EDUCATIONAL ESCAPE ROOMS IN SECONDARY MATHEMATICS EDUCATION

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A dissertation submitted to the Faculty of Education at the University of Malta in partial fulfilment of the requirements for the degree of Master in Teaching and Learning in Mathematics

December 2025

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FACULTY/INSTITUTE/CENTRE/SCHOOL Faculty of Education

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ABSTRACT

My teaching experience, which aligns with both local and international literature (Vella, 2011; Yasar, 2016; Wen & Dube, 2022), suggests that many secondary school students do not appreciate the beauty of mathematics. Instead, the subject is often perceived as boring, difficult or irrelevant (Rameli and Kosnin, 2016), leading to demotivation that hinders students' behaviour, conceptual understanding and academic achievement (Barroso et al., 2021). As a result, the aim of this project-based research was to create an innovative pedagogical resource that could help counter these negative perceptions while enhancing student engagement, motivation and collaboration. The resource could also be used as formative assessment tool, enabling students to receive feedback on their learning and supporting teachers in reflecting on their teaching approaches.

The educational resource developed for this project is an Educational Escape Room (EER) which is similar to recreational escape rooms (ERs) but within an educational context (Nicholson, 2018). In an EER, students work collaboratively to solve a sequence of puzzles within a set time limit. Therefore, EERs provide an active learning environment that integrates problem-solving and teamwork.

For this project, an EER was specifically designed and developed for Year 9 mathematics Level 3 – 3*. The final product is presented in the form of a teacher's resource booklet, which includes all the necessary information for introducing and running the game, details on required materials, suggested hints and debriefing process. The puzzles assess topics from the syllabus, which are percentages, Pythagoras' theorem and trigonometry, bearings, and simultaneous equations. Students must work together to solve mathematical challenges that allow them to unlock a sequence of nested boxes secured with digit or letter locks and ultimately, complete the final task within the allocated time. In so doing, students actively engage in learning mathematics within a fun, collaborative and safe learning space.

Keywords: Educational Escape Room, Mathematics, Year 9, Active Learning, Collaboration, Formative Assessment

To my mother

who shared her love for mathematics with me,

and to both of my parents

for their unconditional love, constant support, and encouragement

ACKNOWLEDGEMENTS

I would like to express my sincere appreciation to my dissertation supervisor, Dr Diane Vassallo, B.Ed.(Hons)(Melit.), M.Sc.(Lancs.), Ph.D.(Belfast), and my co-supervisor, Dr Michael Buhagiar, B.Ed.(Hons)(Melit.), M.Ed.(Melit.), Ph.D.(Nott.), for their invaluable guidance, feedback, and support throughout this research.

I would also like to extend my heartfelt thanks to Mrs. Dorianne Zammit and Mrs. Marilyn Saliba for providing constructive feedback on the project in the form a teacher's resource booklet.

My deepest gratitude goes to my family, friends, and colleagues for their unwavering support, patience and encouragement throughout this research study and throughout my journey in this new profession.

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LIST OF ABBREVIATIONS

AI	Artificial Intelligence
AfL	Assessment for Learning
CCP	Core Curriculum Programme
EDR	Educational Design Research
EER	Educational Escape Room
ER	Escape Room
FREC	Faculty Research Ethics Committee
GBL	Game-Based Learning
MATSEC	Matriculation and Secondary Education Certificate
MEDE	Ministry for Education and Employment
NCF	National Curriculum Framework
NSO	National Statistics Office
OECD	Organisation for Economic Co-operation and Development
SEC	Secondary Education Certificate
Ss.	Sub-Section
STEM	Science, Technology, Engineering and Mathematics

CHAPTER 1

INTRODUCTION

1.0 Outline

This chapter introduces the research project. Section 1.1 outlines the motivation of the study, while Section 1.2 provides its background. Sections 1.3 and 1.4 define the aims of the project and its outcomes, respectively. Finally, Section 1.5 outlines the structure of this project-based research.

1.1 Rationale of the Study

Mathematics is a subject that has developed over centuries through the contributions of various mathematicians. It is defined by the Cambridge Dictionary (2025) as 'the study of numbers, shapes, and space using reason and usually a special system of symbols and rules for organising them'. Mathematics is regarded as a valuable subject due to its application in various fields, such as science, economics, engineering, art and finance. Furthermore, it plays an essential role in our daily lives as it helps individuals to identify patterns and understand the world around them. As Sharma (2021) notes, people frequently use mathematics in routine tasks such as budgeting, verifying salaries and calculating travel time and costs, often without being consciously aware of doing so. Additionally, mathematics serves as a universal language that facilitates structured communication and order (Abd Algani, 2022).

Yadav (2019) identifies several roles of mathematics in human development, including social, intellectual, vocational and moral dimensions. According to Yadav, the subject has significantly contributed to advancements in transport, communication and technology. It also stimulates cognitive development, fostering students' resilience and determination in problem-solving. Furthermore, Yadav highlights that mathematics prepares learners for vocations where mathematical skills are essential and contributes to personal development by cultivating discipline and persistence. Most importantly, it improves critical and logical thinking skills, enabling individuals to make sound decisions through improved reasoning.

Given its indispensable nature, mathematics is considered a core subject in education such that it is a compulsory subject throughout the compulsory years of schooling; primary and secondary education. In Malta, the National Curriculum Framework (NCF) (Ministry for Education and Employment, MEDE, 2012) identifies mathematics as one of the core subjects together with English, Maltese, and Science and Technology. At secondary level, more specifically, the NCF recommends that 12.5% of instructional time be dedicated to mathematics lessons. NCF also outlines two central aims for teaching and learning mathematics: to involve students in real-life applications of mathematics and to encourage them to pursue further studies in mathematics and related disciplines, thereby enabling them to become mathematically literate and make informed daily-life decisions.

Despite the recognised benefits of learning mathematics, my teaching experience suggests that many students do not appreciate the value and beauty of the subject. “What do I need mathematics for?” and “Why do I have to learn this?” are common questions posed by some of my students. This observation is in line with the literature, both local and international, which suggests that students’ positive attitude and disposition towards mathematics during primary school begins to decline during secondary school (Vella, 2011; Yasar, 2016; Wen & Dube, 2022).

Furthermore, students frequently report various challenges they encounter when learning mathematics. Rameli and Kosnin (2016) identify five main categories of challenges in mathematics learning. The first is students’ negative perceptions, where the subject is viewed as boring, overly difficult, confusing, and lacking relevance. The second concerns teaching practices, where students reported that fast-paced instruction, limited opportunities for questioning and unengaging delivery methods reduced their interest. Unfortunately, teachers often face constraints imposed by syllabus requirements and limited time, which hinder personalised instruction. A third challenge relates to parental pressure, where students feel overwhelmed by high expectations to perform well in mathematics. The fourth involves negative peer influence, with some students disrupting lessons due to their own negative attitudes towards the subject. Lastly, assessment pressures combined with the abstract nature of the subject present further difficulties. This challenge stems from the fact that mathematics is characterised by complex concepts and numerous formulae, leaving students feeling overwhelmed during school-based assessments and examinations.

These challenges frequently result in mathematics anxiety; a condition marked by fear, tension and a lack of confidence (Maloney & Beilock, 2012). Such anxiety tends to be more prevalent among female students due to the persistent gender stereotype that mathematics is a male-dominated subject, particularly during secondary education (Wen & Dube, 2022).

Consequently, students lose confidence in their ability to learn and solve problems, which diminishes their perceived value of the subject.

These negative associations with learning mathematics often lead to demotivation, which in turn hinders students' behaviour, conceptual understanding and academic achievement (Barroso et al., 2021). Internationally, the overall performance in mathematics among secondary students remains a significant concern. In particular, PISA 2022 (Organisation for Economic Co-operation and Development, OECD, 2023) results show that:

- Mathematics performance declined significantly: between 2018 and 2022, OECD countries saw an average drop of 15 points in mathematics; equivalent to nearly one academic year of learning.
- Large shares of students perform below proficiency: around 30% of 15-year-olds scored below Level 2 in mathematics; the minimum proficiency level expected for meaningful participation in society.
- Socio-economic disparities persist: disadvantaged students are seven times more likely to be low performers compared with their advantaged peers, with circa 47% falling below Level 2 versus circa 14% of advantaged students.

In Malta, statistics released by the Matriculation and Secondary Education Certificate (MATSEC) Examinations Board of the University of Malta revealed that 22% of students failed the Secondary Education Certificate (SEC) mathematics examination in 2024, which is the mathematics examination that local students normally sit for at the end of their secondary education (MATSEC, 2024). In addition, the number of students pursuing mathematics or related subjects in further and higher education continues to decline, which could have a detrimental impact on the Maltese economy. In fact, according to the National Statistics Office (NSO) (2024), only 14.2% of graduates earned qualifications in science, technology, engineering, and mathematics (STEM).

These trends highlight the urgent need for innovative pedagogical strategies that can improve student engagement in mathematics. One such approach is the adaptation of recreational escape rooms (ERs) for educational purposes, commonly referred to as Educational Escape Rooms (EERs) (Nicholson, 2018).

EERs provide an alternative learning experience that contrasts with the traditional learning methodologies. This is because EERs combine curriculum-based problem-solving challenges within a game context, thereby fostering engagement and collaboration (Veldkamp et al., 2021). Therefore, they are well-suited to address the issues of disengagement and low motivation in mathematics discussed. Concurrently, EERs create an interactive, student-centred and meaningful learning experience.

1.2 Background of the study

EERs are adapted from recreational ERs, hence it is useful to examine the origins and features of ERs. This background provides the foundation for understanding how their design elements can be applied in educational contexts.

1.2.1 Origins of Escape Rooms

ERs are a global phenomenon that have seen a rapid increase in popularity over the last decade. According to Nicholson (2015), the first activity resembling this concept was developed by the publishing company SCRAP in July 2007 in Kyoto, Japan. It was called the 'Real Escape Game' and consisted of a one-room challenge for teams of five to six players. Thereafter, between 2012 and 2013, ERs began to appear across Asia, Europe, Australia, Canada and the United States of America. In North America, the first ER opened in 2013.

It is important to note that the development of ERs cannot be attributed to a single origin. Rather, the concept evolved from a combination of genres such as live-action role-playing, point-and-click adventure games, puzzle hunts, interactive theatre, and haunted houses. These diverse influences together inspired the creation of the ER experience.

Today, ERs are visited for a range of purposes, including entertainment during travel, family bonding, friendly competitions, and workplace team building. Some participants are also motivated by the challenge of beating the leaderboard for the fastest escape time.

1.2.2 Definition of Escape Rooms

Nicholson (2015) defines an ER as a "live-action team-based game" (p. 1) where participants work together to search for clues, solve puzzles and complete tasks within a room to achieve a goal by a set time frame.

The experience begins with a briefing delivered by the game master, who explains the rules and introduces the narrative; typically, through a short passage or video. The narrative is used to immerse the players in the game and generate excitement. Once the game begins, the team is locked in the room and the countdown starts. Players generally begin by searching the room for clues, which includes props such as numbers, symbols, or images, until they find a puzzle to solve.

Throughout the experience, players must solve a variety of puzzles and ERs can incorporate several different puzzles. Some examples are searching for physical objects, identifying patterns, using symbol substitution with a key, completing crosswords or word searches, and engaging in shape manipulation tasks such as matchstick puzzle. Solving these puzzles leads to the overall goal, which usually is to escape the room. Yet, some scenarios may involve alternative goals, for example, solving a murder mystery, breaking into a vault or defusing a bomb. Common themes of ERs include escaping from prison, exploring a haunted house or finding a missing person. Nevertheless, the game is still called an ER.

The game master monitors the session via a camera to ensure that rules are followed and to provide hints when necessary. Different hint systems are used, some are having to find an item in the room to exchange it for a hint, requesting help using a buzzer or knocking on the door, limiting hint requests, not allowing hint requests until a certain time has passed, or allowing only the gamemaster to give hints without requesting. In the latter case, the game master must judge carefully when to intervene, balancing the need to avoid player frustration whilst preserving the thrill of discovery. In addition, some hints may be given against a penalty of taking time away from the game or adding time to the final score.

The set time limit is generally of sixty minutes, but this may vary. The timer instils a sense of urgency encouraging teamwork and communication. Collaboration is critical for success, along with skills such as delegation, critical thinking, attention to detail and lateral problem-solving. Team size must be manageable, as large groups may lead to disorganisation. According to Nicholson (2015), team sizes commonly range from two to seven players. Moreover, diverse teams tend to be more successful because of having varied gender, skills, experience, knowledge and abilities.

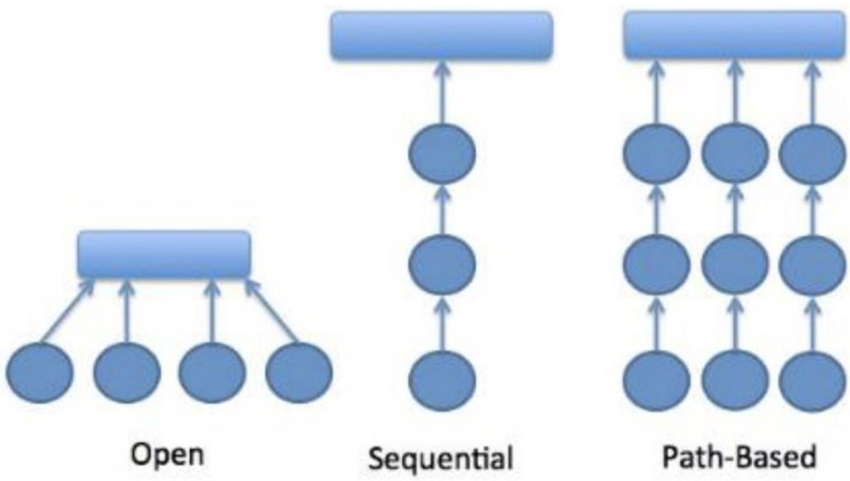
Once the goal is achieved, players engage in a debriefing session with the game master. This allows participants to reflect on the experience and provide valuable feedback to ER designers. Feedback is beneficial because creating ERs is a complex process involving careful creation of puzzles, balancing difficulty, finding materials that would not be easily destroyed, ensuring that enough time is allocated, and conducting playtests to ensure a smooth experience.

1.2.3 Structure of Escape Rooms

Nicholson (2015) explained that there are three main structures for organising puzzles in ERs, as shown in Figure 1 below.

Figure 1.1

Structures of ER Puzzles



Note. See Nicholson, 2015, p. 17.

The first structure is open which allows players to solve multiple puzzles in any order. All puzzles must be completed to reach the final objective. While this model promotes independence, it is rarely used because it limits the ability to scaffold tasks and can be confusing for players.

The second structure is a sequential, sometimes referred to as a linear structure. Players are presented with one puzzle at a time to solve to move to the next puzzle. This structure is widely used, especially in small rooms and promotes collaboration as all players must focus on the same task (Nicholson, 2015).

The third structure, also common in ERs, is path-based. It involves multiple linear paths. Once each path is completed, its solution contributes to the final meta-puzzle that unlocks the room. Nicholson (2015) explained that the advantage of this structure is that it allows players to work in sub-groups while still maintaining puzzle scaffolding and a clear progression, unlike the open structure.

1.2.4 Escape Rooms in Mathematics Education

ERs require team members to collaborate under time constraints to solve puzzles. Similarly, mathematics demands the use of logical reasoning and problem-solving skills to arrive at solutions. This alignment makes ERs particularly suitable for mathematics classrooms. In fact, Babazadeh and Frigerio (2021) found that using ERs in mathematics lessons enhanced students' problem-solving abilities, even among lower-performing students. Andrews and Bagdasar (2023) highlighted the value of ERs as a collaborative revision tool. Likewise, Saleh Alabdulaziz (2023) observed that ERs enhanced motivation, autonomy, and achievement in mathematics learning, counteracting students' negative attitudes towards the subject. These findings suggest that the use of ERs in educational contexts can make mathematics more engaging through puzzle-based challenges.

1.3 Aims of the Project

International literature (Veldkamp et al., 2022; Taraldsen et al., 2022) has examined the use of EERs in various contexts. However, research on their application in Maltese secondary mathematics classrooms remains limited, and most studies focus on evaluating their effectiveness rather than providing examples of EERs with guiding instructions and tasks.

The aim of this project is to design and develop an EER for Year 9 mathematics students, aligned with the national curriculum. The primary intention behind this EER is to enhance student engagement with the subject, overcoming the commonly held notion that the mathematics is boring (Brown et al., 2008). Therefore, through this project, students will learn in an active learning environment that fosters deeper engagement, motivation and critical thinking skills (see Sub-section (Ss.) 2.1.2).

Another key aim of this project is to help students develop collaboration skills within the framework of social constructivism (see Ss. 2.1.2), thereby enhancing their communication and teamwork abilities. Moreover, this EER project offers an alternative method of formative assessment (see Ss. 2.1.3), similar to Maths Trails, in which students follow a route and engage with mathematics through hands-on tasks in a different environment, such as measuring, estimating and calculating. The nature of EERs allows educators to observe students' reasoning processes, making it possible to identify misconceptions in real time.

1.4 Project Outcomes

The dissertation will be divided into two sections: the 'Project' and the 'Project Report'.

The project consists of the design and development of the EER kit, presented in the form of a teacher's resource booklet. The booklet includes an instructions manual for running the game, as well as all the required materials and resources. The booklet specifies the target student group, learning objectives, the teacher's role, ideal team size, play duration, and the puzzles. Each puzzle follows a loop of challenge, solution, and reward. The booklet also features a narrative that will fully immerse the students in the game, along with guidelines for hint provision and any penalties that may be imposed for hint usage. Moreover, similar to recreational ERs, the project includes details on a post-game debriefing to allow students to reflect on the educational objectives of the game.

The project report is the written part of the dissertation, and it includes four chapters. These are the introduction, literature review, research methodology and conclusion.

1.5 Chapters Overview

Chapter 1 introduces the study by discussing the importance of mathematics, the challenges students face in learning the subject, and information about the growing popularity of ERs as a recreational activity. Furthermore, it highlights the aim of the project and its outcomes.

Chapter 2 presents a review of the literature, focusing on the different learning theories, including behaviourism and constructivism. It also explores collaborative learning, gamification and game-based learning (GBL). Moreover, this Chapter outlines the aims of EERs, their pedagogical underpinnings, structure, benefits and challenges.

Chapter 3 describes the methodology used for the design and development of the project.

Chapter 4 concludes the project report by revisiting the aims of the project and reflecting on its challenges, limitations and possible improvements. The chapter also offers recommendations for further research, and presents a personal reflection on the overall experience of completing this project-based disseration.

CHAPTER 2

LITERATURE REVIEW

2.0 Outline

This chapter presents a review of existing literature. Section 2.2 outlines some of the different learning theories. Section 2.3 describes collaborative learning, while Section 2.4 distinguishes between game-based learning and gamification. Section 2.5 gives a definition for EERs and relates it to pedagogical foundations, describes the structure of EERs, and elaborates on their benefits and implications for implementation. Lastly, Section 2.6 concludes the chapter.

2.1 Learning Theories

Many educational psychologists have long been concerned with the way humans learn, as the process of learning is complex and constantly evolving due to various influencing factors (Ertmer & Newby, 2013).

Examining the definition of 'learning', literature shows that there is no single, universally accepted definition. Schunk (2012) defines learning as "an enduring change in behaviour, or in the capacity to behave in a given fashion, which results from practice or other forms of experience" (p. 3). In other words, learning occurs when knowledge is acquired through studying, teaching, instruction or experience (Clark, 2018). Therefore, learning is viewed as a dynamic process, shaped by the teacher's effort to help students learn in accordance with their interests and needs (Muhajirah, 2020).

The varying definitions of learning arise not from disagreements over the concept itself, but from differing interpretations made by educational psychologists (Ertmer & Newby, 2013). This has led to the development of diverse learning theories. Learning theories provide essential foundations for effective teaching, curriculum design, and support structures that enhance student achievement and holistic development in education (Giannoukos, 2024). These theories describe learning methods, the role of the teacher, the internal and external factors that influence learning, and how knowledge is transferred to the learner and/or constructed by the learner (Clark, 2018). Learning theories are normally grouped under two distinct and overarching umbrellas, namely behaviourism and constructivism, each offering distinct perspectives on how learning takes place (Burhanuddin et al., 2021).

Understanding different learning theories is vital for teachers to select the most effective strategies for teaching and learning, based on the characteristics of the learners and the learning context, including what is to be learned. However, there is no one-size-fits all approach; the best strategy depends on the task, learner needs, and context (Saunders & Wong, 2020; Muhajirah, 2020). Equipped with this knowledge, educators can then adjust their pedagogy to maximise the quality of students' learning with the aim of achieving more effective outcomes.

2.1.1 Behaviourism

Behaviourism was introduced as a psychological school of thought by John B. Watson Watson, an American psychologist, in 1913 (Muhajirah, 2020). It was later developed into a theory of learning through the contributions of Edward Thorndike (1905), Ivan Pavlov (1927), and B. F. Skinner (1938).

It emphasises observable behaviour and measurable outcomes (Pšunder & Ribič Hederih, 2010). Indeed, "learning begins when a cue or stimulus from the environment is presented, and the learner reacts to the stimulus with some type of response" (Clark, 2018, p. 174). For instance, when students are shown a foreign language word such as "gatto" alongside its English equivalent cat, they begin to associate the unfamiliar term with its meaning. In this case, the word "gatto" functions as the stimulus, while the student's recognition or articulation of cat constitutes the response. This stimulus-response relationship is central to the behaviourist understanding of learning.

This form of learning, referred to as conditioning, includes both classical and operant forms. Classical conditioning, introduced by Ivan Pavlov (1927), demonstrated how a repeated association of stimuli could condition responses, such as a dog salivating at the sound of the bell through repeated pairing with food. In contrast, operant conditioning, developed by B. F. Skinner (1938), focuses on reinforcing voluntary behaviour through rewards. Skinner's experiments showed that rats learned to press a lever to get food as a reward each time the action was repeated (Clark, 2018). Thus, desired behaviours can be encouraged through positive and negative reinforcement, while undesired ones may be discouraged through punishment.

In behaviourism, the teacher assumes a dominant role, actively transferring knowledge to students. The theory primarily addresses external factors that influence learning, such as environmental conditions, psychomotor reactions, and habit creation, while prioritising learning outcomes (Muhajirah, 2020). In the classroom, this approach can help create a structured environment that supports rote learning, memorisation and effective classroom management. For learners with limited prior knowledge, lower cognitive abilities, or heightened anxiety, behaviourist strategies may offer an effective method for achieving learning objectives (Pšunder & Ribič Hederih, 2010). Thus, behaviourism is particularly suitable for tasks that require factual recall, repetition, and behaviour management.

However, the behavioural learning theory is often criticised for its narrow focus on observable accomplishments and for overlooking the role of cognition in learning (Clark, 2018), which essentially refers to the mental processes involved in acquiring, understanding, and applying knowledge. Consequently, critics of the behaviourist approach to learning argue that its emphasis on external reinforcement can limit the development of critical-thinking and problem-solving skills. Additionally, because students are viewed as passive learners who only respond to external stimuli, intrinsic motivation may be undermined, potentially diminishing the quality and depth of their learning experience.

2.1.2 Constructivism

Given that behaviourism is more concerned with efficiency rather than effectiveness (Muhajirah, 2020), theorists started to question its effectiveness for learning with understanding and begun exploring alternative theories. One such theory is constructivism, which emphasises the learning process rather than solely the outcomes. It is "a theory that equates learning with creating meaning from experience" (Bednar et al., 1991 as cited in Ertmer & Newby, 2013, p. 55). Therefore, learners construct knowledge by linking new information to their prior experiences and beliefs. Learning occurs when there is what Piaget (1964) refers to as 'cognitive conflict', which requires learners to connect prior knowledge with new information and engage with the processes involved in learning. This aligns with Dewey's (1916) assertion that "teaching and learning is a continuous process of reconstruction of experience" (Vassallo Grant, 2023, p. 24). That is to say that from a constructivist perspective, learners actively construct knowledge through the interaction of their experiences and prior mental frameworks, rather than passively absorbing information. In so doing, constructivism places emphasis on learner-centred, meaning-making processes, and highlights the role of learner reflection in learning. This is because reflection allows learners to process and interpret their experiences, and to draw connections between new information and prior knowledge. These processes have the potential to lead to deep conceptual understandings.

Two important facets of constructivism are discovery learning and social constructivism (Clark, 2018). Discovery learning, identified by Bruner (1961), suggests that learners should be provided with resources and opportunities to construct knowledge rather than simply being given information. Vygotsky's (1978) social constructivism emphasises that learners build knowledge through social interactions with a "more knowledgeable other"; someone with greater expertise in the content. More specifically, from a social constructivist perspective, engaging students in groupwork is crucial because it aligns with the core belief that learning is a socially mediated process. In other words, according to Lev Vygotsky (1978), knowledge is also constructed through interaction with others, including other learners, and the surrounding culture. Vygotsky (1978) also introduced the concept of the Zone of Proximal Development (ZPD), which highlights that learners can only construct new knowledge with appropriate support, known as scaffolding. Scaffolded learning involves the teacher providing the student with hints, encouragement and breaking tasks into smaller, manageable parts (Psunder & Ribic Hederih, 2010). An essential element of constructivism is the importance attached to errors, as mistakes help students progress towards the correct understanding.

Despite the continued dominance of behaviourism (Psunder & Ribic Hederih, 2010), teachers must recognise that it is not the only learning theory. In constructivism, learners are active participants in the learning process, creating knowledge rather than simply acquiring it. This approach promotes motivation, autonomy and responsibility. Moreover, the teacher's role changes to that of a facilitator and mediator, providing guidance and building students' confidence to engage with others and develop skills for reflection and communication. Clark (2018) emphasises that constructivism also helps learners develop creativity and problem-solving skills. Consequently, this learning theory is particularly suited to high-level tasks, such as, "heuristic problem solving, personal selection and monitoring of cognitive strategies" (Ertmer & Newby, 2013, p. 61).

However, a challenge of constructivism is that if the teacher does not design tasks at an appropriate level for students, there is a risk of cognitive overload and disengagement. Additionally, some students may not actively participate in groupwork, and the approach may not be ideal for students with special needs (Psunder & Ribic Hederih, 2010). Teachers also would need to exert more effort when introducing constructivist approaches to learning, particularly if students are accustomed to behaviourist approaches.

2.1.3 Learning Theories and Learning Mathematics

Many teachers today use both behaviourist and constructivist approaches when teaching mathematics (Ampadu, 2023). As outlined in Section 2.2, the choice of approach depends on various factors. Nonetheless, literature highlights that behaviourism continues to dominate in most mathematics classrooms (Klinger, 2011; Kashefi et al., 2017; Ampadu, 2023).

Mathematics lessons taught through a behaviourist lens generally follow a set sequence. This involves the:

> … teacher demonstrating a method, process, routine or algorithm to be used in particular circumstances, followed by the class attempting to solve routine questions using the set procedure. (Orton, 2004, p. 29)

Therefore, skill-and-drill exercises are central to this approach, characterised by stimulus-response relationships where the focus is on the correct answer. For instance, if students are presented with an equation such as $x - 8 = 10$, they respond with the answer $x = 18$. Here, the equation serves as the stimulus, while the answer is the response. Instrumental understanding, which is characterised by students learning rules without reasons and without learner talk, is therefore fundamental in behaviourism (Moloto et al., n.d.) which introduces in class teacher-led methods that side-line student questioning and active participation in general (Ampadu, 2023). However, quite understandably, this learning style does little to address the challenges students encounter in learning mathematics, as mentioned in Section 1.1.

In contrast, constructivist approaches emphasise conceptual understanding, encouraging students to move flexibly between physical and abstract representations (Moloto et al., n.d.). Shoaf-Grubbs et al. (2004, p. 6) argue that “talking about mathematics helps to bring it to life and to build confidence in one’s abilities”. From this perspective, classroom dialogue becomes central, as learners construct knowledge through discourse, reflection, and collaboration.

Assessment in this approach is also aligned with constructivist principles and is typically formative, which is often referred to as Assessment for Learning (AfL).

Klenowski (2009) defined AfL as:

> … everyday practice by students, teachers and peers that seeks, reflects upon and responds to information from dialogue, demonstration and observation in ways to enhance ongoing learning. (p. 264)

Similarly, Black et al. (2003) stress that AfL is formative when classroom evidence is used to adapt teaching so that it better meets students' needs, placing the learner at the centre of decision-making.

Nevertheless, teaching mathematics through a constructivist approach is not without its challenges. It requires greater planning, more resources, and additional time, and not all students willingly participate in classroom discourse, often due to peer pressure (Kashefi et al., 2017; Klinger, 2011; Ampadu, 2023). Furthermore, while many teachers claim to employ constructivist methods, their classroom practices often remain rooted in behaviourism (Kashefi et al., 2017; Ampadu, 2023). Yet, behaviourism is not without value; it remains necessary in certain contexts, as some topics in mathematics are most effectively taught through direct instruction and practice (Orton, 2004).

2.2 Collaborative Learning

One way for teachers to adopt a social constructivist approach in their lessons is by creating a collaborative learning environment. This happens when "group members work in one team in order to contribute their comments, ideas and opinions about a particular topic" (Alzahrani & Woollard, 2013, p. 6), a process which would then allow them to "solve a problem, complete a task, or create a product" (Laal & Laal, 2012, p. 491).

Collaborative learning is often used interchangeably with cooperative learning. While Laal and Laal (2012) argue that cooperative learning is a subset of collaborative learning, Jacobs (2015) treats them as equivalent, stating that they both represent student-centred approaches where group work is central. Following Jacobs, both terms are treated as the same in this dissertation. Jacobs further emphasises that the focus should be on creating flexible opportunities that generate cognitive conflict for the construction of knowledge, regardless of the terminology.

According to Johnson and Johnson (2008), effective collaborative learning requires five key elements:

i. **Positive interdependence**: each group member's contribution is essential for success, fostering mutual responsibility.
ii. **Individual and group accountability**: members are collectively responsible for achieving the group's goals while being individually accountable for their roles.
iii. **Social skills**: effective group work requires trust, clear communication, and teamwork.
iv. **Face-to-face interaction**: group members actively cooperate in the team, sharing and refining their ideas through discussion.
v. **Group processing**: group members evaluate their progress and adapt their strategies to improve outcomes.

Johnson and Johnson (2014) warn that simply seating students together can result in competition or individual efforts unless all the above five elements are present. Put differently, the teacher is expected to guide and help students engage fruitfully in collaborative learning activities, which are central to a social constructivist approach to learning.

Collaborative learning fosters a deeper understanding of concepts through social interaction and critical discussion. It not only enhances cognitive skills, such as critical thinking and problem-solving, but also builds motivation and interpersonal skills. Thus, the learning experience becomes more engaging and meaningful.

2.3 Gamification and Game-Based Learning

Technology plays a crucial role in the lives of today's 21st-century learners. Consequently, traditional pedagogies may not always be the most effective method for teaching and learning (Liu et al., 2020). These learners, characterised by shorter attention spans, require engaging and stimulating approaches to perceive a subject as relevant (Doublet, 2021). This challenge is particularly pronounced in abstract and complex subjects like mathematics. As students progress, many lose interest in the subject due to the repetitive and monotonous mathematical classroom exercises (Kalloo & Mohan, 2010; Saleh Alabdulaziz, 2023).

In addition to maintaining student interest, there is a growing need to foster a deeper understanding of underlying concepts, moving beyond the prioritisation of summative assessments (Al-Azawi et al., 2016). To address this, 21st-century learners need to develop essential skills such as creativity, problem-solving, collaboration and cooperative interaction (Brezovszky et al., 2019; Chung & Chang, 2017). These skills are particularly vital in mathematics, where students must analyse, evaluate and apply abstract concepts. Therefore, there is a need for innovative and active methodologies that motivate and engage students. Moreover, such methodologies encourage students to take ownership of their learning by constructing knowledge through experience and collaboration with peers.

Two methodological approaches that address student motivation and engagement are gamification and GBL. These terms are often used interchangeably because both are based on game theory, have similar benefits and tend to be used together (Hartt et al., 2020, Tu et al., 2014). However, they have distinct definitions and applications.

Both gamification and GBL draw on the concept of a game, which Kapp (2012) defines as:

> … a system in which players engage in an abstract challenge, defined by rules, interactivity, and feedback, that results in a quantifiable outcome often eliciting an emotional reaction. (p. 23)

In educational contexts, games combine elements of fun and learning, making lessons more enjoyable and meaningful (Al-Azawi et al., 2016).

Gamification is the use of "game design elements, game mechanics and game thinking in non-game activities to motivate participants" (Al-Azawi et al.; 2016, p. 133). In other words, gamification incorporates game-like tools and elements, such as prizes, leaderboards, achievement badges, progress bars, levels, fixed rules and player effort (Figueroa-Flores, 2016; Al-Azawi et al., 2016), into lessons to meet learning objectives. For instance, in a mathematics lesson, gamification could be introduced by having a leaderboard for the fastest time to solve an equation. Becker (2021) also suggests that educators may apply this approach by embedding course material within a game-inspired narrative. For example, in a geometry unit, lessons could be framed as a detective story where students act as 'Geometry Detectives,' solving problems on angles, shapes, and area to unlock clues and progress through the story line. In this way, mathematical content is included within a game-like narrative, turning the unit into an engaging adventure while still meeting learning objectives.

In contrast, GBL is the "use of games in a learning context" (Becker, 2021, p. 3). Plass et al. (2015) argue that the game used in GBL may not necessarily be digital, but it could also be physical. In fact, teachers can create manipulative games that are aligned to the curriculum and learners' needs, allowing for deep exploration. Therefore, the learning content is embedded in the game itself. Antipolo (2021) explains that games like snakes and ladder, bingo and wheel of fortune can be adapted for GBL. For instance, snakes and ladder could include special tiles requiring players to solve a mathematical problem. If solved successfully, the player advances a number of tiles, progressing further than others.

In summary, GBL involves using game as part of the learning process, while gamification does not require the use of a specific game or electronic devices. Instead, gamification enhances existing tasks with game-like incentives.

2.3.1 Pedagogical Theories, Gamification and Game-Based Learning

Both gamification and GBL are grounded in constructivist principles, with their foundation in the theory of experiential learning (Joshi, 2024; Antipolo, 2021). Rather than absorbing information passively, students are encouraged to actively engage with the material, collaborate with peers, and construct knowledge through their experiences. Games provide interactive environments in which learners experiment, make decisions, and observe immediate consequences, enabling them to refine their understanding through trial and error. In addition, many educational games integrate problem-solving scenarios and collaborative elements that require learners to negotiate meaning with peers, test hypotheses, and build shared solutions. This aligns with Kolb's (1984) belief in learning by doing. Indeed, Kolb (1984) described experiential learning as a four-step process:

> … (1) engaging in individual experiences, (2) observing and reflecting, (3) forming knowledge and testing concepts in new situations, (4) applying and testing concepts. Kolb [2014] as cited in Uyen et al., 2022, p. 3

Experiential learning has been shown to improve students' attitude towards mathematics, mathematical creativity and achievement (Uyen et al., 2022; Venkatraman et al., 2019).

Gamification and GBL also improve students' motivation, which can be explained by the self-determination theory (Deci & Ryan, 1985). This theory suggests that three psychological needs must be satisfied for individuals to be motivated: autonomy, competence and relatedness. Motivation increases when participation in an activity promotes these needs (Kam & Umar, 2018).

i. Autonomy means that the student has a choice on how to solve a mathematical problem.
ii. Competence refers to challenging students at appropriate level to their learning ability.
iii. Relatedness refers to opportunities to work with peers and face mathematical challenges in a non-threating environment.

Likewise, flow theory (Csikszentmihalyi, 1990) explains the conditions for optimal learning in gamification and GBL. For learners to achieve deep engagement, the activity must reach a "state of consciousness called flow - a state of concentration so focused that it amounts to absolute absorption in an activity" (Csikszentmihalyi, 1990, p. 1). Games create flow because they provide clear goals and rules, offer immediate feedback on player actions, and allow difficulty levels to be adjusted to match learner ability. This ensures challenges remain neither too difficult nor too easy. In mathematics education, this may involve providing instant feedback when solving problems, clear scoring systems, and adaptive difficulty that responds to student performance. In this way, students can become deeply immersed in problem-solving processes, perceiving mathematics as both meaningful and enjoyable.

2.3.2 Benefits and Implications of Gamification and Game-Based Learning

Gamification and GBL have demonstrated significant advantages in education, including mathematics (López-Belmonte et al., 2019; Moreno-Guerrero et al., 2020). Firstly, these methodologies foster enjoyment, making the learning process more pleasant (Anastasiadis et al., 2018). Secondly, since students are placed at the centre of the learning process, there is greater engagement and motivation to learn (Al-Azawi et al., 2016; Fuentes-Cabrera et al., 2020), with motivation being both intrinsic and extrinsic (Hartt et al., 2020). Thirdly, students are more focused and willing to participate (Figueroa-Flores, 2016) due to the game structure within a learning environment. Thus, students feel less pressure in these contexts and are not afraid to make mistakes (Espinosa, 2016), fostering a supportive learning environment.

Additional benefits of such active methodologies include enhanced collaboration and interaction with peers (Fuentes-Cabrera et al., 2020; Saleh Alabdulaziz, 2023), the promotion of healthy competition and creativity (Figueroa-Flores, 2016), and improved academic performance (Yildirim, 2017). In addition, students receive immediate feedback from the game (Antipolo, 2021). Consequently, students develop a more positive attitude towards learning and educators may observe favourable behavioural changes. For instance, in a study conducted by Liu et al. (2020) on the creation of a gaming environment incorporating elements of both gamification and GBL, students were more involved, interested and motivated to learn. Similarly, Hartt et al. (2020) found that students preferred gamified lectures over traditional ones due to increased engagement.

Nonetheless, implementing these innovative pedagogies presents challenges and requires careful planning (Figueroa-Flores, 2016). If poorly executed, gamified or game-based approaches risk becoming a distraction that offers little educational value. Teachers, therefore, need to understand students' preferences and the learning objectives before deciding whether to adopt these methodologies. This is because teaching approaches must align with learning goals (Tu et al., 2014). As highlighted by Hartt et al. (2020), there are instances where direct instruction may be more effective than gamification or GBL, depending on the content and context. When deemed appropriate, teachers must ensure that the game elements or game play align with the learning objectives, to maintain the intrinsic motivation emphasised in self-determination theory, that challenges are appropriately scaffolded in line with Vygotsky's ZPD (1978), and that the balance between difficulty and skill supports the flow state described by Csikszentmihalyi (1990). In addition, teachers must ensure that adequate resources are available, that various strategies are employed for greater autonomy and that an element of feedback is included (Tu et al., 2014). Furthermore, teachers need to keep abreast of technological advancements to effectively implement these methodologies (Saleh Alabdulaziz, 2023).

2.4 Educational Escape Rooms

Ss. 2.4.1 introduces and defines EERs. Ss. 2.4.2 describes the learning theories that relate to EERs. Ss. 2.4.3 focuses on the structure and design of EERs. Ss. 2.4.4 gives the advantages of

EERs while Ss. 2.4.5 describes the challenges and implications associated with the implementation of EERs. Ss. 2.4.6 summaries this section on EERs.

2.4.1 Introduction and Definition

In recent years, the popularity of ERs has inspired educators to explore their potential for teaching and learning. As Veldkamp et al. (2020) observed EERs “started bottom-up with enthusiastic teachers” (p. 1) where these were initially put into practice and consequently, EERs became the focus of theoretical research due their educational value (Nicholson, 2018).

Lamas (2018) defines EERs as a;

> … creative learning environment that can be designed for any educational level and uses the design features of escape rooms to which specific educational elements and purposes must be incorporated. (p. 9)

Therefore, while EERs resemble recreational ERs in structure and design, they have an educational context. In Piñero Charlo’s (2020) study, educators further explained that EERs require “the mobilisation of curricular knowledge” (p. 1) such that students apply what they learn. Taraldsen et al. (2022) argue that EERs can be used as a didactic tool in primary and secondary education, and in teacher education. In fact, EERs have also gained popularity from primary to higher education, as well as in professional development programmes (Sanchez & Plumettaz-Sieber, 2018). Moreover, Piñero Charlo (2020) noted that several studies reported successful use of EERs across various fields such as nursing, pharmacy, psychology, and STEM courses.

2.4.2 Pedagogical Foundations

EERs derive their educational strength from their alignment with various learning theories (Vorderobermeier et al., 2024). Firstly, EERs incorporate elements of behaviourism; students are positively reinforced when they progress in the game, while negative reinforcement limits students’ ability to escape (Zhang et al., 2018). Secondly, EERs align with social constructivism as students actively engage in the team to construct their own knowledge (Ouriachi & Wim, 2020). Thus, knowledge is acquired through the experience of the EER, which also includes scaffolded learning through hints. Thirdly, EERs naturally support collaborative learning (Lopez-Pernas, 2023). Students must interact meaningfully with their teammates to solve challenges, and positive social interdependence may be promoted through small team sizes (Veldkamp et al., 2020).

There is also an ongoing debate about whether EERs are a form of GBL or gamification. Moura and Santos (2019) note that while some researchers view EERs as GBL, others argue that they represent a form of gamification. On one hand, EERs can be considered as GBL because the recreational ER is adapted to an educational context, allowing students to acquire and apply knowledge and improve their skills through the feedback given from the game. Thus, the game itself is the medium for learning. On the other hand, EERs may be seen as gamification due to their incorporation of game-like elements, such as time limits, rewards and competition in a non-game setting to enhance motivation and engagement.

2.4.3 Structure and Design of Educational Escape Rooms

Similar to an ER, EERs typically involve students grouped into teams, working under time constraints to solve puzzles, unlock clues and achieve the objective of the game, escaping the room or solving a mystery (Lopez-Pernas, 2023). Therefore, EERs generally include a narrative to immerse students into the storyline (Andrews & Bagdasar, 2023). In EERs, the teacher takes the role of game master. Nicholson (2015) compares an effective gamemaster to an effective teacher; knowing when to provide hints and when to allow students to persevere independently. Timely support is critical since offering guidance too early may diminish the satisfaction of discovery.

Unlike traditional ERs, EERs are normally conducted in classrooms. Teachers need to set up and clear the game environment within limited lesson time. Moreover, the number of participants playing at the same time is greater than ERs (Veldkamp et al., 2020). Teachers need to adapt the activity to accommodate an entire class rather than a small group. Additionally, EERs are designed for specific learners with clear learning goals in relation to curriculum content, while ERs are primarily for entertainment.

Furthermore, the structure of EERs mirrors that of ERs, which can be linear, path-based or open. It is vital that teachers choose a structure consistent with the learning intentions of the game, as this choice influences perceptions of collaboration and critical thinking. For instance, a linear path tends to promote collaboration skills (Hamilton et al., 2021). Andrews and

Bagdasar (2023) remarked that open structures are rarely used in EERs due to their complexity; hence, requiring considerable guidance from teachers.

Table 2.1 below summarises the main differences between ERs and EERs:

Table 2.1

Recreational vs Educational ERs

Feature/Aspect	ER	EER
Purpose	Entertainment and fun	Learning and skill development
Setting	ER venues	Classroom or educational environment
Participants	Small groups	Whole class or small student groups
Objective	Escaping the room	Clearly defined curriculum aligned
Role of Facilitator	Game master	Teacher as facilitator and game master
Structure	Linear, path-based or open	Linear, path-based or open

2.4.4 Benefits of Educational Escape Rooms

The growing use of EERs is driven by the various advantages associated with their use, which can be broadly categorised into affective, cognitive and curricular benefits.

Affective Benefits

EERs increase student engagement, motivation and autonomy (Veldkamp et al., 2021; Fuentes-Cabrera et al., 2020). The game setting creates a safe environment in which students feel less pressure, are more willing to make mistakes and actively participate. In mathematics education, Saleh Alabdulaziz (2023) found that EERs helped students manage learning anxiety, while improving their achievement, motivation and autonomy. Motivation also improves with the fact that EERs offer a "change in school routine for something more fun" (Moura & Santos, 2019, p. 191) which creates a sense of excitement and curiosity. The time limit often encourages students to remain focused and support their team, promoting shared responsibility.

Cognitive Benefits

By design, EERs promote the development of 21st century skills, such as critical thinking, creativity, active listening, problem-solving, teamwork and communication (Taraldsen et al., 2022; Babazadeh & Frigerio, 2021). This is because the design of the game requires students to work in teams, meaning that learners engage in peer-to-peer discussions and collective decision-making to achieve the learning goal. Nicholson (2018) highlights that this dynamic reinforces the idea of winning or losing as a team.

EERs also map directly onto mathematical thinking. For example, solving a set of linked puzzles to unlock a box mirrors algebraic reasoning tasks that require sequential logic. Geometry-focused puzzles that involve spatial manipulation or measurement calculations allow students to apply and extend their understanding of shape and space. Timed estimation challenges reinforce number sense and fluency under pressure.

In addition, students need to think more thoroughly than a regular lesson (Veldkamp et al., 2020) and need to communicate, which contributes to improvements in verbal competences (Moura & Santos, 2019). In mathematics, students must often engage in multi-step reasoning and abstraction, processes that are mirrored in the scaffolded challenge progression of EERs. These environments encourage persistence with complex problem-solving, a key component of mathematical thinking. Therefore, teamwork and communication play an important role to finish the game in time.

Curricular Benefits

EERs can cater for different learning styles whether audio, visual or kinaesthetic (Andrews & Bagdasar, 2023) and can be applied to any curriculum content (Moura & Santos, 2019). This is due to the fact that EERs are developed by teachers and can be tailored to meet specific learning objectives. Lopez-Pernas (2023) remarked that EERs positively impacted learning across various subjects and educational levels, regardless of team size or technology used. Even low-performing students have shown increased interest, engagement and improved problem-solving skills when EERs are used in mathematics (Babazadeh & Frigerio, 2021).

Beyond curriculum alignment, EERs also enhance learning authenticity by placing students in real-life scenarios (Taraldsen et al.). They are generally used to apply and assess acquired knowledge and skills in a different context (Piñero Charlo, 2020) rather than to introduce new content. In this way, educators can identify misconceptions in real-time and adjust future learning accordingly (Andrews & Bagdasar, 2023).

2.4.5 Challenges and Implementation Considerations

Despite their many benefits, EERs are complex to design and implement. Andrews and Bagdasar (2023) highlight the significant time and resources required to ensure a successful learning experience. As such, educators expect a high return on investment given the planning complexities to design, create, conduct and evaluate (Lopez-Pernas, 2023).

To ensure effectiveness, Moura and Santos (2019) emphasise the importance of the teacher keeping in mind the learners' pedagogical requirements, that is their characteristics, learning needs, and the intended learning objectives. This implies that puzzles need to be designed in line with the curriculum, to avoid the risk of the fun element outweighing the learning outcome. This balance is considered one of the biggest challenges for educators.

Moreover, Lopez-Pernas (2023) suggests that the puzzles designed for EERs should strike a balance; not so easy that they become boring and not so hard that they cause frustration, learning anxiety and quitting the game. This balance is a core condition for the "flow" described by by Csikszentmihalyi (1990). Elumir (2018) recommends puzzles to be fair, unambiguous, have one single solution and hints that make sense. In this way, with team collaboration students can finish the game.

The teacher's role is also crucial. Teachers need to introduce the game, explain the rules, monitor progress and provide hints when necessary. Veldkamp et al. (2020) stress that giving hints either too early or too late can lead to frustration. Teachers also need to make decisions regarding group size, group composition and timing (Taraldsen et al., 2022). Groups of three to six students reduce the likelihood of free riders, ensuring that all members participate. Heterogeneous groups, composed of students with varied skills, promotes collaboration (Vorderobermeier et al., 2024). Timing is also an essential factor, where teachers need to ensure that students have enough time to discuss, make mistakes and solve each task; dynamism criterion (Piñero Charlo, 2020). Although time limits increase pressure and resilience, Hermanns et al. (2017) found that students felt frustrated for having insufficient time to complete the activity, which in turn diminished the learning experience.

Furthermore, the time constraint within EERs often limits the opportunity for educators to provide direct feedback or to take advantage of a learning opportunity. Instead, immediate and unambiguous feedback is given through in-game mechanisms such as hints and the opening of locks. However, a vital phase of the EERs is the debriefing session (Taraldsen et al., 2022). This is because EERs do not finish when the final code is obtained (Piñero Charlo, 2020). Instead, students need to engage in a reflective discussion to consider what they learned from the game, how they approached and solved the puzzles, and to offer feedback to the teacher. Nicholson and Cable (2020) suggest that this reflection phase should take up approximately one-third of the total lesson duration.

2.4.6 Summary of Educational Escape Rooms

EERs create environments that are both motivating and engaging for students by combining the engaging elements of ERs with particular learning objectives. Grounded in theories such as behaviourism, constructivism, collaborative learning, and flow, EERs support both cognitive and affective development. In mathematics, they can enhance problem-solving, spatial reasoning, and number sense.

Effective implementation of EERs rely on careful puzzle design, well-managed group dynamics, appropriate timing, and balancing fun with learning. A structured debriefing phase is essential for consolidating knowledge and encouraging reflection.

Overall, EERs are more than an innovative classroom activity; when thoughtfully designed, they offer a versatile approach that can improve both student learning and attitudes towards mathematics.

2.5 Conclusion

This chapter reviewed literature relating to learning theories, collaboration, and gamification and GBL. It also reviewed EERs, including its definition, relation to learning theories, structure, advantages and challenges for implementation. The following chapter explains the research methodology of the study.

CHAPTER 3

RESEARCH METHODOLOGY

3.0 Outline

This chapter outlines the methodology adopted for the research project. Section 3.1 presents the rationale for choosing a project-based dissertation, Section 3.2 discusses the ethical considerations, and Section 3.3 outlines the process followed in project-based research. Section 3.4 explains the design of the project, while Section 3.5 details its development.

3.1 Rationale for Project-Based Dissertation

The decision to opt for a project-based dissertation stemmed from my desire to conduct research that was both meaningful and relevant to my profession as a teacher. I aimed to design a project that could serve as a formative assessment tool and provide meaningful feedback on students' learning in the classroom. This was important to me because it allowed me to explore new ways of engaging students in mathematics while also offering an opportunity to reflect on and refine my own teaching and learning approaches, ultimately supporting my growth as an educator.

For this reason, a project-based approach was deemed most appropriate as it allows the researcher to design and develop a project that can actually be implemented within a classroom setting. In this case, the project is an educational product, such as a textbook, resource pack, or game that directly supports teaching and learning. According to Bušljeta (2013), educational resources are intended to

> assist the teacher with the presentation and transmission of educational content and the achievement of educational objectives, whilst aiding the students in acquiring knowledge and profiling different abilities and values. (p. 57).

McKenny and Reeves (2012) further emphasise that a clear rationale for the creation and development of such a project must exist. This is because the outcomes of the research are directly applicable to real educational contexts. The rationale for this particular project was discussed in Section 1.1, and the educational resource designed and developed through this research is the EER, presented in the form of a teacher's resource booklet (see Appendix B).

My inspiration also came from the increasing popularity of Mathematics Trails being implemented in local schools; an assessment approach that was completely new to me when

I entered the teaching profession. I aimed to create something equally innovative and engaging, yet distinct and which could be implemented within the classroom setting. At the same time, the resource was intended to enhance student motivation and engagement in learning mathematics.

Overall, a project-based approach offered an opportunity to bridge theory and practice by designing a tangible educational resource that directly supports the teaching and learning of secondary mathematics.

3.2 Ethical Considerations

The project did not involve the collection of primary data from human participants. Consequently, it was enough to complete the online ethics declaration form, which I later submitted to the Faculty Research Ethics Committee (FREC) for record-keeping purposes. See Appendix A for the email that I received confirming ethical clearance to proceed with my project-based research.

Although no participants were involved, other ethical considerations guided the design and development of the project. I ensured that the tasks included in the game were fair and pedagogically aligned with the students' curriculum so as to support, rather than hinder, student learning. Care was also taken to design a narrative that was suitable for the students' level and gender neutral, avoiding content that could disadvantage or exclude learners.

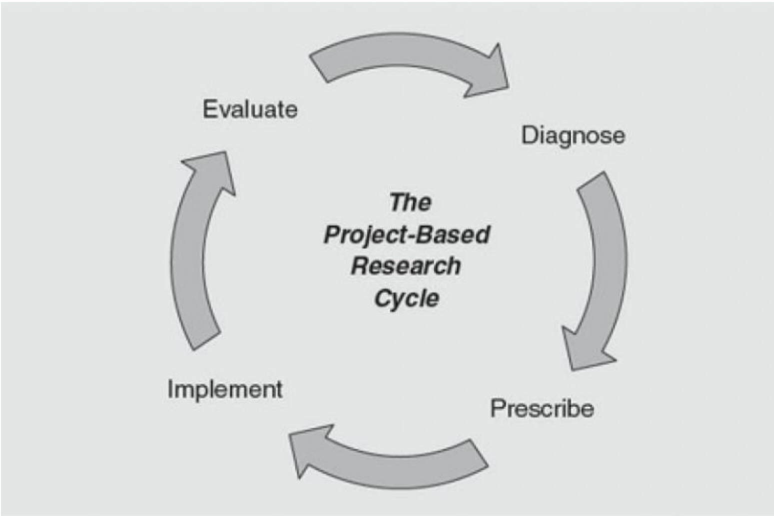
Financial accessibility was another key consideration; hence, I ensured that the resource would not be financially burdensome. The materials chosen were reasonably priced such that any school wishing to implement the project could do so. Lastly, the design process adhered to the principles of academic integrity. All external sources, such as online tools to generate puzzles and theoretical frameworks that helped with the design of the project, were properly referenced.

3.3 Overview of the Project-Based Research Process

Stoecker (2013) outlines a cycle for project-based research consisting of four stages: diagnosing, prescribing, implementing and evaluating, as shown in Figure 3.1 overleaf.

Figure 3.1

The Project-Based Research Cycle



Note. *See Stoecker, 2013, p. 20.*

Diagnosing involves identifying a problem or issue, while prescribing entails developing a plan to address that problem. In this research, the problem was identified in the rationale for the study (see Section 1.1), and the plan to address it involved the creation of an educational resource; the EER. Implementation refers to the actual project or action designed to overcome the issue, and evaluation assesses whether the project effectively addresses the problem.

Stoecker (2013) notes that prescribing is often the most challenging stage due to the complexities involved in project design, whereas evaluation can be the problematic because it is sometimes confused with diagnosis. Examples of project-based research provided by Stoecker include theatre projects and art-based projects.

McKenney and Reeves (2012), who explore Educational Design Research (EDR) as a means of bringing about change, describe a similar sequence specific to educational contexts. Their model includes analysis and exploration, design and construction, evaluation and reflection, and implementation and spread. In the analysis and exploration phase, the problem is identified through literature review, investigations and contextual observations. Subsequently, ideas are generated through brainstorming sessions so that the researcher can design and construct an initial solution. The solution is then evaluated for its effectiveness in addressing the issue, followed by reflection to identify areas for improvement before implementation.

While McKenney and Reeves' model positions evaluation before implementation, both frameworks emphasise the importance of reflection and improvement. However, in the case of project-based dissertations within pedagogical research at the University of Malta, the implementation and evaluation stages are not required. Therefore, this research focuses solely on the design and creation of the project.

3.4 Design of the Project

Apart from reviewing literature to analyse what EERs consist of, several online platforms were explored, including, Twinkl, Teachers Pay Teachers, TES Global and Breakout EDU. Although many EERs found online were designed for primary level students, this exploration provided valuable examples of narratives, riddles, lock mechanisms, resources, and other creative ideas. Moreover, it contributed to a deeper understanding of how EERs are structured. This preliminary research indicated that designing an effective EER requires careful consideration of several key factors, which are discussed in the following sections.

3.4.1 Year Group Selection

The EER was designed to target Year 9 students. This particular year group was chosen because it represents a critical stage in students' mathematical development. At this stage, many students begin to lose interest or confidence in the subject (Vella, 2011 and Yasar, 2016), yet it is also a period when they start preparing for the SEC examinations. This is because 10% of the school-based assessment in Year 9 contributes to the final SEC level, making it an important foundation for their overall achievement.

This year group was also chosen because many topics in the Year 9 syllabus are completely new to students. Consequently, the Year 9 Mathematics syllabus was used as the basis for designing the EER. This syllabus, grounded in the curriculum principles outlined in the NCF, aligns with the Learning Outcomes Framework. This framework specifies the essential knowledge, skills, and competencies that learners are expected to develop by the end of their compulsory education.

Locally, the Mathematics SEC syllabus is structured into three levels; Level 3 – 3*, Level 2 – 3, Level 1 – 2, with each level reflecting different levels of proficiency and expected learning outcomes (Learning Outcomes Framework, 2024). An alternative programme is offered to those students who will not achieve a SEC qualification level; in some schools, this is referred to as the Core Curriculum Programme (CCP). This programme is designed to help students apply basic competencies of mathematics in everyday contexts.

In mixed-ability classrooms, teachers typically follow the Level 3 – 3* syllabus, as it represents the maximum mathematical content students encounter at that stage. For this reason, the EER was designed according to the Year 9 Level 3 – 3* syllabus because it includes the widest range of topics and ensures that the resource is suitably challenging and inclusive.

3.4.2 Topics Selection

The Year 9 Level 3 – 3* syllabus was first reviewed to identify topics taught at this level and to determine which would be most suitable for inclusion in the game. Following a detailed examination, specific topics were selected as summarised in Table 3.1 below and primarily cover percentages, simultaneous equations, bearings, Pythagoras' theorem and trigonometry.

Table 3.1

Year 9 Track 3 Topics Chosen for EER

Strand	Subject Focus	Reference to SEC	Learning Outcome
2	Number – Numerical calculations	2.2ap	I can work through simple situations involving percentage increase and decrease (<100%) (e.g. finding the discount, profit, loss and selling price, excluding reverse percentage calculation)
		2.3ay	I can work through complex situations involving personal and household finance. (E.g. earnings, simple interest and VAT.)
3	Algebra – Fundamentals of Algebra	3.3aa	I can solve algebraically two simultaneous linear equations.
4	Shape, Space & Measures – Measures	5.3b/c/d	I can draw, interpret and use three-figure bearings.
		5.3u	I can use the trigonometric ratios to find unknown lengths and angles in right-angled triangles.

5	Shape Space and Measures – Euclidean Geometry	5.3mn	I can interpret and use Pythagoras' Theorem in 2D shapes.
		5.3prs	I can interpret and use the converse of Pythagoras' Theorem in 2D shapes. I can deduce that a triangle whose sides are in the ratio of 3:4:5 or in the ratio of 5:12:13 is a right-angled triangle.

Note. See Learning Outcomes Framework, 2024.

The selection was guided by some key considerations. Firstly, these topics are mainly new to students at this stage, as many of them such as bearings, simultaneous equations and trigonometry, are introduced for the first time in Year 9. This makes them suitable for assessing both conceptual understanding and procedural application. Secondly, they were chosen because they frequently appear in problem-solving situations, meaning that students must understand them well to apply them effectively. Lastly, personal preference also influenced the choice of topics as I aimed to select areas that I enjoy teaching and that can be used to create engaging GBL experiences.

In addition, including a variety of topics allowed for the assessment of a broader range of learning outcomes within a single game. However, the design of an EER could easily be adapted to focus on fewer topics explored in greater depth or with increasing complexity, depending on the learning objectives and available time.

3.4.3 Duration of the Game and Number of Tasks

The game was designed to take place during a double lesson, with a total duration of approximately 80 minutes. This decision was based on comparisons with recreational ERs, which typically last around 60 minutes. A standard 40-minute lesson was deemed insufficient as the game is divided into three distinct phases: introduction, gameplay, and debriefing, as shown in Table 3.2 overleaf.

Table 3.2

Phases and Duration of the EER

Phase	Time
Introduction	10 minutes
Gameplay	55 minutes
Debriefing	15 minutes
	80 minutes

The introduction phase, lasting approximately 10 minutes, involves the game master who is the teacher, dividing students into groups of four or five, introducing the narrative, and explaining the rules. The gameplay phase is timed at 55 minutes, during which students work collaboratively to solve all the tasks. If time elapses before they complete the final challenge, they must stop, similar to what happens during a recreational ER. The session concludes with a 15-minute debriefing period, during which students reflect on their experience and share feedback both with their peers and with the teacher. This allows the teacher to identify any mathematical misconceptions, gather insights on the effectiveness of the tasks, and determine areas where the teaching and learning process may be improved.

Since the EER was designed for classroom use, both setup time and available resources were naturally more limited than in recreational ERs. Nonetheless, the aim was to maintain a comparable level of engagement and immersion. For this reason, the game incorporated a set of nested boxes with locks that students must open sequentially to complete the activity. With 55 minutes allocated for gameplay, five tasks of approximately 10 to 15 minutes each were developed to retain a sense of urgency and excitement. Consequently, the puzzles were designed to focus on application and reasoning rather than lengthy or overly complex calculations, ensuring that they were achievable with the given timeframe.

3.4.4 Structure of the Educational Escape Room

The EER follows a sequential structure, requiring teams to solve one puzzle before progressing to the next. This structure was intentionally chosen to promote collaboration and teamwork because it requires all members to contribute towards a shared goal rather than working individually on separate tasks. The latter is what may happen in open-structure designs. Within each task, students can still divide responsibilities and use their individual skills to work efficiently, but they must ultimately come together to solve the puzzle and advance in the game. In some instances, team members can also check each other's work before agreeing on the final solution to open a lock.

Each task is also designed to be independent of the others. This allows students to start afresh with each new puzzle, maintaining motivation and engagement throughout the game. Furthermore, this structure provides flexibility for teachers, as specific puzzles can be removed or reordered depending on available time and topics covered in class. Teachers may also design their own puzzles to further tailor the EER to their students' needs.

3.5 Development of the Project

Having determined the year group, topics, duration, and structure, the next stage was to begin developing the project. Ss. 3.5.1 explains the choice of the narrative, while Ss. 3.5.2 outlines the creation of the teacher's resource booklet. Finally, Ss. 3.5.3 describes the development of the physical materials used in the game.

3.5.1 Choice of Narrative

For students to be fully immersed in the game, the EER was designed around a strong narrative. The choice of storyline considered both the age of the students and the need for a gender-neutral theme so that the game could be implemented in any school setting. Year 9 students are generally aged between thirteen and fourteen years; hence, the story needed to be engaging enough to capture and maintain their attention.

For this reason, students were assigned the role of detectives on a special mission, giving them a sense of importance and purpose similar to that found in detective or mystery films. The game was set in Valletta, Malta's capital city, which was chosen for its historical significance, particularly its association with wartime shelters and the legacy of Grandmaster Jean de La Valette, as well as for its cultural familiarity to students. Furthermore, an element of mystery was maintained throughout the storyline, with each task containing a short continuation of the overarching narrative. This structure helps to maintain students' motivation and curiosity as they progress through the game.

To make the introduction more engaging, a PowerPoint presentation was created using Microsoft PowerPoint. Teachers may use this presentation instead of reading the story aloud themselves, and it can be accessed directly through the teacher's booklet. The presentation includes not only audio recordings of the narrative but also the game instructions, both generated using artificial intelligence (AI) through the online platform Evernote. Subtitles were added to support students who prefer reading to listening. Additionally, AI-generated images were created with ChatGPT (OpenAI, 2025), and these were incorporated into the presentation to visually represent key scenes and enhance the immersive experience. The prompts used to generate the images were carefully aligned with the storyline to ensure consistency between the visuals and the narrative.

The narrative in the end served as a solid foundation for the entire project, as it established the visual presentation and the structure of the teacher's resource booklet.

3.5.2 Teacher's Resource Booklet

The final product of the EER project is presented in the form of a teacher's resource booklet (see Appendix B). This booklet acts as an instructional manual that allows any teacher to implement the EER effectively in their classroom. It provides comprehensive guidance on every aspect of the game, including the duration of each phase, required materials, introduction procedures, gameplay tasks, suggested hints and debriefing. The booklet also highlights that the EER was designed in such a way that teachers can replace puzzles and customise the game, while still maintaining compatibility with the physical artefact, to meet the needs of their students.

The first few pages of the booklet outline the purpose of the resource and include a brief foreword describing the overall procedure of the EER. One specific detail is that the teacher acts as the game master to supervise the game. The booklet also provides a flowchart to give teachers a visual overview of the game's structure and a materials checklist before delving into the detailed sections.

The introduction phase, which should last approximately 10 minutes, guides the teacher on how to divide students into groups, explains the different learning approach for the lesson, and includes details on both the narrative and the game instructions. The narrative was previously discussed in Ss. 3.5.1, which also includes reference to the instructions since these are delivered through AI-generated audio.

The gameplay phase, which is timed and cannot take more than 55 minutes, is presented in the Tasks section of the booklet. Each task includes the student task card, estimated completion time, targeted learning objectives quoted from the Year 9 Level 3-3* syllabus, preparation steps and required materials, detailed solutions and photos of the task components and set-up. The sequence of topics was deliberately designed to mix levels of difficulty, as shown in Table 3.3 below.

Table 3.3

Sequence of Topics

Task Number	Topic
1	Percentages with VAT
2	Pythagoras' Theorem
3	Bearings
4	Trigonometry
5	Simultaneous Equations

Tasks 1, 3 and 5 are slightly more demanding conceptually, while Tasks 2 and 4 are more procedural. For instance, Task 2 was allocated the longest time (15-18 minutes); however, if groups work efficiently, it can be completed in less time. Task 3, on the other hand, is the most time-intensive because students must first assemble a puzzle and then decode the problem before solving the bearings questions and breaking the code to the lock.

Following the task section, the booklet includes guidelines for providing hints during gameplay. While teachers may adapt this aspect according to their class, the system adopted for this project was that each group has two free hint cards which can be used at any time during the game. Additional hints incur a three-minute penalty added to the team's final score time. The game master may also provide free hints to groups who are struggling significantly. In addition, this section includes a non-exhaustive list of possible hints for each task. However, these may be adapted to suit student needs.

Consequently, the final phase of the game is the debriefing session, designed to last no more than 15 minutes. The section provides guiding questions to encourage student reflection and class discussion about the learning experience. It also contains a scoring sheet that teachers can use to record feedback and a feedback slip for students.

At the end of the booklet, a quick teacher reference is provided. This condensed guide summarises the timing of each phase, the lock combinations and the debriefing prompts, allowing teachers to quickly refer to essential information during the game.

In terms of presentation, the booklet uses the font Calibri throughout, except for the student task materials. The latter are written in Times New Roman to complement the historical theme of the game, as its traditional serif style reflects the classical aesthetic associated with the narrative. The font size for teacher content is 12-point, while the font for student materials ranges from 13-point upward, depending on the layout and available space. The booklet is designed with a white background, but research by Rello and Bigham (2017) suggests that coloured backgrounds, particularly yellow, can enhance readability for all learners and especially those with dyslexia. Therefore, the booklet may be printed on yellow paper so that all items feature a yellow background to support accessibility and inclusivity.

Apart from opening locks, each task incorporated a creative resource to ensure that students would not simply be solving mathematical problems in isolation. Therefore, the inclusion of tangible materials makes the experience more engaging and immersive. Task 1 included text written with invisible ink, requiring students to use a torch with blue light to reveal the hidden message. Task 2 featured a crossword generated through the online platform Education.com, while Task 3 involved a decipher poster printed as a 4 x 5 portrait jigsaw puzzle, created using the website cuttle.xyz. Task 4 used a Guess Who? board game, and Task 5 incorporated a compass wheel designed in Microsoft Word. Furthermore, a magnifying glass is also provided at the start of the game together with the other required materials, to serve as a red herring. Some tasks also required students to deduce lock combinations after solving the mathematical challenges, such as forming a five-letter word. These elements enhance creativity and engagement.

3.5.3 Development of the Physical Educational Escape Room Kit

As outlined in Ss. 3.5.2, the teacher's resource booklet includes photos of the physical materials required for the game. These visuals serve as a clear reference for teachers, helping them understand what is needed to prepare and organise the EER in the classroom. To successfully implement the game, teachers must assemble the necessary physical components described in the booklet.

Figure 3.2

Physical EER Box, Task 1 Folder and Items to be Hidden in the Classroom

Figure 3.2 above shows some of the EER items, including materials that would be hidden around the classroom, the folder placed on each group's workstation, and the locked box containing the remaining tasks and locked nesting boxes. The decision to design a physical EER rather than a digital version was made to enhance the immersive and interactive nature of the experience. Handling real objects, such as boxes, locks, and clues, was considered essential for engaging students more deeply and encouraging collaboration and problem-solving.

However, choosing a physical EER also involved certain costs and logistical considerations. It is recommended that one complete set of four nesting boxes be prepared for the whole classroom, with each box containing folders labelled according to group colour as shown in Figure 3.3 below.

Figure 3.3

One Set of Nesting Boxes and Corresponding Task Folders

This approach balances authenticity with cost-effectiveness. This is because the total expense for preparing a single set of nesting boxes and locks amounted to approximately €100. Furthermore, letter locks were purchased online since they were not available locally. In contrast, other group materials, such as magnifying glasses, torches, and jigsaw puzzles, were more affordable and could be purchased for each group. Figure 3.4 overleaf illustrates what each folder should contain, and which materials are required for each group.

Figure 3.4

Materials required for Each Task

A limitation of having only one set of nesting boxes is that the game master would need to continually re-lock boxes until all groups complete a task. An alternative recommendation included in the booklet suggests that each group could use a tablet to access an online quiz for entering lock solutions. When a correct answer is submitted, the group calls the game master to receive the next task folder. This quiz would need to be created by the teacher. While this option reduces the logistical challenges, it may lessen the immersive and hands-on experience that characterises the game.

A short video was created to demonstrate all the physical items used in the game if it were to be played by a single group. This can be accessed through the following link: https://tinyurl.com/59judubc. The teacher's booklet also suggests that the complete kit may be borrowed by contacting the author. However, it should be noted that the version prepared for this research was designed for one group of students only and serves as a model prototype. Therefore, documents requiring student input would still need to be printed.

Overall, the physical EER kit complements the teacher's booklet by transforming the instructional design into a tangible, ready-to-use classroom experience.

3.5.4 Informal Evaluation

Section 3.3 highlighted that no formal evaluation was required for the scope of this research. However, an informal evaluation process was still carried out during the development of the EER to refine and strengthen the final product, presented in the form of a teacher's resource booklet. This informal evaluation was conducted in two stages.

The first stage involved using ChatGPT (OpenAI, 2025) as a feedback tool during the creation of the game tasks. After completing each task, feedback was sought regarding the clarity, structure and level of difficulty. This process helped identify areas where instructions could be made clearer or where the mathematical challenges required adjustment.

The second stage focused on reviewing the teacher's resource booklet, including the game itself. The booklet was shared with two experienced mathematics teachers who acted as critical friends. Both teachers described the resource as creative and engaging and provided feedback on aspects such as layout, content clarity and technical wording. Their suggestions, such as using the technical term 'Level 3 – 3*' instead of Track 3 and placing a flowchart of the game at the beginning of the booklet, were subsequently incorporated to improve usability and enhance the overall quality of the booklet.

3.6 Conclusion

This chapter outlined the methodological process undertaken to design and develop the research project. The approach was guided by both theoretical insights from the literature and practical exploration of existing resources. The next chapter concludes the dissertation by revisiting the aims of the project, discussing its challenges and limitations, identifying possible improvements and areas for future research, and presenting personal reflections on the experience of completing this project-based dissertation.

CHAPTER 4

CONCLUSION

4.0 Outline

This chapter concludes the project report of this project-based dissertation. Section 4.1 revisits the aims of the project, while Section 4.2 examines the challenges and limitations encountered during the design and development of the EER, as well as the areas in which it could be improved. Section 4.3 outlines suggestions for future research, and Section 4.4 concludes the chapter with personal reflections on the overall process.

4.1 Revisiting the Aims of the Project

The main aim of this project was to design and develop an EER for Year 9 mathematics students in alignment with the national curriculum. This intention behind the project was to enhance student engagement and motivation in mathematics while also helping students develop collaboration skills. Accordingly, the project was designed for Year 9 Level 3 – 3* students and included topics such as percentages, bearings, Pythagoras' theorem and trigonometry, and simultaneous equations.

The final project achieved these aims by integrating key features designed to promote engagement and encourage teamwork within a classroom setting. Examples of these features include a strong narrative, time constraints, locks, and sequential challenges that require students to collaborate and think critically under pressure.

Another aim of this project was to provide teachers with an alternative method of formative assessment. The teacher's resource booklet includes all the necessary information for teachers to implement the game in their classroom to assess students' learning in an engaging and interactive way. Additionally, the EER can be used in mathematics clubs or educational camps as an enrichment activity.

4.2 Challenges, Limitations and Areas for Improvement

This project-based dissertation, which involved the design and development of a mathematics EER for secondary education, presented both challenges and limitations, outlined in Ss. 4.2.1 and 4.2.2 respectively. Moreover, areas for improvement emerged through reflection on the completed project as discussed in Ss. 4.2.3.

4.2.1 Challenges

One major challenge was balancing the educational content with creativity to ensure that the fun and immersive elements of the game were not compromised. This was addressed by including a short narrative section at the beginning of each task, ensuring continuity in the storyline and maintaining student engagement throughout. This approach prevented the activity from resembling a traditional assessment consisting only of mathematical questions preceded by a brief story. Furthermore, a small additional challenge was included at the end of some tasks to maintain interest after solving the mathematical questions. This was done to prevent students from becoming disengaged by simply entering the numerical solution of a question in a digit lock. As a result, most tasks include a final step in which students follow specific instructions to determine the combination for a digit or letter lock.

Another challenge arose when incorporating letter locks in the game. These were not available locally and therefore had to be purchased online after confirming that 4-letter, 5-letter and 6-letter locks were available for delivery to Malta. However, when the locks arrived, it was discovered that not all wheels contained the full alphabet, requiring adjustments to the original lock words in Task 2 and Task 4. The initial solutions, “UNITY” and “GATE”, had to be replaced with “SHINE” and “ROAD” respectively, based on the letters available. This issue did not occur with the 6-letter DaVinci lock, as it is larger and includes all the letters of the alphabet.

4.2.2 Limitations

A key limitation of designing and developing an EER within a classroom setting is the restricted availability of resources compared to a recreational ER. In the latter, the environment is purpose-built to ensure full immersion, often equipped with props and technologies such as flashing lights or sound effects. These features are difficult to replicate in a classroom context, though not impossible, because setup time, physical space, and available equipment are limited.

Another major limitation of this project is that the EER was not implemented or evaluated since this was not a requirement of the research. This was also due to time constraints; otherwise, a more extensive evaluation could have been incorporated. Consequently, the effectiveness of the EER in improving student learning, engagement and collaboration skills could not be assessed. Nevertheless, informal evaluation was conducted throughout the design process as outlined in Ss. 3.5.4.

4.2.3 Areas for Improvement

Reflecting on the design and development of the project, potential areas for improvement emerged. One enhancement would be to include tasks that offer a greater level of challenge, particularly since students work collaboratively and can benefit from one another's strengths. For example, a trigonometry extension question that could have been incorporated to deepen conceptual understanding is "$If \cos\theta = \frac{4}{5}, find\ the\ value\ of \sin\theta$".

Another improvement would be to develop differentiated version of the tasks created to cater for all the levels within the SEC syllabus rather than simply focusing on Level 3 – 3*. This would ensure that the game remains accessible and appropriately challenging for all learners, especially in mixed-ability classrooms.

Additionally, the teacher's resource booklet could have been improved by including blank hint slips within the hints section. These could be cut out and used by the teacher to provide customised hints when the prepared ones are not suitable. This would reduce the chance of other groups overhearing verbal hints and ensure that all materials required for providing support during gameplay are readily available.

A final improvement would be to include guidance for teachers on strategies for forming groups to encourage balance participation and effective collaboration, particularly in classes with diverse abilities.

4.3 Areas for Future Research

The major limitation of not implementing and evaluating the project, as discussed in Ss. 4.2.2, can be addressed through further research by evaluating the effectiveness of the project in enhancing students' engagement, motivation, critical thinking, and collaboration in mathematics within the context of game-based learning and gamification. Therefore, although I am satisfied with what I have achieved in my project, future researchers might want to investigate the use of EERs in the mathematics classroom.

An area for future research would be to conduct a pilot study with a group of mathematics teachers who could first play the game themselves. Their feedback would help identify areas for improvement, both in the gameplay and in the teacher's resource booklet. The EER could then be tested with students and teachers could also implement it in their own classrooms, allowing for the collection of quantitative and qualitative data to evaluate its educational impact.

Another example of future research could involve the design and development of a digital version of the EER. This would help reduce logistical challenges and simplify classroom setup. However, it would require the researcher to possess technical expertise or to acquire skills in using appropriate software tools.

Alternatively, future projects could focus on expanding the number and variety of tasks included in the EER to cater for different ability levels and to cover a broader range of mathematical topics. Such developments would enhance differentiation and inclusivity while providing teachers with greater flexibility in how the resource is implemented.

4.4 Conclusion: Personal Reflections

Designing and developing this project has been a truly rewarding learning experience. From the beginning, I knew that I wanted to create a resource that could be used in the classroom and that would help challenge the common perception among students that mathematics is boring. However, at first, I was unsure how to achieve this as it required a level of creativity that I had not applied in lesson planning. Nevertheless, through extensive online research and exploration of ideas, I gradually began to develop a clearer vision. Once the topics were selected and I started focusing on one task at a time, new ideas began to flow more naturally.

Undoubtedly, creating an EER for secondary education required considerable time, not only to generate ideas but also to structure the game and prepare all the necessary materials. Yet, it was time well spent because the process helped me understand how games can be effectively integrated into teaching to make learning more engaging. I realised that even adapting a simple classroom activity and embedding it within a narrative can capture students' attention and make learning more memorable. After all, students often remember lessons that differ from their usual routine. Therefore, this project reminded me of the importance of incorporating creative and interactive elements in my future lessons.

In conclusion, the design and development of the teacher's resource booklet for this EER have been an insightful and enriching experience that has deepened my understanding of how mathematics can be taught through innovative methods. I believe that students who try out this game will enjoy the experience as much as I enjoyed creating it, and that it will contribute to helping students view mathematics as a meaningful and enjoyable subject.

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[1] The APA referencing style was adopted throughout the project report.

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APPENDICES

Appendix A: Ethical Clearance Email

L-Università ta' Malta

Ylenia Vella <ylenia.vella.13@um.edu.mt>

The status of your REDP form (EDUC-2024-00426) has been updated to Acknowledged

form.urec@um.edu.mt <form.urec@um.edu.mt> 22 April 2024 at 08:31
To: ylenia.vella.13@um.edu.mt

Dear Ylenia Vella,

Please note that the status of your REDP form (EDUC-2024-00426) has been set to *Acknowledged*.

This status change was accompanied by the following explanation/justification: *Dear Ylenia Vella, This is to acknowledge that FREC has received the online Research Ethics application EDUC-2024-00426 Ylenia Vella (for FREC records) together with your supervisor's endorsement. Your application will be filed for possible future audit purposes. This means that you can proceed with your research since you did not declare any potential issues in Part 2 of the online URECA Form. Kind regards. Natalie Formosa FREC Secretary f/Dr Joseph Gravina*

You can keep track of your applications by visiting: https://www.um.edu.mt/research/ethics/redp-form/frontEnd/.

*****This email has been automatically generated by URECA. Please do not reply. If you wish to communicate with your F/REC please use the respective email address.*****

Appendix B: Project

The project which is a teacher's resource booklet can be accessed using the below link:

https://tinyurl.com/3zyyd3vx