and interactive activities that integrate gamification elements, these components were chosen to enhance motivation and engagement.

While creating the treatment, assessment was taken into consideration since it is a key element in education. One of the first things to consider is to make sure that assessments are aligned with the objectives and curriculum standards because it optimizes the quality of education (Biggs, 2013). Furthermore, if educators consider knowledge that students are expected to learn according to their previous knowledge, it will maintain consistency and coherence in the learning process.

In addition to that, when students know that they will be assessed with what they have seen in lessons, it can promote student learning (Brown & Race, 2012). This is quite important since students will notice that their efforts will bring them satisfaction and recognition for having completed a test successfully. Additionally,

effective planning that involves proper time management leads to less time spent. This means that teachers can save a lot of time if they plan in advance.

When designing and implementing assessments for learners, it is also essential to consider the following key elements:

Validity. It refers to the extent to which an assessment accurately measures what it intends to measure (Chapelle, 2019). This means that educators must make sure that tests truly assess the specific skills that are being evaluated. According to Ross (2019), a valid test is the one that reflects the learners' actual abilities, not only the ability to take tests. For instance, a test that is intended to measure speaking proficiency should reflect real-word situations where speakers can use authentic language rather than memorizing chunks of phrases that are artificial (Soozandehfar et al., 2019).

Validity is not only a superficial definition, but it also involves other subcategories that educators must consider. Taherdoost (2016) mentions that the type of validity called content is in charge of the alignment with the curriculum and the one responsible for measuring how well a concept or idea is transformed into an operating reality is called construct validity. In addition, the author mentions that criterion validity is the extent to which a measure is related to an outcome and face validity refers to the subjective judgment non-experts have over a specific field.

For instance, in the context of scientific concepts, asking for relevant academic reading and right clear and understandable instructions as well as presenting a format that is similar to students can be the part of face validity. Then, educators can check if these texts are representative of the types of text that students use in lessons and teachers can also check if the level of difficulty of the

questions is appropriate for them, that would be content validity. While making the questions for the test, teachers may focus on critical thinking skills such as understanding main ideas, identifying details, making inferences so that the tests can have a relationship with the skills being tested, that would be a type of construct validity. Finally, criterion validity would involve checking if the test scores correlate with other measures of reading ability such as their performance during lessons in similar tasks or their performance on standardized tests.

If there is a lack of validity, there can be misinterpretations of what students are learning as well as inappropriate instructions (Abdulhamid et al., 2020). Because of this careful plan, the development of valid assessments requires careful consideration of the purpose that educators are trying to measure, the way content is used in the right context, and the selection of suitable tasks for language learners.

A reliable test produces consistent results when administered repeatedly under similar conditions. According to Richard (2024), reliability refers to the consistency of an assessment. It also ensures that a learner's score is not significantly affected by factors unrelated to such as test format variations or rater bias (Huang & Foote, 2010). Several methods are used to establish reliability, including test-retest reliability (comparing scores from multiple administrations of the same test), inter-rater reliability (comparing scores from different raters), and internal consistency reliability (measuring the consistency of items within the test) (McCrae et al., 2011). High reliability is crucial for making accurate judgments about learner progress and for identifying areas needing improvement (Mason,

2007). The utilization of clear scoring rubric, standardized procedures, and well-defined assessment criteria can improve this reliability (Panadero et al., 2017).

All things considered, creating reliability in tests leads to benefits such as accuracy, consistency in the results, and fairness. If the designed reliable assessment produces consistent results over time in different contexts under similar circumstances, it means students can take the same test multiple times with similar grades. This consistency will measure what it is intended to be measured. In addition, reliability ensures that all students are treated fairly where teachers can avoid situations where students' scores may be influenced by external factors rather than their current skills. This allows teachers to have meaningful interpretations of students' results so that educators can be confident that scores really reflect students' abilities.

Another term to consider is practicality which refers to the feasibility and efficiency of administering, scoring, and interpreting the assessment. In this line, Becker et al. (2017) suggest taking practical considerations including the time required for administration, the monetary resources (e.g., budget, equipment costs), the materials used (e.g. classrooms, technology, or paper), and human resources (e.g. task creators, raters, or test administrators).

Having taken these aspects into consideration, educators can implement tests effectively as long as the classroom settings are optimal. Nowadays, technology-assisted assessment tools can enhance practicality because they can provide answers automatically and give immediate feedback as soon as the students finish the test, which is something that make large-scale assessments faster, automating scoring, providing immediate feedback, and facilitating large-

scale assessments (Veettil, 2024). Because of these benefits, Quizziz was considered to be part of this research. However, access to technology and the need for teacher training should be carefully considered (Veettil & Singh, 2024).

Palmer (2004) defines authenticity as the degree to which the assessment tasks and materials reflect real-world use. Authentic assessments utilize tasks and materials that are similar to those found in real-life situations where students can use what they learned in the classroom in real-world contexts (Atmojo, 2021). Because of this exposure, students feel more confident and prepared to face academic challenges and deal with professional settings much better.

Using authentic language in test design or activities offers a lot of advantages since they primarily focus on learners' preparation for real-world situations. One major benefit is that they mirror content use in real contexts, which provides an accurate reflection of the learners' communicative competence (Albiladi, 2019). This is good since a lot of high-stakes exams rely on measuring this type of content. For example, Fitriana et al. (2019) found that using authentic materials in reading activities with texts found in real-world contexts can significantly improve learners' reading comprehension skills due to their authentic nature.

Furthermore, authentic language in tests offers better washback, positively influencing teaching and learning (Spratt, 2005). Exposure to authentic language materials prepares learners for real-life communication, motivating them to improve their skills even after leaving school. The use of cartoons in lessons for young learners (Arıkan & Taraf, 2009), for example, provides an engaging and authentic context for learning vocabulary.

It is always important to take accountability when it comes to the application of new concepts in the classroom. Sometimes, some elements can bring benefits, but with some consequences that not everyone considers. In this way, washback, defined as the effects of assessment on teaching and learning (Atmojo, 2021), is a feature that most educators have to plan carefully. In the literature, two types of washback have been identified to cause positive and negative influences (Hung, 2012). For example, if teachers implement regular quizzes related to the topics seen in class, or encourage students to participate more, this is highly likely to represent positive washback. Additionally, if teachers really focus on feedback and they identify areas for improvement, it may result in better learning outcomes (Iskandarovna, 2024).

However, if teachers discourage students or promote undesirable attitudes in the classroom, it may lead to negative washback, thus damaging all the learning and teaching process (Taylor, 2005). For example, for the majority of students, high-stakes exams are extremely difficult because most of the courses that focus on these exams do not really reflect the practice in the classroom with the real exam. In addition, these exams focus heavily on scientific topics, which is an area that most of the students struggle with because this content does not develop these skills. Consequently, students may feel stressed (Jerrim, 2023), and they will pay more attention to memorization rather than content.

Another important feature to consider is the nature and extent of washback since it depends on various factors such as the design of the assessment, the context where it is being implemented, and the perceptions of both teachers and learners on what assessment is (Kim & Hwang, 2022). Other considerations that

educators must take into account are those related to the right selection of materials, the activities implemented, the strategies that students use, and the objectives of the lessons (Saif, 1999). The author also believes that in order to have positive washback, there should be specific and clear instructions about what is contained in the tests and tasks done during the class.

All in all, it is important that everyone involved in the learning process is aware of what is being taught and what is expected from the lessons. It is also fundamental to understand how to reduce negative washback effects to have effective teaching and learning experiences (Muñoz et al., 2019).

Scoring and grading are essential components of assessment because they convert learner performance on assessment tasks into meaningful scores. Scoring involves assigning numerical values or ratings to learner responses based on pre-defined criteria, while grading involves assigning letter grades or other categorical classifications to learner performance (Figlio & Lucas, 2004). The methods used for scoring and grading could significantly impact the validity and reliability of the assessment. Therefore, holistic scoring, which involves assigning a single overall score based on a general impression of the response, is often quicker and more efficient than analytic scoring, which involves assigning separate scores to different aspects of the response (Huang & Flores, 2018). However, analytic scoring could provide more detailed feedback to learners and improve the reliability of the assessment by reducing rater bias. The development and use of clear scoring rubrics are vital for ensuring consistency and fairness in scoring and grading. Researchers have investigated the effectiveness of different scoring methods, with

some studies suggesting that analytic scoring may be more reliable and informative than holistic scoring (Huang & Flores, 2018).

3.3 Research Design

There were two types of data that were recollected through this study. First, quantitative data from the BUAP scores during the pre-test phase was collected through a standardized diagnostic exam that was administered to all participants in order to assess their initial knowledge about biology.

Since the core of the study was the treatment phase, the group of students were exposed to the techno pedagogical design using the website Quizizz. This treatment consisted of thirty interactive lessons with innovative activities that served as an independent variable in the study. Additionally, weekly evaluations from the techno pedagogical course were collected to keep track of students' improvement.

After having taken the course for a period of four months, a post-test was conducted using the same standardized exam administered at the beginning. This allowed me to measure the impact of the treatment on the students' biology concepts.

Finally, a questionnaire consisted of 15 questions five-point Likert Scale and an interview consisted of 5 questions were applied to the group in order to know their perceptions, motivations, and experiences to analyze, organize, and present themes and patterns.

Taking into consideration the theoretical framework of gamification as a form of improving the learning process, the hypothesis focuses on the fact that biology students who were exposed to techno pedagogical intervention based on Quizizz

will demonstrate a significant increase in their mean post-test scores for scientific concept learning compared to their pre-test baseline. On the other hand, the null hypothesis (H0) is based on the fact that the techno pedagogical model used with Quizizz does not influence on the learning of basic scientific biology concepts.

3.4 Description of the Context

Selecting people to target for data collecting, in addition to the sort of data to gather, is an essential component of studies. Even though gathering data from an entire population would be the most dependable way to learn about a certain group of people, it is impossible to do since this approach is costly, time-consuming, and highly unworkable. Due to this issue, it is advisable that a sampling that reflects the population be chosen. Podesva and Sharma (2014, p. 4) defines sampling as “some people in the group in such a way that their responses and characteristics reflect those of the group from which they are drawn”. All in all, the sampling method to be used in this research is a non-probability sampling method, which in this case is a convenience sampling.

According to Mirhosseine (2020), there are some steps to take into consideration in order to select the participants. For example, the primary requirement is that they must be accessible to the researcher in terms of availability and willingness to participate in the study. The researcher also needs to make an invitation to participate in it where they are convinced to be part of the study. Another step is to establish a rapport with the interviewees as well as finding mutually convenient times for interviews. Logistics is also another key component to consider since it is necessary to arrange a schedule for the interview.

Despite following all these steps thoroughly, Emerson (2021) believes that convenience sampling has some limitations since it may not be the most suitable in cases where the population has been extensively studied. However, this is not the case for this study since it is an area that has been barely explored because it took place in a regional school.

The sample for this research was conducted at Escuela Preparatoria Enrique Cabrera Barroso Regional from Benemérita Universidad Autónoma de Puebla (BUAP), which is a public high school.

3.5 Description of the Participants

The participants of this study were 60 students of first semester who are currently studying in this institution and are part of different communities near the school. Their social status, technological skills, and English level are similar so that the population will be equally represented. There were 33 female and 27 male participants whose ages ranged from fifteen to sixteen. Besides that, all of them are Spanish native speakers from Mexico.

Additionally, when creating top-notch research procedures, establishing inclusion and exclusion criteria for study participants is a mandatory practice since they may impact the external validity of the results of the study. According to Patino and Ferreira (2018, p. 84), inclusion criteria are “the key features of the target population that the investigators will use to answer their research question”. On the other hand, characteristics of potential study participants who match the inclusion criteria but have extra traits that can hinder the study's progress or raise their chances of a negative outcome are known as exclusion criteria.

All things considered, the following inclusion and exclusion criteria were designed to ensure that a suitable sample of teenagers for this research were carefully recruited.

3.5.1 Inclusion Criteria

Since the target population is a BUAP High School, these criteria will aim teenagers from fifteen to sixteen years old with a basic to intermediate level of English language learning experience in a formal setting as well as access to technology for the gamified course. Additionally, the standardized biology test, which is mandatory, helped to create a more homogenous baseline for measuring the impact of the course. Another feature to consider is parental consent, which was a written informed consent obtained from a parent or legal guardian for all participants.

3.5.2 Exclusion Criteria

These criteria minimized factors that could potentially confound the results since they could have interfered in various ways. For instance, the exclusion of participants with diagnosed learning disabilities or extensive prior gamified learning experience helps to isolate the specific effects of the gamified course being developed.

3.6 Description of the Instruments

In the previous chapter, it was stated that four types of instruments were used. They were a standardized biology test, a techno pedagogical biology course (treatment), a questionnaire, and an interview. The BUAP standardized test was used to gather quantitative data from the pre-test and post-test phases with the participants. The treatment involved various activities related to biology scientific

concepts with gamification elements using the website Quizizz. Finally, a questionnaire and an interview were applied to identify students' perceptions towards the techno pedagogical model.

1. The standardized pre-test and post-test were used to objectively measure the participants' scientific knowledge in biology before and after the treatment (the techno pedagogical design). This test focuses on basic scientific biology concepts for high school students and its validity is widely recognized.

2. There have been some studies that have explored the effectiveness of using Quizizz (Degirmenci, 2021; Irwansyah, & Izzati, 2021; Pertiwi, 2020). This app offers a dynamic and engaging learning experience that benefits students in several ways. Firstly, it transforms traditional quizzes into interactive games that can incorporate gamification features, capturing students' attention and motivating them to participate actively. For example, research has shown that using gamification provides more active and motivated learners through stimulation of curiosity (Huseinovi, 2023; Kaya & Era, 2023). These tasks that use gamification elements such as leaderboards or rewards often create competitive atmosphere that encourages students to participate more in classes (Huei, 2020). Another study conducted by Kaban (2021) states that this motivation may lead to more engagement with the materials creating a positive attitude towards the content taught in schools, which means it will increase positive washback.

Secondly, Quizizz allow students to track their progress as soon as they finish the task or the exam where they can see the reports and identify areas that need to be improved (Bicen & Kocakoyun, 2018). Since this feature gives students the power to know the answers, it can lead to ownership of their learning process,

which may be useful when it comes to developing better learning habits (Panmei & Waluyo, 2022).

Finally, using Quizizz along with gamification provides collaboration, which is a skill that is promoted in every classroom. A study done by Sanosi (2018) demonstrated that educational apps and interactive quizzes provide more opportunities to practice in a fun and engaging way with others. Since students work collaboratively in these types of environments, they create a more active learning experience (Berns et al., 2016; Doumanis et al., 2018).

As some of the benefits have been shown, the choice of Quizizz as the testing platform is driven by its practical benefits since it is easy to use, and students do not need to take long and boring tutorials because it is extremely intuitive. Moreover, Quizizz automates scoring and grading, saving time and reducing administrative burdens (Yunus & Tan, 2021). This immediate feedback is aligned with formative assessment principles by offering students insight into their performance and guiding further learning (Black et al., 2004). Additionally, automated feedback helps students recognize areas that need to be improved by reinforcing the learning process without the delay associated with the fact that teachers have to grade manually, which is always time consuming.

All in all, Quizizz is a platform that is accessible for everyone since it is completely free. It is also helpful because educators do not need to spend too much grading since it does it automatically. In addition, it generates reports with statistics that can be used to show how students have made progress, thus, getting valuable data for this research since it shows graphs with a statistical analysis.

3. The fifteen-question Liker scale questionnaire was conducted in order to quantify students' perceptions regarding engagement, motivation, and conceptual understanding while using the techno pedagogical design. Responses ranged from 1 (Strongly disagree), 2 (Disagree), 3 (Neutral), 4 (Agree) to 5 (Strongly Agree). Additionally, the test is divided into three categories (emotional, behavioral, and cognitive engagement). However, this division was not included in the questionnaire so that participants were not aware of the kind of category they were answering. These three sections are meant to be only theoretical.

This questionnaire was based on a study done by Gaggioli et al. (2024) where the authors used it to know the level of engagement of students while using gamification. In order to verify the instrument reliability, the researchers calculated Cronbach's Alpha coefficient. The result was .849, which is a value considered to be acceptable, thus confirming the reliable use of this instrument since it has been implemented successfully.

4. The interview protocol used consisted of five open-ended questions designed to obtain qualitative narratives about the participants' personal experiences with the techno pedagogical design. This instrument focused on capturing a wide range of details regarding motivational shits and specific feedback on the platform used. These five questions were developed by Polat (2014) in a study where gamification was used in order to determine the participants' level of engagement, measure the participants' enjoyment, and evaluate the participants' overall opinion of the platform used.

3.7 Description of Data Collection

This research focused on collecting two primary types of data:

1. Standardized entry and exit level tests were administered to assess students' biology knowledge at the beginning and at the end of the course. This data allowed tracking changes in their biology knowledge resulting from the implementation of the techno pedagogical design on Quizizz, which incorporated interactive activities with gamification elements. All the data obtained from this process was quantitative.

Both tests were conducted under controlled classroom conditions to ensure consistency. There was a fixed time limit to answer questions and there was strict adherence to standardized instructions. After that, scores were calculated and recorded to determine if there was a change in scientific knowledge after having taken the treatment.

2. Data related to the intervention itself was collected continuously and automatically by the Quizizz platform throughout the experimental period. This included quantitative metrics such as individual student scores, accuracy, time taken per assignment, and leaderboard rankings. Moreover, the primary role of the researcher in this stage was to collect all the data securely by extracting and organizing this quantitative data.

3. According to Dörnyei & Taguchi (2010), a questionnaire is defined as any written instrument that presents respondents with a series of questions or statements to which they are to react. The authors mention that it is primarily used as a research instrument for measurement purposes to collect reliable and valid data from respondents. For this research, a questionnaire focused on participants' experiences of the gamified techno pedagogical course and their perceptions was conducted. Fifteen close-ended questions were adapted from a study done by

Gaggioli et al. (2024) and translated into Spanish by the researcher. In addition to that, they were categorized into three sections: cognitive, behavioral, and emotional engagement. Moreover, in order to ensure the instrument's reliability, they employed Cronbach's Alpha coefficient, which produced a coefficient of .849. This value is considered to be acceptable since it confirms the instrument's effective previous implementation.

This questionnaire was administered only once to the group that used the techno pedagogical design immediately after the post-test was completed. This timing ensured that students' responses reflected their entire experience with it. The questionnaire was administered electronically using Google Forms during a class session in order to guarantee a high response rate and maintain anonymity. Participants were given explicit instructions on the five-point Likert scale format and were assured that their responses were essential for the study, not for grading purposes. All the data obtained was then downloaded in an Excel format.

4. Besides, an interview with 5 open-ended questions was employed to obtain qualitative additional information about the students' engagement. These five questions were based on a study conducted by Polat (2014). According to the author, the purpose of these questions was to determine their level of engagement and enjoyment as well as evaluating their general opinion of the system used.

Open-Ended Questions

1. In your opinion, what was the most confusing part of "Quizizz"?
2. Would you like to be in a class where "Quizizz" is used again? Why?
3. If you were to explain "Quizizz" to a friend from another class, what would you tell them?

4. If you could make changes to “Quizizz”, which part would you change and why?

5. If you have any other positive / negative opinion you would like to share about “Quizizz”, please write them.

The qualitative data from the interview was collected after it had been administered. Students who took part in the techno pedagogical design were invited to participate in face-to-face interviews. The interviews were conducted in a quiet, private setting to foster trust and encourage participation. Before starting, verbal consent was secured from each participant. Their response was transcribed and this allowed for qualitative thematic analysis in order to explore students’ perceptions.

3.8 Description of Data Analysis

In order to obtain quantitative data, pre-test and post-test scores from BUAP tests were analyzed using statistical analysis to determine if there are statistically significant differences in biology after the treatment was conducted.

3.8.1 Central Tendency

Students’ scores were done by using descriptive statistics in order to understand the average pre-test and post-test exam scores (mean) and the spread of scores (standard deviation) within the stages of the group (before and after the treatment).

3.8.2 Testing Process

All the analyses presented were used with Statistical Package for the Social Sciences (SPSS), which is a widely used software package for analyzing research data. This software is known for guiding users through the entire research process

and helping them choose the right data analysis technique for their project. This accessibility to beginners and effectiveness as a reference for data analysis has been noted, making it a valuable and useful tool for researchers (George & Mallery, 2013).

Furthermore, in a study by Gholami (2015), the SPSS software (version 16) was used to change data into numerical interpretable forms and determine the relationship between self-efficacy and teachers' burnout. This indicates the versatility of SPSS in handling and analyzing various types of data with impressive accuracy.

Moreover, in order to obtain qualitative data, a questionnaire and an interview were conducted among students. This data was transcribed and analyzed using thematic analysis techniques to identify recurring themes and patterns related to teenagers' perceptions and experiences of the gamified course's impact.

The data collected from both the questionnaire and the interview were analyzed using Thematic Analysis. According to Braun and Clarke (2012, p. 57), “Thematic Analysis (TA) is an accessible, flexible, and increasingly popular method of qualitative data analysis. Learning to do it provides the qualitative researcher with a foundation in the basic skills needed to engage with other approaches to qualitative data analysis”. In addition, Braun et al. (2016, p. 191) stated that “TA offers a method for identifying patterns (“themes”) in a dataset, and for describing and interpreting the meaning and importance of those”. Since this research focuses on identifying patterns and themes, it is highly convenient to use TA. In order to carry out a thematic analysis, six steps are needed:

Familiarizing with the data. This phase means immersing with all the data obtained. It is necessary to read and reread to have a better understanding.

Generating initial codes: In this step, it is essential that one identifies and labels meaningful segments of the data that relate to the research question.

Searching for themes. Here, one should begin to look for both patterns and connections between the initial codes. It is also important to group related codes together to form potential themes.

Reviewing themes. This phase involves examining the themes in relation to the coded data and the entire dataset. In this step, it is fundamental to assess if the themes are coherent, distinct, and reflect the data.

Defining and naming themes. Once one has a set of potential themes, one must refine their scope and content. It is time to develop clear definitions and choose concise names that capture the essence of each theme.

Writing up. The final step involves presenting the thematic analysis in a clear and coherent manner. It is important to articulate the findings, provide evidence that support the analysis from the data, and discuss the implications of the themes in relation to the research question (Braun and Clarke (2012).

Table 1

Analysis Model

RQ	**Instrument**	**Purpose**
Students' construction of scientific concepts based on the gamified techno-	Pre Post Treatment	Improvement

pedagogical biology course		
Students' perceptions towards the gamified techno pedagogical biology course	Questionnaire Interview	Identify perceptions

3.9 Ethical Considerations

Before starting the data collection process, all participants in this research were required to sign a consent form that explains the purpose of the research and their rights as participants. Since they are teenagers, another consent form was handed in to their parents in order to get their permission. The consent forms also stated that all data would be kept confidential and anonymous. This consent form was given in order to have permission so that students could participate in the techno pedagogical design that was created on Quizizz.

Furthermore, the pre-test and the post-test were administered under non-threatening conditions so that students were assured that their scores would not affect their course grades, thus ensuring the honesty of the data collected for this study. In addition, informed consent was secured from the school where the study took place, ensuring that they understood the purpose of the study, its duration, and the voluntary nature of participation. Moreover, regarding the platform used (Quizizz), participants' personal information was anonymized and all the data that

was generated by the platform such as scores, response times, engagement metrics were handled carefully in order to guarantee confidentiality and privacy.

3.10 Conclusions

This chapter outlined the methodology used to explore the potential of using techno pedagogical courses with gamification elements in order to increase the learning outcomes and motivation of high school students learning biology in L2. The explanatory sequential design was mentioned since it is a mixed method approach that integrated both quantitative and qualitative data so that it provides a better understanding of the research problem. The use of a quasi-experimental design with a standardized test, a Likert questionnaire and an interview ensured a better evaluation of the effectiveness of gamification.

Additionally, careful consideration of assessment, validity, reliability, practicality, washback, scoring and grading were used to aim the accuracy, consistency, and fairness of the instruments used. The selection of the website Quizizz was suitable for increasing the practicality of the study while also providing engaging learning experiences. Ethical considerations were also rigorously addressed to ensure the informed consent of participants as well as their guardians in order to safeguard the confidentiality of the data.

The methodology shown in this chapter permitted the data collection presented for the findings discussed in subsequent chapters.

CHAPTER IV: RESULTS

4.1 Introduction

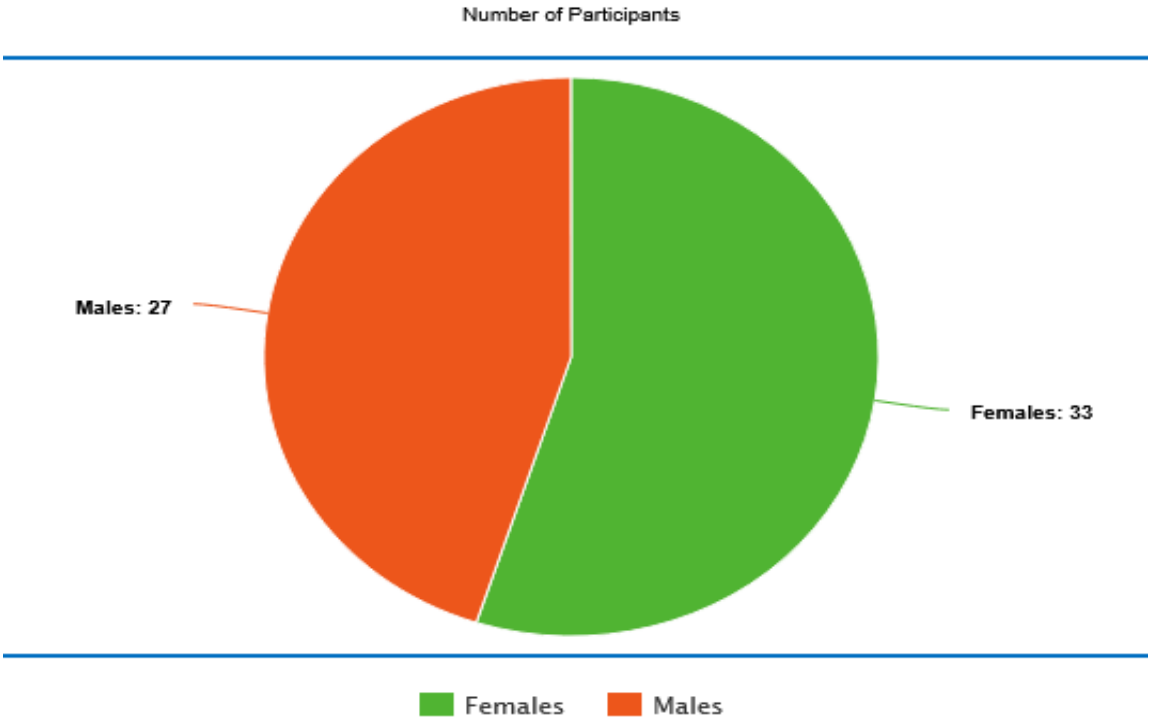
This chapter presents the findings of the study investigating the impact of a gamified techno pedagogical course on the learning outcomes of high school L2 biology students. The results are organized in order to provide a clear overview of the data gathered, analyzed, and presented throughout the research process. This chapter will thoroughly detail the data analysis procedures employed, including both quantitative and qualitative methods. Specifically, it will present the findings from the pre-treatment phase, the treatment phase, and the post-treatment phase. Furthermore, the post-treatment phase will further explore the post-test results, describing the quantitative changes that were observed in student performance during the BUAP test. Additionally, a questionnaire collected quantitative information about their perceptions and an interview examines the qualitative data gathered on their overall perceptions concerning the impact of gamification and its implementation within the techno pedagogical design for the biology course. Finally, this chapter will conclude with a summary of the key findings and their implications for the research questions posed in this study.

All in all, the findings are presented with a detailed description of the activities done in every step of the research.

First, to ensure equal representation, both female and male participants were considered equally so that the gender distribution is closer to 50% for both males and females. As seen in graph 1, male participants constitute 45% of the total of the participants, while female participants constitute 55% of the total of the participants (60 in total).

Graph 1.

Participants



4.2 Pre-treatment Phase

Before the techno pedagogical design was introduced, a standardized BUAP test was used to determine the students' starting biology knowledge levels.

Table 2

Findings in the pre- test

Number of students	Average
18	7
25	7.4
12	7.8
4	8

1	8.8

As is seen in Table 2, the majority of participants (25) had an average of 7.4 during the pre-test, indicating that they may have been struggling with getting high scores in biology. 18 students were at the bottom with only a score of 7 and 12 obtained 7.8. These results seem low in comparison to the final results in the post-test. Additionally, only four students obtained a grade of 8 and only one individual succeeded in getting an 8.8, which means only a few were able to get a high score.

4.3 Treatment phase

A techno pedagogical course was created for this stage. As mentioned in chapter 3, Quizizz was the platform used for this, and it involved different activities to complete in a limited period of time.

The experiment's span was thirteen weeks, from September 11th, 2024, to December 11th, 2024. This course consisted of 29 interactive quizzes related to biology topics such as bio elements classification, vitamins, lipids, respiration, photosynthesis, and body systems. Each of these quizzes contained from 19 to 53 dynamic questions such as multiple choice, spotting the difference, reorganizing, drag and drop, recordings, or matching. The number of questions varies depending on the difficulty of the topic since there are some that are more difficult than others. Another feature to consider is that some topics have more information than others, thus, requiring more questions to be asked. Additionally, these quizzes included gamification elements such as badges, leaderboards, rewards, and a system of points.

There were also other features such as getting extra time after answering a question correctly, extra attempts in case a student made a mistake, and the possibility to answer one wrong question at the end of the quiz. Moreover, the activities included a lot of visual aids to make the activities more engaging (see figures 1, 2, 3, 4, and 5).

Figure 1

A slide containing information related to the biology course.

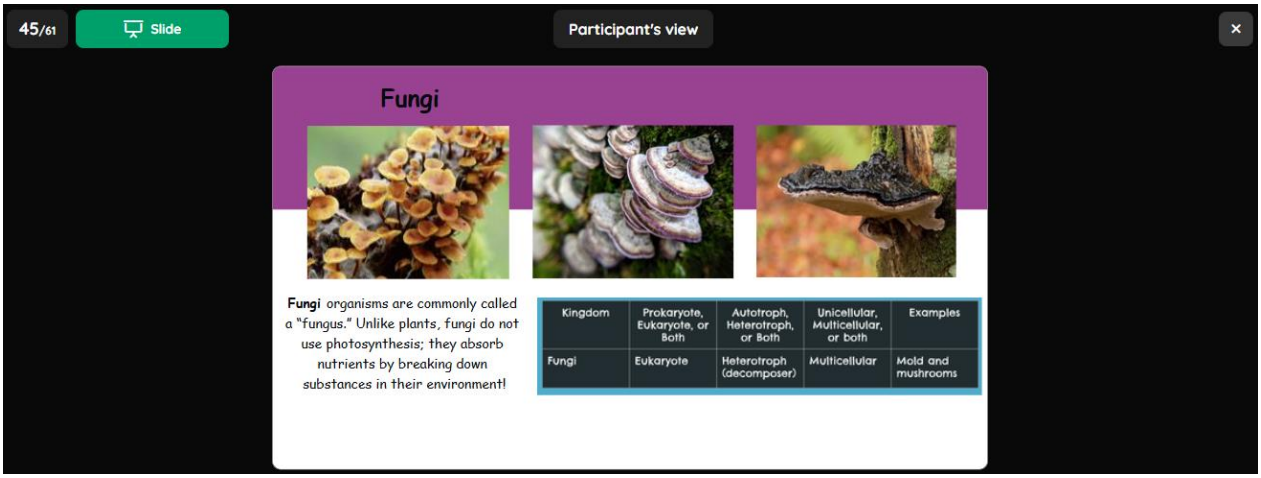


Figure 2

A poll question to engage students with the topic.

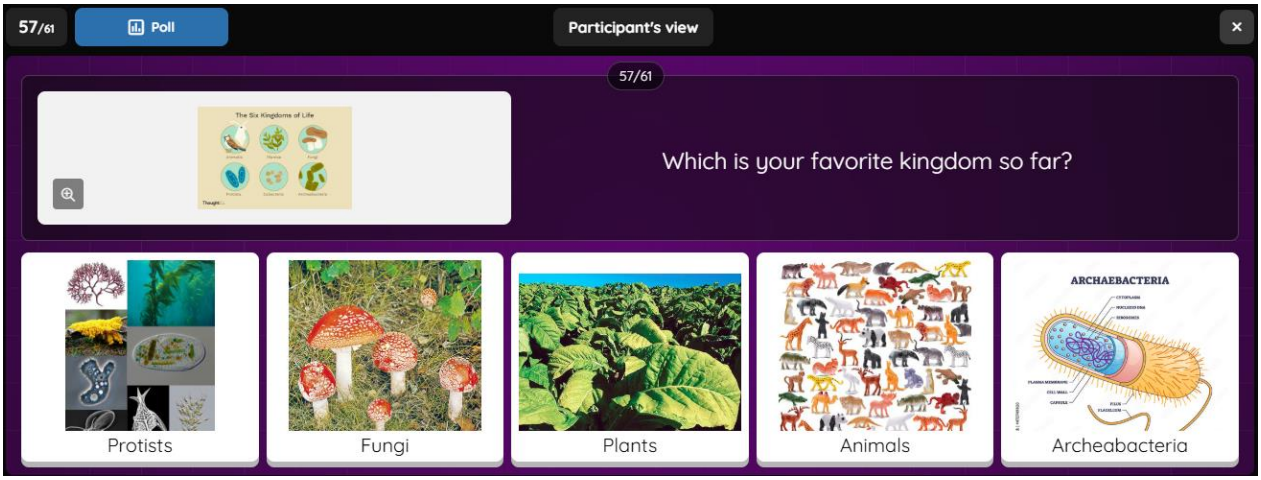


Figure 3

A Labeling question to test students' knowledge.

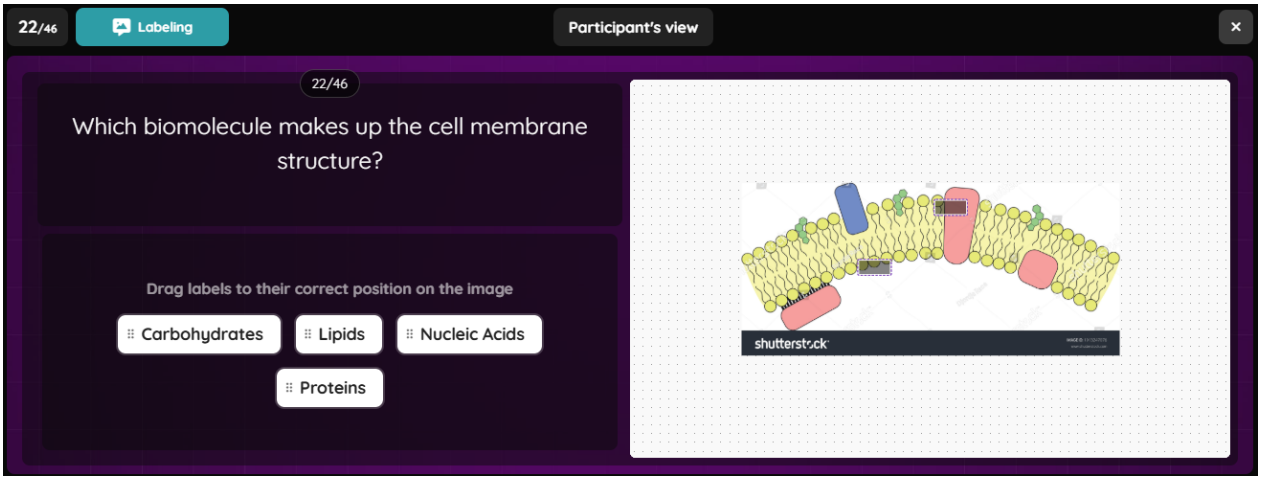


Figure 4

An activity where students have to categorize some concepts.

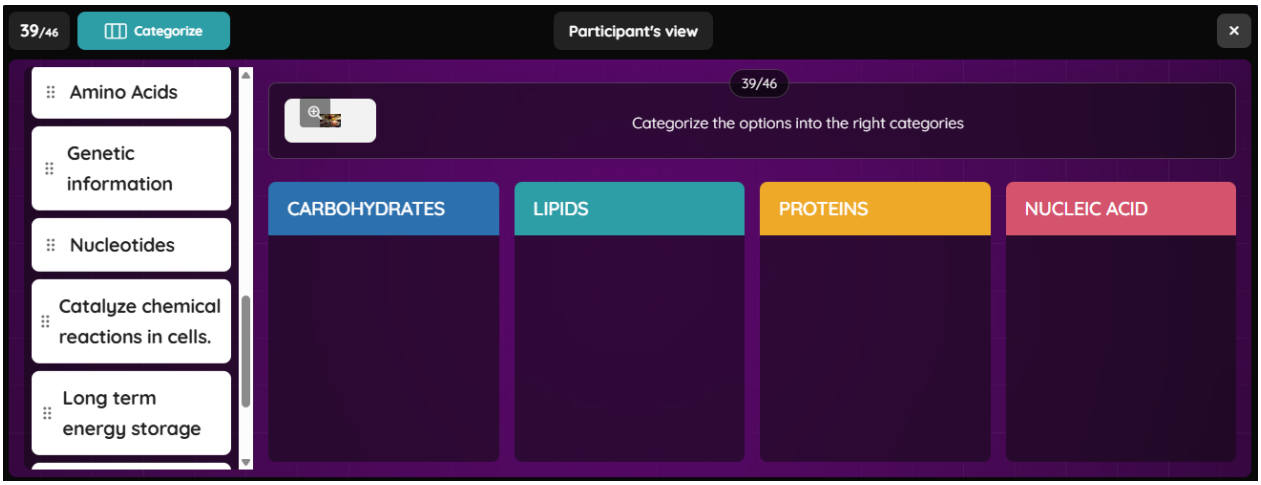
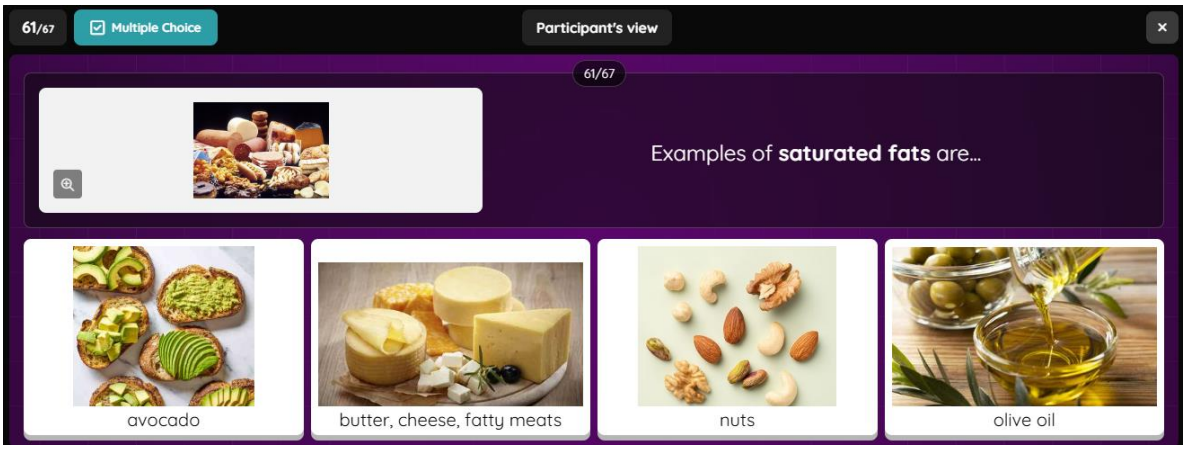


Figure 5

A multiple-choice question about saturated fats.

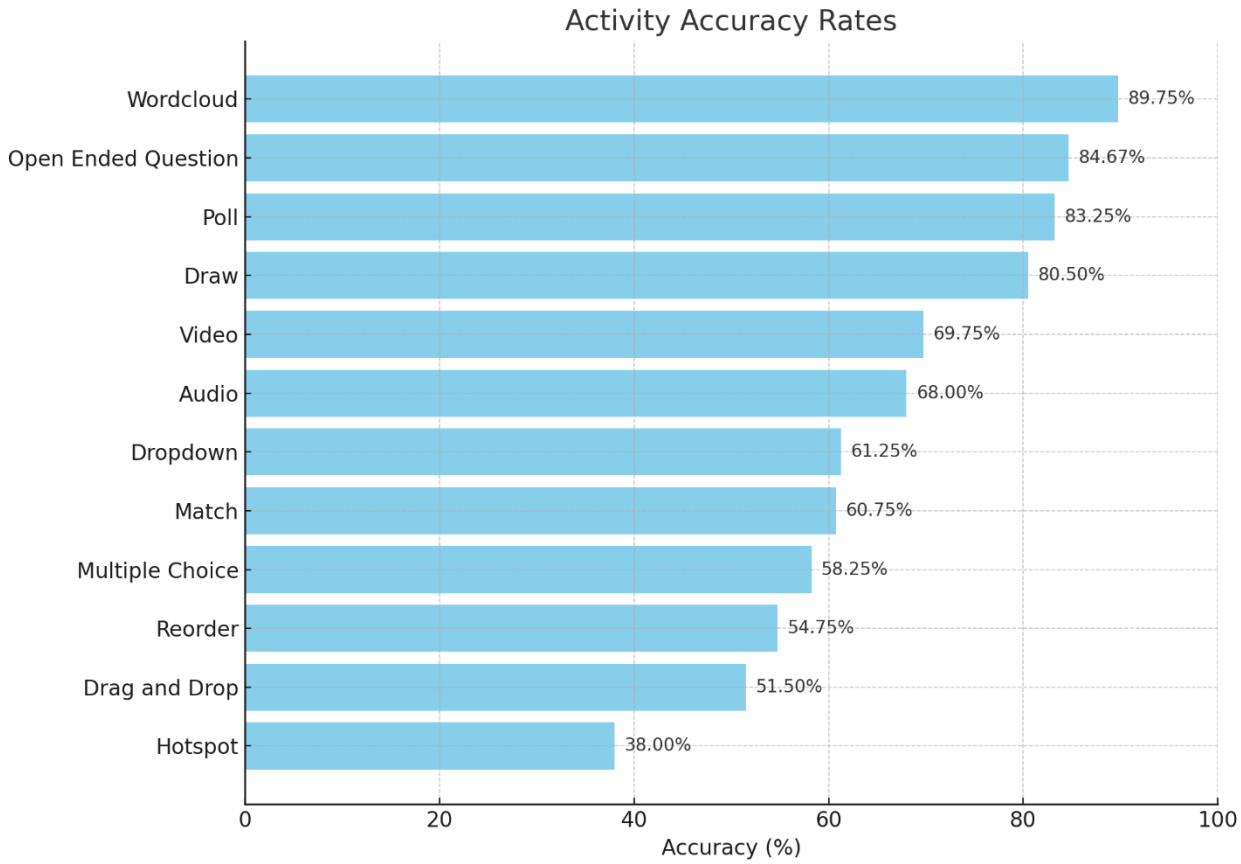


In the techno pedagogical design different types of questions were used in order to have a large variety of tasks. According to the type of these activities, the accuracy rates associated with them varied significantly depending on their kind.

For instance, the most accurate question types were Wordcloud (89.75%), Open Ended Question (84.67%), and Poll (83.25%), while Reorder (54.75%), Drag and Drop (51.5%), and Hot Spot (38%) yielded the lowest performance (see Graph 2).

Graph 2

Activity Accuracy Rates for Quizizz Activities



The activities used are based on the following characteristics.

a. Initial Non-Scoring Questions. The tests begin with a question, “How are you?”, which holds no value in scoring, but that I consider important to show students that human part is missing from using a website. This inclusion is intended to assess the emotional state of students, creating a supportive and student-centered environment. A subsequent brainstorming question (Wordcloud) is followed in order to activate prior knowledge and set the stage for more complex tasks. According to Taleb (2013), the use of brainstorming improves creative thinking so that students can increase their problem-solving skills as well as their critical thinking.

b. Multiple-Choice Questions. They are found in the sections Poll, Draw, Dropdown and Hotspot. They are used to assess recognition and understanding of concepts. These questions are the first to appear because they are the easiest since the possible answers are shown. This format is practical as it allows for objective scoring and reduces the potential for bias (Crocker & Algina, 2006). Multiple-choice items are reliable due to their consistency in scoring, supporting the test's validity when designed with clear and relevant content (DiBattista & Kurzawa,2011).

c. Reorder Words. Reordering tasks require students to manipulate words into coherent sentences, testing their syntactic and morphological skills. This type of task simulates real-life situations where students must understand language structure, thus enhancing content authenticity (Lewkowicz, 2000). Here, we can see that the level of difficulty is increasing little by little, but it is still not that hard.

d. Matching Words. Matching exercises are designed to test word associations and relationships, reinforcing the students' ability to identify corresponding concepts. The clear instructions and straightforward format ensure high reliability and ease of scoring (Davis, 1993).

e. Drag and Drop. Interactive drag-and-drop tasks simulate a real-world story student have to complete. This item type supports the authenticity of the test by mimicking language use in practical contexts (Lewkowicz, 2000). The clear task format aids in maintaining reliability while testing deeper cognitive connections between biology concepts.

f. Categorizing. Categorizing items test students' ability to group words based on their function or form. This activity encourages analytical thinking,

aligning with higher cognitive processes outlined in Bloom's taxonomy. The practical and interactive nature of categorization tasks helps reinforce test reliability and engage students in an authentic application of language skills. Furthermore, Terrel et al. (2021) employed game-based visual literacy activities with card-sorting on biomolecules such as proteins or lipids, which is a task where students have to categorize concepts. The findings showed that these activities moved students toward expert-like sorting and better structure–function understanding.

g. Matching. Matching ensures students can recognize relationships between concepts. This adjusts to the goal of demonstrating understanding beyond simple memorization, reinforcing validity through meaningful language use (Rahayu, 2018).

h. Video-based Task. A multimedia element is incorporated where students watch a video and then apply their understanding by answering the questions presented. This task enhances the authenticity of the test by combining visual and auditory learning, mimicking how language is processed in real situations (Wu & Stansfield, 2001). The inclusion of multimedia also increases engagement and ensures comprehensive assessment.

i. Open Cloze. The open cloze section, which is worth the highest number of points, tests students' ability to apply their biology knowledge in a contextually rich environment. This task requires them to consider the broader context, enhancing the test's validity by assessing deeper skills (Das & Majumder, 2017). Additionally, Beldar (2025) highlights the importance of using open-ended assignments because they promote student engagement, encourage self-directed learning, and improve learning outcomes.

4.4 Post-treatment Phase

To evaluate if the treatment improved the scores of the students after taking the techno pedagogical course, the average of both the pre-test and post-test was obtained. These results suggest that students obtained a higher score after having been exposed to the gamified course.

Table 3

Comparison between the pre-test and the post-test averages.

Number of students from the Pre-test	**Average**	**Number of students from the Pos-test**	**Average**
18	7	9	8.6
25	7.4	6	8.8
12	7.8	14	9.4
4	8	20	9.6
1	8.8	11	9.8
Average	7.40		9.24

The data presented show a clear upward trend after having taken the techno pedagogical course. The table shows that students scored 8.6 or higher. Specifically, 9 participants averaged 8.6, 6 participants averaged 8.8, 14 participants averaged 9.4, 20 participants averaged 9.6, and 11 participants averaged 9.8.

This comparison reveals a substantial improvement in the distribution of grades. While the pre-test results were concentrated in the lower range, the post-test results show a significant movement towards the higher end of the grading

scale. This suggests that the techno pedagogical course delivered via Quizizz was effective in enhancing students' understanding of the biology concepts assessed. This aligns with a study carried out by Göksün and Gürsoy (2019) where they found that the use of gamification improves academic achievement and student engagement.

The comparison between both tests results shows a clear success rate in answering the first research question: To what extent does a gamified techno pedagogical course improve the construction of scientific concepts of high school students in a biology class?

The substantial shift in mean scores provides strong evidence of improvement. While the overall pre-test average for the experimental group was 7.40, the post-test average rose significantly to 9.24. This demonstrates that there was an increase in those who took the course. Additionally, there is a high concentration of participants who scored 8.6 or above in the post-treatment phase. This substantial rise in performance confirms that implementation of Quizizz course was effective in enhancing students’ construction of biology concepts, thereby supporting the alternative hypothesis for a better academic achievement.

4.5 Overall Perception Concerning the gamified techno pedagogical biology course and its Implementation

The questionnaire generated a large volume of data regarding students’ perceptions on the techno pedagogical design. In order to summarize, interpret, and organize the data of these results, descriptive statistics were employed.

All response data from the questionnaire were downloaded from Google Forms and then coded, and analyzed using SPSS. This software was selected due to its intuitive use as well as its accessibility and efficiency for performing the necessary descriptive statistical calculations with precision (Nagaiah & Ayyanar, 2016).

The measures used for data presentation were the mean and the standard deviation (SD). The resulting mean score represents the central tendency of the participants' agreement or disagreement with the statement. For a five-point Likert scale questionnaire (5 = Strongly Agree, 4 = Agree, 3 = Neutral, 2 = Disagree, 1 = Strongly Disagree), a mean score of 3 indicates a neutral response, while scores approaching 5 indicate strong or positive agreement. Scores that are close to 1 indicate strong disagreement. Moreover, standard deviation was used to measure the dispersion within the response for each item. A smaller SD indicates that the responses are tightly clustered around the mean, while larger SD suggest a wide spread of opinions (Livingstone, 2004).

In order to answer the second research question (How do high school students perceive the gamified techno pedagogical biology course?), quantitative analysis of the questionnaire responses was conducted. Graph 3 shows a good degree of students' engagement and motivation, underlining the effectiveness of the adopted approach.

Table 4

Participants' attitudes towards the use of Quizizz

			Mean (M) and Standard Deviation (SD) from question 1				
Q.	**Likert**	**Percentage**	**No.**	**Min**	**Max**	**M**	**SD**
When I	**scale**		**Students**				
worked in	1	1%	60	1	5	3.8833	.82527
game	2	1%					
activities, I	3	30.4%					
felt	4	49%					
interested	5	18.6%					

The mean in question 1 is 3.8833, which indicates that most participants tend to agree with the statement. The low standard deviation (.82527) suggests a low dispersion of responses, which means that opinions are concentrated around the mean. It is also worth noting that interest is a key driver of engagement. For instance, research by Hamari et al. (2014) suggests that gamification, through elements like points and badges, significantly increases user engagement and interest in educational tasks.

Table 5

Perceived Usefulness and Enjoyment of the Tool

			Mean and Standard Deviation from question 2				
Q.	**Likert**	**Percentage**	**No.**	**Min**	**Max**	**M**	**SD**
When I	**scale**		**Students**				
answered	1	1%	60	1	5	4.2333	.87074
the	2	2%					
questions	3	12.7%					

of the	4	45.1%
games, I	5	39.2%
felt		
curious		
about the		
correct		
answers		

The mean in question 2 (4.2333) is above the Agree value (4), indicating a strong tendency for participants to agree or strongly agree with the statement. Moreover, the low standard deviation (.87074) shows that responses are highly concentrated around the mean. The feeling of curiosity is a cognitive and emotional response often triggered by game elements. In a study done by Deterding et al. (2011), the authors identified that well-designed gamification could tap into intrinsic motivations such as curiosity. This creates a sense of challenge and discovery.

Table 6

Enjoyment of the Course through Gamification

			Mean and Standard Deviation from question 3				
Q.	**Likert**	**Percentage**	**No.**	**Min**	**Max**	**M**	**SD**
I thought	**scale**		**Students**				
this	1	1%	60	1	5	3.9667	.84305
course	2	2.9%					
was fun	3	22.5%					
because	4	44.1%					
of the	5	29.4%					

game activities							

In question 3, the mean is close to 4 (3.9667), which indicates that most participants agree that the course was fun thanks to the activities. Furthermore, the standard deviation is low (.84305), but slightly higher than the previous question, showing a slightly greater dispersion of responses. It merits attention that fun is a primary component of play and a powerful motivator. Kapp (2012) defines gamification as the use of game-based mechanics and aesthetics to engage people, which leads to the creation of having a fun and enjoyable experience to facilitate learning.

Table 7

Motivation through Gamified Learning Paths

			Mean and Standard Deviation from question 4				
Q.	**Likert**	**Percentage**	**No.**	**Min**	**Max**	**M**	**SD**
I	**scale**		**Students**				
enjoyed	1	2%	60	1	5	3.9000	.95136
this	2	2%					
course	3	20.6%					
thanks	4	50%					
to the	5	25.5%					
gamified							
learning							
path							

The average score in question 4 is also close to the Agree value (4), which is 3.9000 as shown, suggesting that participants enjoyed the course due to the gamified learning path. In addition, the low standard deviation (.95136) shows strong agreement in responses. It is considered that enjoyment of the overall learning path is a measure of the course's design. All in all, a study found that a gamified course path (points, levels, challenges) increased motivation and improved performance versus a non-gamified path (Domínguez et al., 2013).

Table 8

Impact of Game Elements on Learning Processes

			Mean and Standard Deviation from question 5				
Q.	**Likert**	**Percentage**	**No.**	**Min**	**Max**	**M**	**SD**
I	**scale**		**Students**				
enjoyed	1	2%	60	1	5	4.4167	.76561
learning	2	1%					
new	3	6.9%					
things in	4	40.2%					
this	5	50%					
course							

With a mean of 4.4167, there is a clear tendency to agree or strongly agree with the statement. The standard deviation of .76561 confirms that responses are quite clustered around the mean. Gamification can transform complex information into manageable, interactive tasks as it was seen in a study conducted by Rowicka and Postek (2023). The authors showed that gamified approaches can be effective

tools for increasing learning outcomes and improving knowledge acquisition. Thus, leading to satisfaction of users after having used it.

Table 9

Attention to Feedback Sessions

			Mean and Standard Deviation from question 6				
Q.	**Likert**	**Percentage**	**No.**	**Min**	**Max**	**M**	**SD**
I listened	**scale**		**Students**				
carefully	1	1%	60	1	5	4.0667	.88042
during	2	1%					
the	3	22.5%					
feedback	4	50%					
sessions	5	25.5%					

The mean of 4.0667 indicates that participants in general agree that they paid attention during the feedback sessions. In addition to this, the standard deviation of .88042 shows a low data dispersion. Feedback has one of the largest effects on learning when it is timely and informative, which aligns with how gamified systems surface feedback frequently (Huang et al., 2019).

Table 10

Motivation and Need Satisfaction

			Mean and Standard Deviation from question 7				
Q.	**Likert**	**Percentage**	**No.**	**Min**	**Max**	**M**	**SD**
I paid	**scale**		**Students**				
attention	1	2.9%	60	1	5	3.8667	.99943
to	2	4.9%					

questions, comments and feedback from other students	3	23.5%
	4	39.2%
	5	29.4%

Question 7 has a mean of 3.8667. In this question, students tend to agree with the statement. The higher standard deviation (.99943) compared to other questions might indicate a wider range of opinions. Extrinsic rewards and social recognition are well-documented motivators in gamification (Flores-González, 2025). Sailer et al. (2017) conducted a meta-analysis showing that game elements like points, badges, and leaderboards positively impact motivation and cognitive outcomes.

Table 11

Effort and Persistence in Learning Activities

			Mean and Standard Deviation from question 8				
Q.	**Likert**	**Percentage**	**No.**	**Min**	**Max**	**M**	**SD**
I worked	**scale**		**Students**				
hard to	1	1%	60	1	5	3.7167	.90370
respond	2	2.9%					
to the	3	25.5%					
requests	4	47.1%					
of the	5	23.5%					
activities							

of the games							

Question 8, which focuses on students' performance, has a mean of 3.7167. This indicates that students tend to agree that they worked hard on the game activities. Additionally, the standard deviation of .90370 shows that the responses are clustered around the mean. Gamified systems are designed to encourage persistent effort (Flores-González, 2025). Ryan and Deci (2000) highlight how game mechanics can drive user behavior by rewarding both effort and persistence. Because of this, the learning process is more compelling.

Table 12

Collaboration with Classmates

			Mean and Standard Deviation from question 9				
Q.	**Likert**	**Percentage**	**No.**	**Min**	**Max**	**M**	**SD**
I was able	**scale**		**Students**				
to	1	2.9%	60	1	5	3.7167	.90370
collaborate	2	5.9%					
with peers	3	32.4%					
during	4	37.3%					
discussion	5	21.6%					
and feedback sessions							

The value of the mean is close to 4, which is 3.7167 and it means it has a positive tendency towards an agreement on the statement (4). This indicates that

students' opinions on collaboration are mixed. Moreover, the standard deviation of .90370 confirms a greater dispersion of responses. In a piece of research carried out by Sailer et al. (2017), it was shown that working together with teammates fosters relatedness and collaborative behaviors within gamified activities.

Table 13

Active Participation and Engagement

			Mean and Standard Deviation from question 10				
Q.	**Likert**	**Percentage**	**No.**	**Min**	**Max**	**M**	**SD**
I tried to be	**scale**		**Students**				
active in	1	2%	60	1	5	3.9000	.87721
participating	2	4.9%					
during the	3	24.5%					
gamified	4	45.1%					
learning	5	23.5%					
path							

When it comes to becoming active during the gamified path, results show a mean of 3.9000. In this question, most students feel active in their participation since the majority of them agreed on the fact that they were more active. The standard deviation of .87721 indicates a dispersion of responses, although with a positive focus. Suh et al. (2018) mention that gamification shifts the learner from a passive recipient to an active participant. The authors noted that a sense of agency and active participation are key psychological outcomes of effective gamified learning.

Table 14

Recognition of Progress through Game Mechanics

			Mean and Standard Deviation from question 11				
Q.	**Likert**	**Percentage**	**No.**	**Min**	**Max**	**M**	**SD**
I am able	**scale**		**Students**				
to	1	1%	60	1	5	4.000	.73646
recognize	2	1%					
my	3	18.6%					
progress	4	61.8%					
during	5	17.6%					
the							
gamified							
learning							
path							

Recognizing progress is essential when learning. The mean of 4.000 shows that students tend to agree that they can recognize it. The lowest standard deviation of all the questions (.73646) indicates strong agreement among the responses, meaning most students agree or strongly agree with this statement. Visualizing progress is a powerful motivator. The use of badges, points, and progress bars are fundamental gamification elements that provide tangible evidence of achievement and a clear path forward for the learner (Deterding et al., 2011).

Table 15

Role of Friendly Competition in Participation

	Mean and Standard Deviation from question 12

Q.	Likert	Percentage	No	Min	Max	M	SD
Game	**scale**		**Students**				
activities	1	2%	60	1	5	4.0167	.87317
were a	2	2%					
form of	3	21.6%					
friendly	4	46.1%					
competition	5	28.4%					

The average score of question 12 is 4.0167, which indicates that students agree that the game activities were a friendly competition. Besides this, the standard deviation of .87317 indicates that the responses are quite clustered. Competition, when managed appropriately, can be a positive and engaging force. Barratt (2017) found that using a friendly, low-stakes competitive approach in a learning context can increase motivation and improve academic performance.

Table 16

Retention and Recall of Learned Content

			Mean and Standard Deviation from question 13				
Q.	**Likert**	**Percentage**	**No.**	**Min**	**Max**	**M**	**SD**
I am able	**scale**		**Students**				
to	1	2%	60	1	5	3.7333	.88042
remember	2	4.9%					
the	3	32.4%					
knowledge	4	41.2%					
gained	5	19.6%					
through							

game activities							

For question 13, the mean of 3.7333 is closer to agree than neutral, meaning that students generally remember the knowledge acquired. Along with this result, the standard deviation of .88042 shows a moderate dispersion of responses. Knowledge retention is often a challenge in traditional learning. Brull et al. (2017) argue that the interactive, multi-modal nature of gamified activities can lead to deeper cognitive processing and better long-term retention of information.

Table 17

Development of Critical Thinking Skills

			Mean and Standard Deviation from question 14				
Q. This course helped me improve my critical thinking skills through various types of activities	**Likert scale**	**Percentage**	**No. Students**	**Min**	**Max**	**M**	**SD**
	1	1%	60	1	5	4.0167	.77002
	2	1%					
	3	19.6%					
	4	55.9%					
	5	22.5%					

The mean of 4.0167 in question 14 indicates that students agree that the course improved their critical thinking skills. Also, the standard deviation of .77002 suggests that responses are highly concentrated around the mean. According to Qian and Clark (2016), gamification can develop higher-order thinking if players solve problems and make strategic decisions. The authors highlight that well-designed game elements can encourage players to engage in both complex problem-solving and critical thinking.

Table 18

Usefulness of Group Work for Problem Solving

			Mean and Standard Deviation from question 15				
Q.	**Likert**	**Percentage**	**No.**	**Min**	**Max**	**M**	**SD**
The group	**scale**		**Students**				
work during	1	1%	60	1	5	3.8333	.80605
the activities	2	2%					
of the	3	29.4%					
games was	4	49%					
useful to	5	18.6%					
solve the							
problems							
related to							
the							
performance							
of the task							

The mean of 3.8333 in question 15 indicates that students agree that group work was useful for solving problems in the activities. In addition, the standard

deviation of .80605 shows a low dispersion of responses. Collaborative problem-solving is a social and cognitive skill. Johnson and Johnson (2009) described how social mechanics, like group activities and team-based tasks, are designed to make group work not only useful but also a core part of the experience while learning.

In order to obtain rich, contextual, and detailed qualitative data, an interview consisting of five open-ended questions was conducted. This instrument was designed to elicit the perceptions and experiences of the participants regarding the techno pedagogical design. This interview data served to triangulate the findings from the standardized tests and the Likert scale questionnaire so that it could provide a deeper understanding of how and why the gamified course may have influenced their attitude and test scores.

As indicated before, this data analysis was accomplished by using a Thematic Analysis based on Brown & Clarke (2008). The following lines explain the findings considering these categories: language and usability barriers, gamification as a learning motivator, conceptualizing the tool, user-suggested improvements, and overall platform perception.

1. Language and usability barriers**.** From the information gathered in this study, question 1 (What was the most confusing part of using "Quizizz"?) covers the importance of using a tool that is easy to use**.** The responses to this question were similar, but they mainly focused on two aspects: the use of the English language and technical problems.

Nineteen students mentioned that the fact that the platform was in English was the most confusing or difficult part. It seems their English level and the

advanced vocabulary used were a little bit difficult for them even if the biology concepts are basic. Secondly, fifteen of the participants found parts related to accessing, registering, optimizing, or how the application worked on their devices confusing.

Even though the opinions seem negative, it is worth noting that they are not related to the platform itself, but to external factors that are not completely related to the techno pedagogical course. Overall, it is shown that students often have a positive impression of gamified courses, which make them feel more engaged and motivated. This is supported by a study conducted by Cheon and Cheong (2014) who found that students' attitudes towards a gamified course were highly positive, with learners reporting increased enjoyment and a more favorable view of the learning process itself. This confirms that gamification can successfully improve the overall learning experience from the student's perspective. Some of their answers are: *Qué estaba en inglés; Que era en inglés; Inscribirm;, El cómo acceder; Que estaba en inglés y algunas veces no le entendía; Lo de grabar; Pues para seguir las actividades; hacerlo en celular, por la pantalla; Pues algunas veces en como registrar; A veces te retrasa un poco que la pregunta no se muestre en el celular y tengas que voltear a otra pantalla diferente; Cuando teníamos que grabar videos; La interfaz del menú era algo complicada al inicio; Tardaba para cargar la imagen a veces.*

Even though these answers may reflect a difficulty in using the website, these questions help the improvement of the website so that it can become more effective and efficient in the future.

2. Gamification as a learning motivator. A prominent theme that emerged from the data was the role of gamification as a motivator to learn. In question two (Would you like to be in a class where "Quizizz" is used again? Why?), the participants positively commented on the benefits of using gamification while learning basic biology concepts. Thirty-nine students responded affirmatively because they found the platform to be fun, entertaining, or dynamic.

According to Bernik et al. (2018), students in a gamified class reported higher levels of satisfaction and motivation compared to those in a traditional class. Their findings suggest that game mechanics are effective at promoting student engagement and enjoyment. The qualitative data collected from the interviews revealed the following responses: *Si, porque es divertido; Si, porque fue interesante y por los audios aprendía más; Sí, puede mejorar mi aprendizaje sí, me pareció entretenido; Si, por qué es una manera divertida de aprender; Si, es muy entretenido y ayuda a la comprensión del tema y el aprendizaje del idioma inglés; Si, porque es como estudiar dos cosas; Si, porque ayuda a recordar y poner a prueba lo aprendido; Si me gustaría, pues es muy entretenido e interactivo, además, de que no te aburres fácilmente; Si, ya que aprendemos y nos divertimos a la vez, además de que aprendí palabras nuevas en inglés.*

3. Conceptualizing the Tool. The analysis of participant responses revealed a theme that centers on describing the platform, highlighting its didactic and playful nature. In question three (If you had to explain "Quizizz" to a friend from another class, what would you say?), forty-four participants describe it as a tool or platform that helps to reinforce and acquire knowledge. Roediger and Karpicke (2006) suggest that frequent low-stakes quizzing yields the testing effect, strengthening

long-term retention. Other opinions also stated that it was a fun and competitive activity for learning and that the application helps to practice and improve the English language. This perfectly aligns with a piece of research conducted by Sepehr and Head (2013) where they mentioned that gamification is a key element that highly motivates students to engage in tasks. The qualitative feedback from the students highlights the following points: *Que es una plataforma que ayuda a tus conocimientos reforzando más aparte te ayuda con tu inglés; Que son entretenidos y se los recomendaría si quieres estudiar; Que es una plataforma de juego y estudio; Que es muy práctico; Muy bueno y dinámico; Pues que es una aplicación que te ayuda a aprender biología y además te sirve para practicar el inglés entonces es una buena app; Es un cuestionario virtual muy interesante Que es una plataforma que no solo te pregunta si no te explica y aprendes mejor Son actividades complementarias por medio de preguntas con una retroalimentación; Es una aplicación de juego en la cual encuentras temas de biología y ayuda a repasar y recordar lo aprendido, además de que refuerzas tu conocimiento; Es una app donde puedes adquirir nuevos conocimientos mientras te diviertes, además de que sus actividades son muy intuitivas; Una aplicación en otro idioma donde practicamos temas ya visto y nos divertimos al mismo tiempo.*

4. User-suggested improvements. Upon coding the responses, a key theme identified was some of the improvements that can be made in order to have a better platform. Question four (If you could make changes to "Quizizz", what part would you change and why?) focuses on these suggestions:

The most requested change was for the platform to be in Spanish, which would facilitate its use and comprehension for the students. Students also

suggested improvements in speed, the user interface, and the duration or number of questions in the activities. Additionally, the video recording feature was pointed out as an element to be changed, as several students considered it unnecessary. This question focuses on the importance of taking suggestions into consideration since Cappucio et al. (2004) state that the platform's future development will be shaped by its users, so the methodology must allow the system to continuously adapt to their changing needs. Because of this, improvements to the platform used must be considered. The following are some of the most representative responses from the participants: *El idioma inglés en ocasiones no se entiende; Que tenga el idioma español; Mejorar la rapidez de la aplicación; Que no sea tan lento; Los videos de que pedía al último; Lo de grabar, porque es muy innecesario; Pues hacerlo más cortas las actividades; En la cantidad de preguntas, ya que en algunas eran demasiadas preguntas; Que no aparezca tantas cosas en pantalla; Que algunas veces no se guardan nuestro usuario y le cambiaría esa parte donde se guarde nuestro perfil; La parte de grabaciones; La parte de los videos y diapositivas siento que no retenía la información suficiente como para contestar una pregunta de las 10 diapositivas anteriores y no te podías regresar a leerlas ya; Mejorar la interfaz en celular.*

5. Overall Platform Perception. Data from question 5 (If you have any other opinion, positive or negative, about "Quizizz", explain it) illuminated a notable trend toward the general impressions of Quizizz. Overall, the final opinions about it are overwhelmingly positive. Fifty-four participants praise the platform, describing it as a good, useful, fun, dynamic, and effective tool for learning and studying. According to Wang and Tahir (2020), reviews of classroom game-response tools show

favorable attitudes and higher participation as well as a sense of enjoyment. Some of the responses are presented below: *Opino que es una actividad fuera de lo común en clases lo que la hace interesante y es algo fuera de la zona de confort, lo que puede generar curiosidad y es una forma distinta y buena de aprender; Úsenla en más materias, es muy útil; En mi caso me gustó porque también nosotros como estudiantes podemos hacer nuestras propias preguntas; Es general, es una herramienta bastante útil para el aprendizaje combinado con diversión; Es una herramienta de estudio muy buena y divertida*
Nada más que pongan las diapositivas, pero de poco a poco, no que hagan las preguntas luego y de mucha información, pues en lo personal no tengo buena retención de información y se me olvidaba lo que previamente había leído; Está bien en general; Nada que decir, muy agradecido de haber podido interactuar con esta app; Me gustó mucho trabajar con esta aplicación; Es una buena herramienta de aprendizaje; Positiva, siento que es una buena aplicación para desarrollar y complementar materias; Amé esta manera de estudiar y repasar los temas, ojalá y lo utilizaran siempre; Es una buena herramienta de aprendizaje y de estudio; Las actividades son cortas lo que es positivo pues es entretenido; Positiva porque es demasiado útil; La diversidad de actividades que ofrece además de ser cortas y fáciles; Es una buena herramienta de apoyo para poder tener más conocimiento o poder repasar sobre temas que ya conocemos; Me gustó el trabajo en esta plataforma; Me gustó porque aprendí otras cosas y reforcé algunas; Fue algo divertido, que me dejó conocimientos de los temas gracias; Esa forma de enseñanza es buena; Es muy útil, gracias por hacerla; Me gusta porque es muy

dinámica; Fue una buena idea poner las cosas en inglés, además de que no había un tiempo definido para terminarlo y eso te daba tiempo para pensar.

4.6 Conclusions

The elements presented here were the overall results in the pre-treatment phase, the treatment, and the post-treatment phase, which indicated a positive outcome about the students' performance as well as their perceptions while using Quizizz for their biology class. Furthermore, the data revealed a positive tendency with improved student proficiency.

The following chapter presents the conclusions and the final reflection for further implementation. Despite the fact that the learners used different types of questions in the gamification environment to improve their skills, there is still an enormous gap for further research and implementation that can be done in Mexico or other contexts.

Chapter V: Conclusions

5.1 Introduction

This thesis research investigated the potential of using gamified techno pedagogical interventions to enhance L2 biology learning. The study explored the effectiveness of a gamified approach, delivered through the Quizizz platform, to address the challenges L2 students face in mastering biological concepts. The research process encompassed a comprehensive literature review on gamification and technology integration in education, the design and implementation of a techno pedagogical course, as well as the collection and analysis of student performance data. The findings of this study may contribute empirical evidence supporting the positive impact of gamification on L2 students' understanding of biology. It also offers practical implications for integrating this approach into L2 science classrooms. Ultimately, this study aimed to provide an additional option for biology education, acknowledging that it represents one of many possible approaches and that other factors may also play a role in effective learning.

5.2 Summary of Key Findings

This research highlights the positive impact of a gamified techno pedagogical approach on L2 biology students' learning outcomes. The Quizizz-based course design improved students' understanding of biological concepts, as evidenced by a significant improvement in post-test performance compared to pre-test results. These findings align with a growing body of research that highlights the potential of gamification to create more engaging and effective learning experiences (Looyestyn et al., 2017; Da Rocha Seixas & de Melo Filho, 2016).

Moreover, the implications of applying this gamified design in an educational setting might suggest its potential as a valuable and different strategy to address this topic. The high levels of student engagement observed in this study emphasize the motivational power of gamified elements. Students reported that the game-like features contributed to a more positive and less anxiety-inducing learning environment, which is particularly important for L2 learners who may experience anxiety when dealing with complex scientific content (Pitoyo & Asib, 2019).

In spite of the fact that the benefits of gamification are increasingly recognized, this study offers valuable insights within the specific context of L2 biology education in rural schools. The findings highlight the fact that when gamification is thoughtfully integrated into a techno pedagogical framework, it can significantly enhance students' comprehension, knowledge retention, and overall learning experience.

Furthermore, the research participants acknowledged the role of game elements in developing essential learning skills, such as memory and critical thinking. This suggests that gamification not only enhances content knowledge but also fosters the development of broader cognitive skills that are crucial for academic success.

To sum up, this study supports the notion that technology, when implemented according to sound pedagogical principles, can lead to improved learning outcomes and increased student motivation. Gamified platforms such as Quizizz offer practical tools for educators to create engaging and effective learning experiences. The findings of this research suggest that these types of resources

can be particularly beneficial in supporting L2 learners in mastering challenging subjects like biology.

5.3 Accomplishments of the Aims

The present study successfully accomplished its core research objectives by providing robust empirical evidence for the research hypothesis. The central aim, which was to investigate the impact of a techno pedagogical course on students' outcome, was fully achieved for the following reasons.

First and foremost, in addressing the first research question concerning the effectiveness of the treatment (To what extent does a gamified techno pedagogical course improve the construction of scientific concepts of high school students in a biology class?), the results from the pre-test and the post-test revealed a statistically significant increase in student knowledge. As conducted in previous studies (Zeng et al., 2024; Rizakhojayeva, 2025; Fatah, 2025), this demonstrates that the integration of gamified elements into educational contexts is highly effective in improving students' knowledge. This aligns with the fact that the hypothesis is supported by all the data presented.

Secondly, the second research question, which focused on students' perceptions and engagement (How do high school students perceive the gamified techno pedagogical biology course?), was comprehensively answered through the analysis of the administered questionnaire and interview. All in all, these instruments demonstrated a positive shift in affective and behavioral domains as well as higher levels of motivation and engagement while learning. The triangulation of data from these instruments provided information that shows that a techno pedagogical design not only improved performance but also enhanced the

overall learning experience. This increase in motivation has also been studied previously (Suprianto & Yuliantri, 2025; Sinaga, 2024), thus, indicating that the use of these elements is likely to be effective when implemented correctly.

All things considered, the empirical evidence leads to the strong acceptance of the alternative hypothesis: implementing a well-designed techno pedagogical course leads to a measurable and significant improvement in both student learning outcomes and engagement. This practical utility of integrating technology and gamification into educational settings is definitely another approach that can be used for educators.

5.4 Contributions

This study offers several key contributions to the field of education in challenging subjects such as biology. First, it adds to the limited body of research on the application of gamification in teaching biology in a second language context, which is extremely rare in Mexico or other parts of the world. The fact that a single-group experimental design was used provides a specific case study that demonstrates the effectiveness of a gamified techno pedagogical approach, thus offering a different teaching model for educators in similar L2 environments under similar conditions.

Second, the findings provide empirical evidence that gamification is not just a tool for language acquisition but can also effectively facilitate the learning of specific subject matter such as scientific concepts found in biology lessons. This substantially contributes to the growing evidence base that gamification can be an effective pedagogical strategy across various disciplines. Finally, the integration of both quantitative and qualitative data through an explanatory sequential design

offers a more holistic and comprehensive understanding of the gamified course's impact, which can be seen in both statistical evidence and lived student experiences.

5.5 Further Research

Based on the findings and limitations of this study, some recommendations for future research are suggested to expand upon the current work.

First and foremost, implementing a controlled group can be an option to consider because the one-group experimental design limits the ability to compare outcomes against a traditional teaching method. Taking this into account, future research should use a randomized control trial to compare the effectiveness of a gamified course against a non-gamified one, which would provide stronger evidence of the approach's impact.

Secondly, this study only focused on a short-term intervention (around four months), and it may not be sufficient to see a long-term effect. Future studies could explore the long-term effects of gamification on student motivation, conceptual understanding, and retention of knowledge over a full academic year or semester.

Thirdly, the current study was limited to high school students from a regional school, so it would be a great idea to vary the population. Further research could apply this gamified approach to different age groups such as middle school or university-level students to determine its broader applicability and effectiveness across various educational settings.

Finally, this piece of research used Quizizz as the primary gamification tool, but there are other platforms that can be used. If different gamified tools are explored more deeply, future researchers could compare the effectiveness of

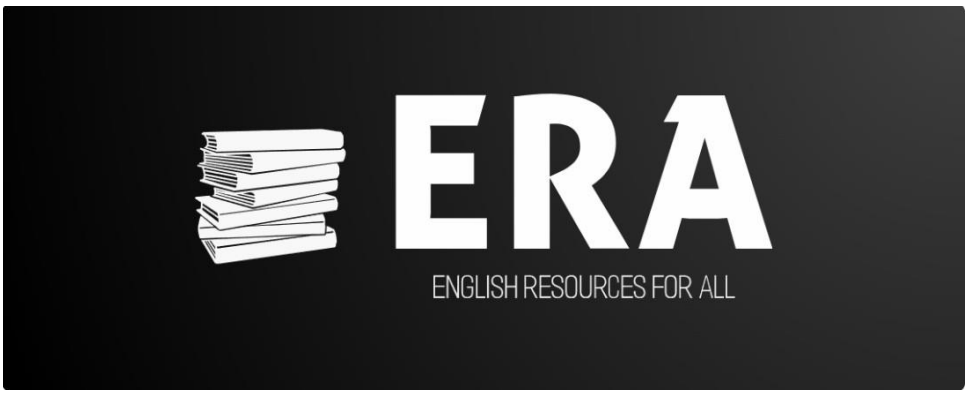
different gamified platforms to identify which features or designs are most effective for teaching specific subjects or skills.

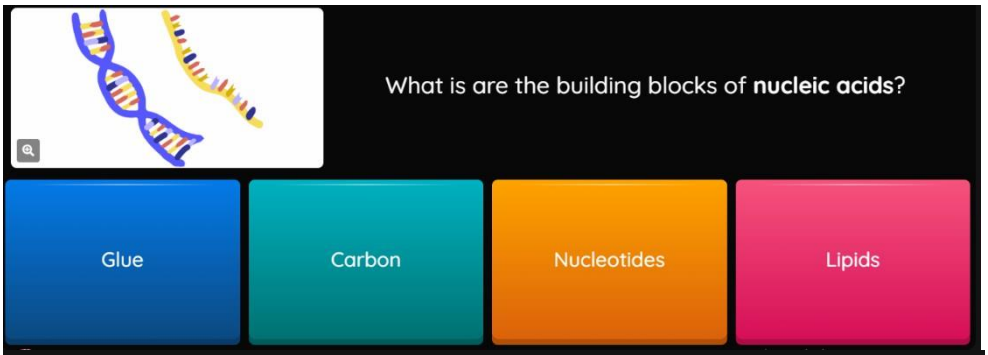
5.6 Conclusions

This study successfully demonstrated the positive impact of a gamified techno pedagogical course on high school students' scientific concept acquisition and their perceptions of the learning experience. The quantitative results provided statistical evidence that the course considerably improved student understanding, while the qualitative data offered students’ positive attitudes towards the gamified approach. Furthermore, the integration of these two data types confirmed that the engaging nature of the course was a key factor in its effectiveness. Moreover, this research enormously contributes to the fields of education by providing a viable model for teaching subject matter through gamification in an L2 context. Even though the study's findings are promising, future research with controlled groups, varied populations, and different gamification platforms is needed to further validate the generalizability of the results. Finally, this study affirms the potential of integrating technology and game-based learning to create motivating, effective, and collaborative learning environments for science education.

Appendix 1

Techno Pedagogical Course on Quizizz





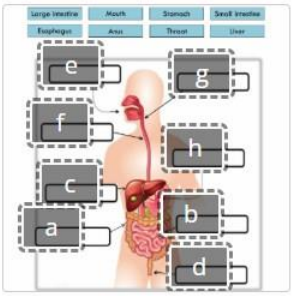
Bonus

Bonus

18. LABELING

1.5 mins • 1 pt

Put these words into the correct box.



- a. large intestine
- b. small intestine
- c. liver
- d. anus
- e. mouth
- f. esophagus
- g. throat
- h. stomach

23. MULTIPLE CHOICE

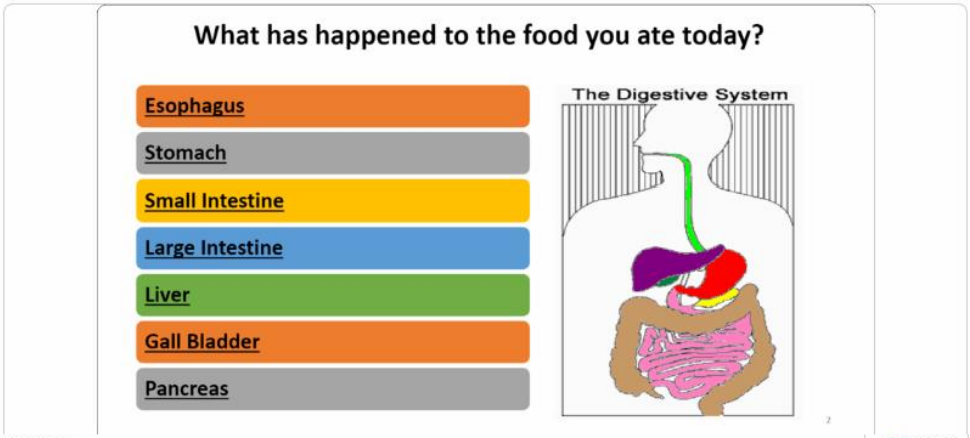
45 sec • 1 pt

Which two parts break down food and nothing is absorbed?

- [x]  Mouth
- [ ]  Esophagus
- [x]  Stomach
- [ ]  Small intestine
- [ ]  Large instestine

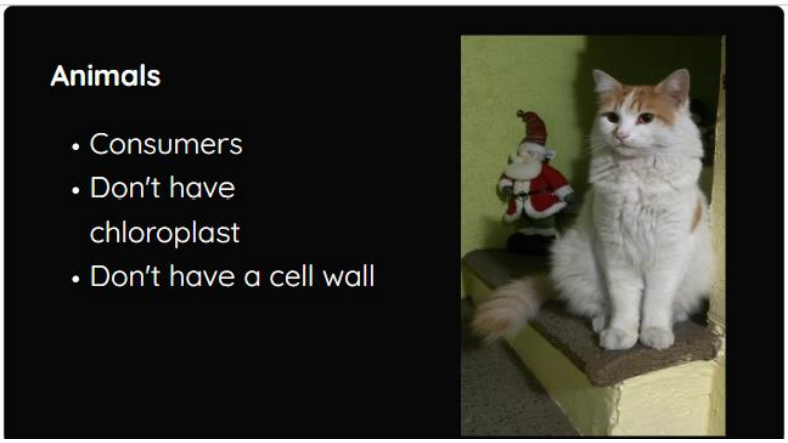
38. SLIDE

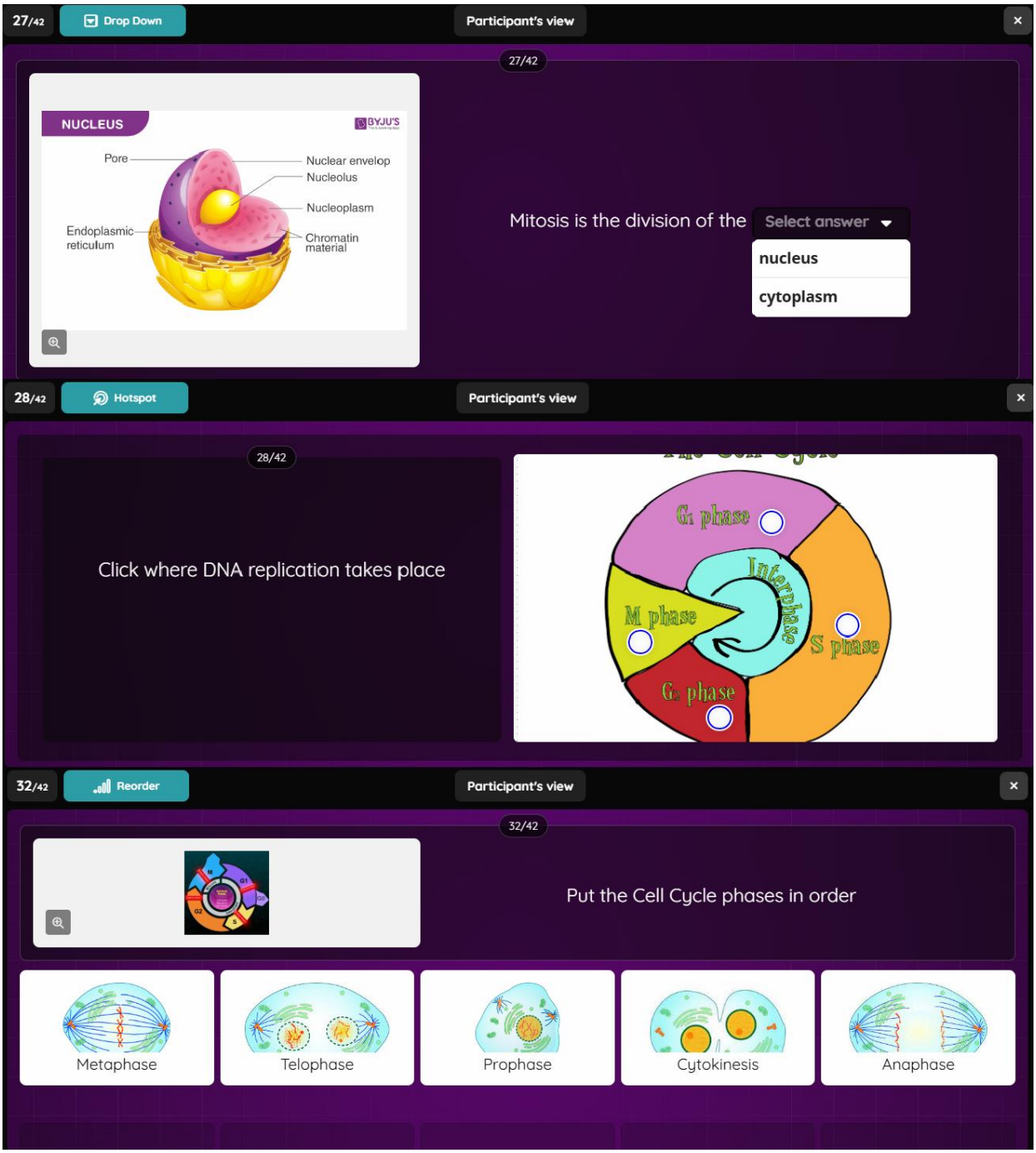
Preview



13. SLIDE

Preview




27/42
Drop Down
Participant's view
27/42
NUCLEUS
BYJU'S
Pore
Nuclear envelop
Nucleolus
Nucleoplasm
Endoplasmic reticulum
Chromatin material
Mitosis is the division of the
Select answer
nucleus
cytoplasm
28/42
Hotspot
Participant's view
28/42
Click where DNA replication takes place
G1 phase
Interphase
M phase
S phase
G2 phase
32/42
Reorder
Participant's view
32/42
Put the Cell Cycle phases in order
Metaphase
Telophase
Prophase
Cytokinesis
Anaphase

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