Enhancing

GAME-BASED LEARNING

in Formal Education using

Simplified Game Authoring Tools

A Design Science Research Study

MOHAMMAD ASSAF

ENHANCING GAME-BASED LEARNING IN FORMAL EDUCATION USING SIMPLIFIED GAME AUTHORING TOOLS: A DESIGN SCIENCE RESEARCH STUDY

DISSERTATION

to obtain
the degree of doctor at the University of Twente,
on the authority of the rector magnificus,
prof. dr. ir. A. Veldkamp,
on account of the decision of the Doctorate Board
to be publicly defended
on Monday 1 July 2024 at 12.45 hours

by

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Cover design: Freepik
Printed by: Ipskamp Drukkers B.V. Enschede
Lay-out: Mohammad Assaf
ISBN (print): 978-90-365-6134-1
ISBN (digital): 10.3990/1.9789036561358
URL: https://doi.org/10.3990/1.9789036561358

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Acknowledgement

In this special tale of debating about game-based learning and trying to navigate the maze of academia, and trying to keep it all rational in the face of parenthood, I find myself perched at the edge of a dissertation. Image a mad scientist on the edge, balancing between code, books, and toys, all the while trying to convince a four-year-old that Daddy's laptop is not a PlayStation. Hail, brave souls who have ventured this deep into the labyrinth that is my dissertation! If you've made it past the deceitful abstract and survived the perilous introduction, you deserve a warm ovation. Another round of applause to the supervisors who really made this academic journey quite less daunting with an infinite amount of patience.

It has really been a long journey in getting to the completion of this PhD dissertation. Indeed, very deep thankfulness and appreciation from the heart go to each one of my supervisors for playing a pivotal role in making this academic endeavor real and successful. First of all, my very heartfelt thanks go to my most esteemed supervisor, Jos van Hillegersberg. His very focused support, penetrating guidance, and scholarly sagacity have been forces of great support all through this research journey. Jos, your encouragement and critique for building have certainly guided me through some of the most difficult moments, and I do not take this privilege for granted.

My special thanks extend sincerely to my daily superintendents, Ton Spil, Guido Bruinsma, for their support, expertise, and mentorship, who have guided me on this unexplored trajectory. Their mentorship has shaped this dissertation with not only consistent and careful academic rigor but also inspired an extension of my awareness into the wide scope of serious games applications. Ton, your insightful perspectives and commitment to academic excellence have been a source of inspiration. Guido, indeed your support and keenness for the development of effective educational interventions have truly made a real and big difference to this work. I owe thanks to the team spirit, which marked the very way of doing things and the combined effort put in, to be able to contribute to the academic weight of this dissertation.

I would like to express my deep thanks to the teachers who participated in my research, particularly those in Palestine who are enduring difficult war conditions at the time of writing these words. Your insights and experiences have added a critical dimension to this research, shedding light on the role of serious games in contexts marked by resilience and determination.

To my family, the pillars of my strength, I owe an immeasurable debt of gratitude. My wife Maha has been very encouraging and understanding above all, very resilient; it is through her support and sacrifices that have been the bedrock on which I built this academic

pursuit. Maha, your belief in me sustained my determination during challenging times, and for that, I am eternally grateful.

I am profoundly indebted to my two children, Muhannad and Alma, for their patience and understanding during demanding periods of research. Muhannad, thank you for being the first tester of my games. I could never be grateful enough for that boundless curiosity, thrill, and willingness with which you plunged into the worlds created by me. In this sense, your constructive criticism and genuine interest in the serious games I developed have really made the testing phase enriching, and at the same time, it has contributed a lot to their fine-tuning in the educational interventions.

Alma, at your tender age, you shall hardly fathom the depth of my gratitude to you at this point. If a few years down the line, you come across these very words, take your playful spirit and the fun times that you brought into this space quite literally; only then will you be able to understand how it gave a lively environment to hard moments of serious research. Alma, your very spirit that filled our house always with joy and lightness, is such a great motivation for me to attempt with every step I take in life in order to achieve that perfect balance. Both of you have been motivating factors in my journey to work for a better educational landscape for the coming generation.

I owe great gratitude to my father and mother for their great support and sacrifices throughout my academic period. Their love and encouragement, though far from them, has long given me the strength to have dreams and strive for them.

I am grateful to my extended family and friends for their encouragement and understanding during this trying period. Finally, I would acknowledge the wider academic fraternity, colleagues, and friends who have extended their helping hand in making this dissertation full of intellectual richness. Great impacts have been set by this research work in terms of sharing ideas and collaborative endeavors. Therefore, writing this dissertation closes both a certain personal milestone and a collective achievement with the support community. Each individual mentioned in this acknowledgment of this document has a share in the unique achievement from this academic pursuit. I am deeply thankful for the collective support, guidance, and inspiration that made this dissertation possible.

Thank you.

Mohammad Assaf

Samenvatting

Deze scriptie presenteert een innovatieve benadering om de uitdagingen die gepaard gaan met de adoptie van game-based learning (GBL) in formeel onderwijs te overwinnen. Met de proliferatie van informatie- en communicatietechnologie (ICT) in leeromgevingen is het potentieel voor GBL om onderwijs met entertainment te combineren toegenomen. Echter, de integratie ervan in schoolcurricula is beperkt gebleven door verschillende obstakels.

Het onderzoek maakt gebruik van de Design Science Research (DSR) methodologie om het "FunHomework" platform te creëren en te evalueren, inclusief een vereenvoudigd auteurstool voor leraren. Dit hulpmiddel is ontworpen om de last van technische aspecten van game-ontwerp te verlichten, waardoor opvoeders zich kunnen concentreren op de pedagogische inhoud. Een significante innovatie die in deze scriptie wordt geïntroduceerd, is het concept van Dynamische Leerinhoud voor het ontwerp van serieuze spellen (SG's), wat de integratie van educatief materiaal in spellen in real-time mogelijk maakt.

De studie identificeert kritieke barrières voor de wijdverbreide adoptie van GBL, zoals problemen met curriculumcompatibiliteit, de technische vaardigheden vereist voor game-ontwikkeling en de beperkte tijd beschikbaar voor leraren. Door opvoeders in staat te stellen SG's te produceren die in lijn zijn met educatieve doelen en de productiekosten te verlagen, streeft het FunHomework platform ernaar de adoptie van GBL in onderwijsinstellingen te faciliteren.

Een essentieel element van het onderzoek is de empirische evaluatie van het FunHomework platform in verschillende onderwijscontexten. De studie betrekt leraren bij het ontwerp en de iteratieve ontwikkeling van het platform, waarbij wordt gezorgd dat het eindproduct hun behoeften en input weerspiegelt. Het platform streeft ernaar de productieoverhead voor educatieve spellen te minimaliseren door compatibiliteit met meerdere spellen te behouden en het delen van leermaterialen te vergemakkelijken.

Deze studie introduceerde het FunHomework platform, een softwareoplossing die bestaande uitdagingen bij de adoptie van GBL aanpakt. Door een reeks innovatieve ontwerpprincipes voor de productie van SG's voor te stellen, verrijkt het platform de kennisbasis rond SG's. FunHomework heeft aangetoond efficiënter gebruik van SG's in formele onderwijsinstellingen te faciliteren, waardoor het wordt gemarkeerd als een verbetering binnen het DSR-paradigma dat een onderzoeksmogelijkheid identificeert en een significante kennisbijdrage levert. Deze tweevoudige bijdrage, die zowel de creatie van een nieuw ontwerp-artefact als de grondige evaluatie ervan omvat, illustreert de effectieve implementatie van DSR-principes. Het verbetert zowel theoretische als praktische inzichten in het naadlozer integreren van GBL in formele onderwijskaders.

Samengevat betoogt de scriptie dat het FunHomework platform effectief de primaire uitdagingen aanpakt die de integratie van SG's in formeel onderwijs belemmeren. Door

spellen af te stemmen op onderwijsdoelstellingen, het proces van spelcreatie voor opvoeders te vereenvoudigen en hulpmiddelen te bieden om de prestaties van studenten te volgen en te beoordelen, toont FunHomework belofte in het verbeteren van het gebruik van SG's in formele onderwijsinstellingen, waardoor het een waardevolle bijdrage levert aan het veld van onderwijstechnologie en de ontwikkeling van GBL-strategieën bevordert.

Abstract

The integration of game-based learning (GBL) into formal education presents a promising avenue for enhancing student engagement and learning outcomes. However, this integration is associated with numerous challenges, such as technical issues in the development of games and how to link the content of the games with learning material in the curriculum. This thesis intends to overcome these barriers in the development of a serious game platform, FunHomework, which provides a simplified game authoring tool that can help educators create and implement serious games (SG) in their teaching practice.

The central research question to be answered during the course of the study is: *How can the introduction of simplified game authoring tools facilitate the integration of game-based learning within formal educational environments?* This question unfolds into various empirical research questions investigated across the thesis chapters, including the specific design features that facilitate the use for teachers, the impact such tools have on teacher attitudes toward GBL, and also the customizable learning contents for students engaged with SGs created through the platform.

The thesis followed the iterative development of the FunHomework platform according to Design Science Research (DSR) methodology, based on designs that incorporated feedback from educators in order to consider the perspectives of teachers and students in the final product. The main feature of FunHomework is the game authoring tool, which aims to bridge the technical challenges that creating SGs can pose for educators, thus making GBL more accessible. The tool allows for the dynamic embedding of educational content into the games, making the SGs versatile for a variety of subjects and learning goals.

Empirically, the study involved twelve teachers and over 200 students from different schools to evaluate the FunHomework platform. The multi-phase study aimed to measure the usability of FunHomework and its ability to influence teachers' attitudes towards using GBL in the classroom. The methodology used in this study involved mixed data collection methods: quantitative and qualitative. Surveys were used to measure teachers' experience in using FunHomework platform, while interviews with teachers were conducted to obtain in-depth responses about individual features of the platform.

This thesis contributes to the field of game-based learning in multiple ways. The FunHomework platform introduces several innovative *design principles* that could be applied to game-based learning production. Moreover, the principle of *Dynamic Learning Content* for SG design was introduced, whereby learning materials are injected into a game at runtime instead of the SG being built based on fixed notation.

Thus, the thesis provides a robust answer to the central research question and investigates how a simplified authoring tool such as FunHomework can enhance the adoption and effectiveness of GBL in formal education. By reducing the technical and time barriers associated with GBL and ensuring that SGs are closely aligned with educational goals, FunHomework facilitates a more widespread and effective use of game-based strategies in classrooms, leading to improved educational outcomes.

The research therefore makes a significant contribution to the field of educational technology, as it aims to fill the gap with practical solutions to the challenges of integrating GBL into formal education. It provides a framework for both facilitating the development and deployment of SGs and advancing our understanding of the design principles that underlie successful GBL. The findings of this study have implications for the communities of educators, game designers, and stakeholders interested in harnessing the potential of GBL to make a qualitative and significant difference in education.

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Chapter 1

Enhancing Game-based Learning in Formal Education using Simplified Game Authoring Tools: A Design Science Research Study

The chapter provides an overview of the main theme of the dissertation focusing on the enhancement of game-based learning in formal education. The foremost objective of the study is to aid teachers to connately utilize games in their classrooms. The chapter then discusses different strategies that are employed to augment game-based learning in educational settings. It unveils the description of various methodologies in the literature which are used to reinforce game-based learning, and have focused on practical frameworks to assist teachers in incorporating games in their classrooms. After that, the chapter discusses the background of the research and the issues which led to its initiation and justifies the importance of it. Furthermore, it discusses the research aim and objectives. The chapter then explains the methodology of the study and describes the sub-studies that were conducted. It concludes with a summary of the overall aims of the dissertation.

1.1 Problem Context and Background of Study

Education is a basic human right and is necessary for sustainable social and economic development, and for the prosperity of society. The importance of education in society lies in the fact that it creates opportunities for acquiring knowledge and skills that are literally changing the world. The educators' pursuit to ensure ample opportunities for students to succeed in society creates the need for consideration of various methods of learning (Spires, 2008). Developing new skills to handle future challenges, and equipping students with new jobs and technologies, including job roles that have not yet been created, is crucial in this effort (Fisch & McLeod, 2009). Prensky explained technology as follows "an entire strategy for how to live, survive and thrive in the 21st Century" (Prensky, 2004, p. 2). (Voogt & Pareja Roblin, 2012) argue that in order to succeed in the 21st century, people must possess a range of competencies that go beyond basic technology awareness, including skills of communication, collaboration, social and cultural adaptability, innovativeness, analysis, productivity in a global setting, ability to acquire skills, self-guidance, planning, versatility, risk-taking, conflict management, and proactive and entrepreneurial approach. These skills need to be developed by individuals at all stages of their lives, including primary school students, continuing learners, and participants in informal education. To effectively develop 21st century skills, the use of active learning techniques that promote self-directed learning is commonly accepted as essential (Bell & Kozlowski, 2008). Games are a type of active learning allowing the learners to have limited control over the gameplay and participate in interactions. Game-based learning (GBL) is based on active learning techniques and promotes learning by emphasizing participation and challenges to attain predefined

educational goals. Games can thus be seen as a tool for developing additional skills for the 21st century (Prensky, 2006; Redecker et al., 2011) along with being "central nodes in the organization of contemporary leisure culture, computer-mediated interaction, visual culture, and information societies" (Simon, 2006, p. 64).

Since last few years, the use of games for educational purposes has grown in popularity. Serious games (SGs), which blend entertainment with the transmission of knowledge, have been identified as a promising tool. These games have a specific purpose other than entertainment, such as education, training, promoting a cause, or substantiating social transformation (Winn, 2009). SGs have significant potential to support learning experiences in various formal and informal settings. There have been many studies that have highlighted the advantages of using SGs, such as their ability to attract and motivate learners, which can aid in different learning experiences.

SGs have been recognized as having great potential for education because of their ability to motivate learners. However, their use in formal education is quite limited to date, and efforts to incorporate them into the curriculum or daily classroom activities have not been as successful as desired. As per their report on the use of Information and Communication Technology (ICT) in education, the European Union (Deloitte et al., 2019) surveyed schools in 31 countries to gauge the progress of ICT in schools. The report showed that 66% of the surveyed students had hardly played digital learning games during their studies, which undermines the potential impact and usefulness of SGs in learning and education.

With the wide availability of technology tools like hardware, connectivity, and software, the challenge facing teachers in finding meaningful ways to incorporate technology in their classrooms is no longer solely due to a lack of access to these resources, thus raising concerns regarding other factors. According to the (Deloitte et al., 2019), several factors contribute to the reluctance to adopt digital games and simulations in schools. These include: a) the absence of good quality curriculum digital content, b) inadequate data offered to teachers, c) poor skills for using and integrating them into teaching, and d) shortage of time to become entirely conversant to use them during classroom activities with the students.

The technique through which SGs are produced and provided to schools appears to bear a significant portion of the blame for this shortfall. (Stevens et al., 2008; Lee & Shumaker, 2021) noted that the activities undertaken for the creation of SGs and other related learning resources for schools are mostly based on documenting the application of these games in classrooms, along with illuminating the learning principles under the purview of pedagogical techniques. However, issues may develop due to the limited knowledge of the teachers' role in molding a gaming experience regarding the development and implementation of games in schools (Stevens et al., 2008; Lee & Shumaker, 2021). The point is that the majority of issues arise when these games are regarded as complete and their educational benefits are addressed without considering the function of teachers inside the game-

based learning setting. In reality, teachers play a critical role in molding and reacting to the complex environmental aspects that influence how games are perceived within educational contexts (Bourgonjon et al., 2013; Wang et al., 2021). Furthermore, their perspectives on what SGs might conceivably deliver in classrooms will inextricably influence judgments about when, how, and for what reasons they will be included in the learning domain (Beavis et al., 2014). Failure to adopt SGs in formal education can be attributed to teachers' attitudes about games, which are, in turn, intimately related to teachers' perception of games (Squire, 2002; Mehrotra et al., 2012). Though multiple teachers might benefit from learning about the educational potential of digital games, they are wary of the difficulties involved in the effective adoption of SGs in schools.

(Pan et al., 2021) identified several obstacles in their research that make it challenging to incorporate game-based learning in schools. They emphasized that apart from the specialized equipment required for games, the shortage of high-quality resources for educational games is a significant barrier that prevents teachers from using games in their instructional practices. The scarcity of quality educational games can be attributed to the high cost of creating customized educational video games. According to estimates, 40% of instructional game innovations underway or recently completed in 2005 were estimated to cost over 100,000 dollars (Michael & Chen, 2006).

According to (Pan et al., 2021), when teachers opt to use game-based learning, they are met with poor theoretical instructions regarding frameworks, curriculum, and teaching support. Aligning games with the curriculum is crucial in the decision to implement game-based learning, but teachers may find it difficult to locate games that are in line with their learning objectives and deliver sufficient feedback on students' progress (Assaf et al., 2019). Furthermore, numerous scholars (Webb et al., 2015; Allsop & Jesse, 2015; Molin, 2017) have claimed that the introduction of new technology may put pressure on teachers and lead to new challenges like inadequate preparation time and adequate student evaluation.

As a result, we can conclude that the application of SGs in formal education falls short of expectations, even with advanced technical innovation and the greater availability of ICT. This undermines the usefulness of SGs and their potential benefits to education, which gives an opportunity to perform the research considering the improved integration of SGs into the curriculum and/or classroom setting in tangible ways, as well as to equip educational institutions and educators with a better knowledge of SGs that can assist learners.

1.2 Game-based Learning in Formal Education

Numerous techniques for improving game-based learning have been discovered in literature. While several academics offered useful SGs that focused on students' perspectives, others proposed theoretical and practical frameworks to assist teachers in implementing

game-based learning in classrooms. We can divide the initiatives made in this area into four categories:

1.2.1 Changing teachers' perceptions of games

According to (Gaudelli and Taylor, 2011), many teachers are unaware or skeptical of the educational potential of digital games, owing in part to a shortage of gaming experience. Many researchers have investigated the role of gameplay and other associated activities in influencing teachers' views about games or game-based learning. (Gerber and Price, 2013) conducted a study to evaluate teachers' perceptions of using commercial off-the-shelf (COTS) video games while teaching English and Language Arts (ELA) courses. The study involved 10 literacy teachers who explored various multi-user virtual settings and experienced playing a COTS game while investigating literacy tasks directly connected to the chosen game. The study unveiled that despite the teachers' acknowledgement of the value of game-based learning methodology, they were apprehensive of the resistance expressed by their schools and colleagues.

(Ray and Coulter, 2010) conducted research to examine the impact of playing digital mini-games on pre-service teachers' perceptions of games. After playing selected mini-games, most of the teachers modified their attitudes positively, and they felt sure that digital mini-games might promote effective learning.

(Kennedy-Clark et al., 2011) conducted a study of 2-hour workshop on the incorporation of game-based learning to evaluate the attitudes of pre-service teachers regarding game-based learning. The study revealed that this workshop induced a significant change in the participants' attitudes towards game-based learning. (Sardone, 2010) performed similar research in which pre-service teachers investigated digital learning games along with employing their selected games while teaching students of middle and higher-grade classes. After the gameplay session, the teachers were instructed to deliver a 20-minute presentation to the class. The findings revealed that games and presentations had a beneficial influence on the teachers' attitudes, making them enthusiastic and confident regarding the integration of digital games into the classrooms.

In short, the studies above looked at how teachers' attitudes and views changed after being introduced to the game-playing experience. Assuming the teachers' awareness of the pedagogical advantages of games and willingness to include them in their academic settings, the teachers might subsequently find it difficult to identify the appropriate game for incorporation in a game-based learning educational setting.

1.2.2 Helping teachers to identify games

As the awareness about SGs and the potential they can bring to the educational environment raised, teachers' decision about the adoption of game-based learning may be now

hampered by the availability of suitable games that can match the pedagogical practices. It is equally difficult for an individual teacher attempting to gamify his or her own instruction to select appropriate games and strike the perfect balance in employing games as a teaching tool (Kangas, 2017).

In this context, a few scholars attempted to categories SGs in order to make it easier for teachers to choose relevant games. The G/P/S model by (Djaouti et al., 2011), which emphasizes the interplay between games and players, is perhaps one of the most popular and latest classifications of SGs. The suggested approach categorizes SGs into three categories, namely gameplay, purpose, and scope, providing educators with rapid observations to readily discover educational games for their students based on the intended objective.

Additional research (Wu, 2015) provided a typology of digital instructional games to assist teachers in becoming acquainted with the chosen game(s) prior to classroom deployment. The typology specifically attempts to assist teachers in finding games that reflect current educational theories (behaviorism, cognitive constructivism, social constructivism, and constructionism). The typology, according to (Wu, 2015), would enable teachers to select games based on intended educational opportunities, target age group and instructional goals, in-game topic area, learning goals, and the technology and resources required to operate the game.

The typologies described here may be useful since many teachers have difficulty identifying games that align with their curriculum needs. Even though organizing games into different categories can help teachers understand the content and teaching potential of the games, they may not have the knowledge or skills to fully utilize the games and design learning experiences that align with their desired educational outcomes. To overcome this challenge, teachers' involvement in the game design process could be beneficial. Collaboration between teachers and game developers motivates teachers to employ game-based learning but may also result in the production of valuable SGs that are tailored to meet the specific needs of teachers and students in schools.

1.2.3 Involve teachers in game design

Multiple researchers recognized the significance of engaging teachers in the creation of SGs, as well as how the design experience might favorably alter teachers' views toward the usage of digital games in instructional settings. (Li et al., 2013) investigated how teachers' perspectives of digital games changed as they designed and built their own instructional games. They investigated pre-service teachers' experience of designing a digital game in a secondary mathematics techniques course at a Canadian institution for this purpose. Approximately 21 teachers were exposed to different online games before engaging in game creation and development with Scratch or any other game design program. Following the development of their own games, the teachers stated in the interview that the game development allowed them to employ all of the 21st century competencies, notably in the

domains of learning and creativity, which helps teachers nurture the innovative thinking of their own learners. According to the findings of the study, a large number of participants faced challenges in converting their design concepts into a game. Some teachers had to make significant modifications to their game designs to make them compatible with the software that was used.

Further research (Sancar and Ozgelen, 2013) attempted to analyze the factors influencing preliminary childhood education pre-service teachers' decision to integrate computer games in two scenarios. In the first scenario, educators were instructed to choose a computer game and incorporate it into their curriculum. In the second scenario, the participants were tasked with modifying the chosen game and incorporating it into their curriculum. According to the survey, all teachers highlighted the challenge in selecting educational computer games due to the computer games that were not appropriate for the learning objectives intended to be taught. It was also discovered that the majority of the teachers made significant alterations to the chosen computer games. According to the interview findings, the main variables influencing their decision to game integration were the attributes of computer games and the opportunity to review their peers' lesson plans.

1.2.4 Using authoring tools

One method for including teachers as designers is to use authoring tools, which can form a simple foundation for extracting the technicalities of game design. The authoring tools can enable teachers to modify games at a low cost, make them available to non-programmers, and facilitate the engagement of non-technical SG stakeholders.

The uAdventure project, introduced by (José et al., 2020), delivers a user-friendly authoring tool for teachers to create educational games having features like learning analytics without any requirement for advanced programming skills. Participants of the initial pilot research required professional guidance to swiftly prototype their game concepts, but nearly no one attempted or achieved success in developing their games. As a result, (José et al., 2020) found that past narrative expertise may be necessary in order to be more competent during the authoring phase. Game creation in uAdventure may be time-consuming since it includes creating game narratives and mechanics, as well as assigning game assets and images and may thus dampen the excitement of teachers implementing SGs in their classrooms, who are often concerned with completing their instructional activities on time.

The uAdventure project demonstrated a beneficial shift in teachers' attitudes regarding SGs by involving teachers in game creation. Teachers are more convinced and drawn to the concept of utilizing games as an educational tool when they can actively engage in the game creation process. The question that now arises is, at what point of the game creation process should teachers be involved? Prior studies attempted to incorporate teachers at early in the planning phase, which we believe has significant downsides:

- Designing SGs may need a certain amount of digital competence and computer abilities, which may force teachers to master new technologies in order to develop their own games and resolve the technical obstacles involved in that approach.
- Game design takes time since it involves the creation of audio-visual effects and animations. For teachers who are under pressure to complete their educational lessons on time, such a labor-intensive and time-consuming task may dampen their excitement about engaging in SG development.

Authoring technologies can enable teachers to modify games at a cheap cost with no technical expertise required. However, we should develop the simplest form of authoring resources in order to avoid overloading teachers with sophisticated software that wastes teachers' time and adds complexity to their responsibilities.

In another study by (Molnar et al., 2015), a different approach to authoring tools was presented through EducaMovil, a game-centric mobile learning tool, allowing teachers to produce customized educational content quickly and easily with the aim of streamlining the creation of educational games to make it more accessible for teachers to use in their classrooms. Teachers may use EducaMovil to generate instructional content for many disciplines and seamlessly integrate it into games at a minimal cost because the platform does not require advanced technical skills or significant expenditures to perform efficiently. EducaMovil attempted to capitalize on increased mobile phone ownership rates among teachers and students, making them a cost-effective way to supplement formal schooling and allow the transmission of educational content at any time and place. Teachers create instructional content using a PC tool, whereas students can utilize a mobile game-based instructional application loaded on Java-enabled mobile phones. (Molnar et al., 2015) exhibited the platform's application in a public school located in a low-income urban neighborhood of Lima, Peru, while reviewing EducaMovil and analyzed teachers' views toward the planned application's employment. Nonetheless, neither thorough facts regarding the platform's actual usage nor instructor input were considered in the review.

Though EducaMovil's concept is intriguing, its mobile game-based instructional application is available only for phones that support Java, and as a result, a) the mobile application cannot be loaded on the latest Android and iOS devices, and b) the games generated through this technology are quite simple owing to the restricted hardware present on Java-enabled phones. This can potentially limit the tool's applicability.

1.3 Research Design

In this study, we recognized that the utilization of GBL in formal education settings has not been as widespread as anticipated. This discrepancy is attributed to multiple challenges encountered at various levels, including infrastructural requirements, quality and cost of educational game resources, teachers' perceptions, and the need for alignment with curricular goals. One promising approach to address many of these challenges involves

the use of game authoring tools in SG development which empowers teachers to take an active role in creating the games they will implement.

The research highlights the significance of teachers' involvement in the development of educational games, and that their active participation could energetically contribute to better utilization of game-based learning in schools. This participation should take into account the adoption challenges mentioned above and integrate teachers' knowledge to encourage them to embrace game-based learning. Therefore, the study used Design Science Research (DSR) methodology to propose a game-based learning platform with simplified authoring tool that considers teachers' needs, and the obstacles that hider utilization of game-based learning in formal education. Next, the main research question is presented, followed by discussing the research methodology and the sub-studies within this research.

1.3.1 Research Questions

This study focused on developing a game-based learning platform named FunHomework, featuring SGs equipped with dynamic learning material. This new development is expected to make the development of SGs easier and to boost the uptake of game-based learning approaches in organized educational environments.

It serves the essence of the platform well: the ability to translate content from a formal educational curriculum into engaging game scenarios - highlighting the introduction of simplified authoring tools. The term "simplified" here emphasizes that the tools are easy to use and accessible, which means that even educators with very little technical experience would utilize them. These tools become relevant for the facilitation—or making easier—the "integration" of game-based learning into the "formal education" system, which is the organized, structured process of schooling at institutions like elementary schools that adhere to standardized curricula.

Moreover, its design is intrinsically linked to the educational setting, which makes it highly flexible for implementation within a range of disciplines and courses. This study also assessed if this type of platform could reach and even overcome common barriers of SG introduction within educational settings. The use and usability of FunHomework within the primary schools was assessed with the aim of answering the following research question:

> *How can the introduction of simplified game authoring tools facilitate the integration of game-based learning within formal educational environment?*

Four investigations were carried out in order to address the main question.

1.3.2 Research Method

The scope of this study was focused specifically on providing practical software that can overcome the aforementioned key implementation obstacles that hinder the adoption of

game-based learning in formal education. In addition, the study aimed at exploring other strategies to address SGs utilization problems, and developing the knowledge for designing SGs, which can be useful for professionals in the game-based learning field.

To achieve this, the research adopted DSR methodology to design, build, and evaluate a game-based learning platform capable of increasing teacher's involvement in the game-based learning environment, and changing, and potentially improving, SG deployment in the pedagogical approach.

A lot of academic studies on game-based learning have employed a variety of approaches to investigate utilization barriers, such as exploratory, quantitative studies using surveys (e.g., Langerud, 2007; Tibet, 2015), action research based on case studies (e.g., Haho, 2014), action research based on detailed literature reviews (e.g., Majila, 2012), and so on. Most of these research works sought to establish a common understanding of adoption issues.

DSR is a research technique for developing creative constructions that are aimed at resolving real-world issues while also contributing to the theory of the area of its implementation (Lukka, 2003). Furthermore, (March and Smith, 1995) viewed design science as a method for discovering novel solutions to problems, understanding the process of exploration, and enhancing the problem-solving process to fulfil human needs. DSR's purpose is to generate scientific information to enable professional intervention or artifact design and to stress its knowledge orientation. Design science is focused on the knowledge to be utilized in developing solutions, which will be followed by actions based on design (Aken, 2004).

For software, the stage in which Information Systems (IS) are created depends inherently on design, which is regarded as an IS research cycle component in the creation and evaluation of ICT artifacts whose purpose is to resolve clearly pinpointed issues (Hevner et al., 2004). Current SG research involves numerous ongoing studies of various topics, so a variety of fields of science are contributing to the overall research outputs. As a result, the nature of SGs derives from multiple disciplines, so SG-related knowledge ultimately aims to create solutions of advanced design that address field problems of complexity and relevance in particular design contexts. The SG field should not be an explanatory science whose method of knowledge development involves only description, explanation, and possibly prediction (Aken, 2005).

To ensure that research is relevant, the scope of environment-related considerations must include individuals, organizations, and types of technologies. Meanwhile, the appropriateness of research must involve the maintenance of rigor, where applicable knowledge is chosen from the collective base of knowledge. The current research involved the development of an artifact and its assessment through a case study-based evaluation. As a result, the researcher was able to refine the development of the artifact and the practical tools that had been created using applicable knowledge and based on actual teacher requirements.

An information system can be built by applying Hevner's framework, and it is possible to transfer the process to SG design, the foundations of which are practical experience and bases of knowledge. The question remains about how design science research might be used with respect to SGs. Design was defined by Klabbers as invented actions intended to make changes to a current situation so it would become more preferable. Klabbers described design using a two-dimensional outlook: design-in-the-small (DIS) referred to designing an SGs, while design-in-the-large (DIL) referred to making a current situation more preferable (Klabbers 2003). The dimensions are closely related, and an event on the second level is influenced by one on the first. Whereas the focus of DIS involves designing, implementing, observing, and improving an investigated game, DIL applies following the events observed during DIS and involves formulating conclusions, creating generalizations, and describing a work as contributing to the overall knowledge.

To that end, DSR was used in this study to a) identify and evaluate possibilities and difficulties related to game-based learning in elementary schools; b) design and implement an SG platform that overcomes key adoption hurdles; and c) evaluate and refine that platform in order to match teachers' needs and make SG utilization more preferable.

Numerous DSR methods have been proposed. However, the underlying research process is uniform across them and may be simplified into three major tasks. The study employs process stages, as proposed by Hevner, as a part of the DSR method, including awareness of the problem, development, and evaluation. The overall design cycle is depicted in Figure 1.1 of the design science research model.

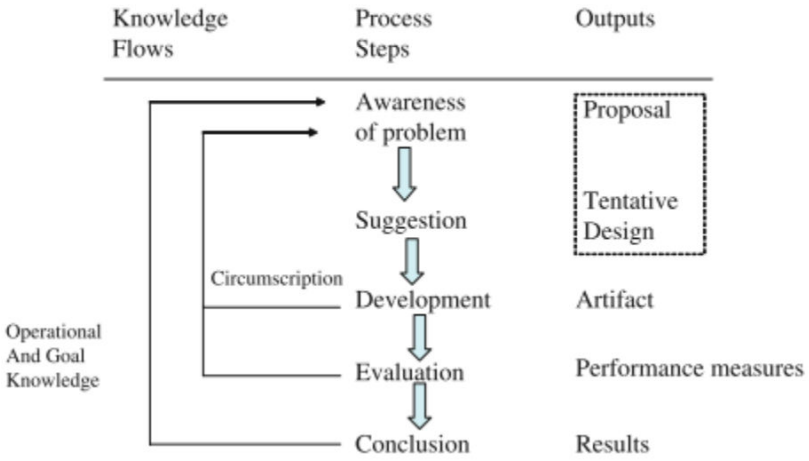


Figure 1.1 General Design Science Research (DSR) Framework
Source: (Hevner & Chatterjee, 2010)

1.3.3 Awareness of the Problem

The first stage of DSR is establishing the awareness of the problem, which entails exploring the circumstances that launch the design process. A driver for the awareness phase is to

find a solution to a particular problem, rather than asking questions answered via explanation (Vaishnavi et al., 2004). For this step, the required resources include knowledge of the state of the problem and the importance of its solution (Peffers et al., 2008).

To that end, the first study was conducted which aimed at analyzing the domain, and included an in-depth examination of existing research on game-based learning in schools. The goal of this review was to gain a comprehensive understanding of the current state of the field and to deeply examine the major requirements and impediments for a viable game-based learning solution. The literature review was conducted using the Grounded Theory method, and it was used to: (a) identify the most significant efforts that promote the adoption of game-based learning in classrooms, (b) explore the key obstacles that hinder the adoption of game-based learning in formal education, (c) uncover the diverse techniques used to increase teachers' acceptance of digital games and their integration in formal settings, and (d) evaluate the extent to which these efforts have helped to overcome the adoption barriers and increase the implementation of game-based learning in education.

The findings of the literature review study were used to establish a solid basis for furthering comprehension of using games in education. It facilitated the development of theories by filling gaps in areas where there is already a wealth of research and uncovering areas where research is lacking. This aided in evaluating the competence/limitation of existing approaches to tackle the problem, as well as identifying the problem and the motivation of this research.

This study revealed that despite the diverse methodologies used to help teachers in utilizing SGs in their classrooms, the problem that has been identified is:

> *The utilization of serious games in formal education is still very limited, therefore, there is a need to enhance game-based learning adoption by providing innovative SG solutions that surmount utilization obstacles.*

This provided an opportunity for research to be conducted to provide such a solution that benefits practice, in particular educators and SGs designers, and boost SGs deployment in a lasting manner that helps learners.

To further investigate the key requirements of the potential solution a second study was conducted. Through the second study, we initiated the examination of teachers' requirements for the artifact which were determined through structured interviews in a qualitative study. The goal of this study was to acquire a deeper understanding of the practical implementation problems being addressed by teachers. A preliminary research effort was conducted to examine educators' perspectives on incorporating educational games in their classrooms and identify any barriers that impede the adoption of this approach. The

qualitative study was conducted in Jordan – which will be later the main country for the implementation and evaluation of the artifact.

The findings of this study were utilized to outline the initial model of potential platform, which can combat the underlying issues that contribute to the absence of SGs adoption in classrooms. The results of this study had replicated the implementation obstacles that were revealed in the literature in study 1, and highlighted significant teachers' recommendations that were vital for refining FunHomework platform design and re-formulating the problem statement.

1.3.4 Development

This activity of DSR includes determining the artifact's desired functionality and its architecture and then creating the actual artifact. This development process is iterative and includes determining user needs and requirements, and reflecting these needs on creating and refining the artifact. This cycle of research activities iterates more rapidly between the construction of an artifact and subsequent feedback to refine the design further (Simon, 1996). Resources required moving from objectives to design and development include knowledge of theory that can be brought to bear as a solution (Peffers et al., 2008). Acquiring the needed feedback that aided the design and development of the potential platform was the goal of the third study.

This stage in DSR is where a concept is developed to solve the problem. It aims at creating a tentative idea of how the problem might be addressed, and envisioning the new functional artifact (Vaishnavi et al., 2004). The essentially creative action of design takes place at this stage in order to assure that the output of the research will be novel and that the artifact is potentially relevant to practice.

For (Takeda et al., 1990), this stage provides concepts for how to solve the problem. This suggestion can be part of a cycle where the artifact may be evaluated, and if the solution does not fulfill the objective, the process starts again with new suggestions.

The previous stage described the problem and drew attention to the areas of emphasis in game-based learning research with regard to the hurdles associated with implementing SGs in formal education. The objective of this stage was to unite the various concepts to derive a conceptual model that enhances game-based learning adoption in formal education by overcoming key obstacles that prevent teachers from utilizing SGs in their classrooms. Accordingly, an attempt was made in the third study to suggest a game-based platform that incorporates a simplified authoring tool that surmounts the aforementioned implementation problems in the previous stage.

In the third study, the development stage was utilized to create a principle for addressing the stated research problem. The potential solution enclosed a prototype of SGs with

Dynamic Learning Content and utilized a mobile app for teachers to manage and modify the game's content. In this demonstration, the initial iteration of FunHomework platform was showcased, which is a game-based education system consisting of two mobile applications - one for teachers to create content and another for students to play a 2D game. The authoring tool enables educators to design instructional content and goals that align with the official curriculum. These materials are incorporated into the games during runtime, making the game dynamic and in line with the teacher's educational goals. The tool also allows teachers to monitor student progress and adjust game elements, as well as keeping teachers up to date on their pupils' activity accomplishments. To maintain kids' attention, the game is utilized to play and complete the learning objectives specified by their teachers.

The intent of this study was to create a tentative design for the artifact, and analyze the issues associated with developing the technical components of such a platform. This prototype will later formulate the basis of the possible solution for the aforementioned implementation problems, and potentially fulfil the intended objective.

The results of the first stage were reflected in the design of FunHomework, which took into consideration the hurdles that generally limit the adoption of game-based learning in schools.

- **Congruence of games with the curriculum**: Using the authoring tool within the platform, teachers can produce games that are compatible with their learning objectives, which can help them to integrate the platform into their educational plans without concerns about game compatibility.
- **Teachers' Time**: In FunHomework, the authoring tool's role is limited to creating the learning content rather than providing game scenarios and mechanics. This can make authoring tool simple and be used without previous technical knowledge, which also leads not to consume much of the teachers' precious time.
- **Production cost**: The game within FunHomework can be used for several school subjects, which can reduce the potential costs that schools normally bear when acquiring multiple subject-specific games. As FunHomework uses an open API, any game compatible with this API can be easily integrated into the platform and used with the same TutorApp authoring tool, potentially reducing costs even further.
- **Student assessment**: To empower teachers to adopt new instructional tools, it is essential to receive sufficient feedback from these tools on managing student performance. Within FunHomework, teachers can track their students' results, as well as export reporting them to be documented and used in the final student performance evaluation.

By the end of this development stage, FunHomework was potentially capable of overcoming major problems that confront teachers during the implementation of SGs in their

classrooms. The verification of the utility of this platform to enhance the utilization of SGs in formal education took place in the next evaluation stage.

1.3.4 Evaluation

The next stage in DSR would be evaluating the artifact, which was designed and developed according to the requirements of the teachers. The evaluation is an essential component of DSR and is emphasized as "crucial" in discussions about how to conduct a DSR (Hevner et al., 2004; Peffers et al., 2008). To measure the improvement progress, the evaluation needs to be cyclical or iterative (William & Black,1996). This phase of DSR is used to estimate a situation before development begins, or - more often - to measure the results after development completes. An *ex-post* evaluation – which was the case in this research - regards a developed system after it has been constructed, designed, or implemented (Klecun & Cornford, 2005). The key purpose of evaluation in DSR is to determine how well a designed artifact achieves its expected environmental utility. A second goal of evaluation is the demonstration of design theory in terms of the quality of the knowledge outcomes (Vaishnavi & Kuechler, 2015), that is, to provide evidence that the theory leads to some developed artifact that will be useful for solving some problem or making some improvement.

To that end, study 4 entailed the implementation of an updated version of the artifact FunHomework, which was implemented in actual school settings to assess it against the desired goal. This evaluation was continued throughout the study and was used to guide the development of design principles and improve the artifact to best suit teachers' needs.

This implementation examined the effectiveness of FunHomework in promoting the use of game-based learning and overcoming obstacles related to its integration in classrooms. The evaluation intended to confirm FunHomework's usefulness in diverse formal education settings with a variety of curricula, schools, and countries. Additionally, study 4 aimed at measuring the impact of introducing FunHomework on educators' decisions to embrace game-based learning by resolving numerous important challenges, like curriculum synchronization, time constraints, and student performance monitoring, as well as lowering game creation costs.

1.4 Overview Of The Thesis

As declared in this chapter, the central research problem is formed by the slow rate of DGBL's adoption in formal learning, which translated into the necessity of innovative solutions to foster DGBL adoption and feasibility, such as the development of an accessible game authoring tool. Applying the DSR methodology, the chapter established a methodical approach to construct and refine such a tool with the aim of overcoming the identified barriers that impede educators from effectively engaging with DGBL. Advancing into the first step of the DSR, awareness of the problem, the thesis progresses to Chapter 2, which

presents a systematic literature review of the breadth of existing research that is pertinent to the overcoming of barriers to DGBL adoption. The literature review will, therefore, expose various strategies and solutions reported in scholarly sources in order to understand, as broadly as possible, the context of the problem and fine-tune the proposed interventions. Through this rigorous examination, the study seeks to map out effective methods and identify gaps where further innovations, like the simplified authoring tool, can make a significant impact.

The rest of the dissertation covers and depicts the four sub-studies. In chapter 2, the first sub-study is presented, which explores the existing research about game-based learning and the obstacles that might prevent teachers from integrating SGs in schools. Then chapter 3 presents a study that investigated teachers' needs and attitudes regarding game-based learning. Thereafter chapter 4 outlines the third sub-study, which focuses on introducing the suggested FunHomework platform and demonstrating the notion of educational games with dynamic content. Chapter 5 describes the study on the deployment of FunHomework in elementary schools and confirms the potential of educational games with dynamic content to augment the adoption of game-based learning in formal settings. Chapter 6 finally summarizes the key findings of the dissertation, discusses the reflections and suggests measures for future research and implementation.

Chapter 2

Awareness of the Problem - Literature Review [1]

The COVID-19 pandemic has reinforced the significance of adopting a technological-approach for advancing the future of education, underscoring the need to bring transformational changes in teaching methods by making them more technology-centric. In this context, Digital game-based learning (DGBL) is an efficacious educational tool to improve the quality of education in future classrooms. According to extant academic literature, digital video games entail myriad benefits, such as enhancing students' learning motivation and boosting their involvement in the learning mechanism. In spite of the constructive characteristics of DGBL, digital games' utilization in formal education remains very limited. Additionally, the uptake for meaningfully embedding these games into everyday classroom practice or the curriculum at large has failed to meet expectations. Given the immense contribution of teachers towards the educational framework, their views on the potential accomplishments of digital games will inevitably affect decisions concerning how, when and the purposes for which they would be coalesced with the learning process. Consequently, game designers and developers have taken commendable measures to encourage teachers to adopt game-centric learning in formal education. This paper conducted a systematic study of scientific literature using Grounded Theory to shed light on the various techniques utilized to shape teachers' acceptance for digital games and their implementation across formal settings. To that end, related studies published in game-based learning and educational engineering journals between 2011 and 2021 were classified into categories, before being reviewed and evaluated to assess their contribution to game-based learning's advancement. The study's findings suggest that it is possible to positively change teachers' attitudes towards DGBL by engaging them in game design, provided that it is done in a cost and time-effective manner. Furthermore, future research must explore innovative approaches to facilitate the acceptance of DGBL by duly considering time and budgetary constraints of teachers and schools, respectively.

2.1 Introduction

The use of games for learning has developed over the past decade. Serious games (SGs) are considered an interesting tool that combines entertainment with knowledge transfer. They have a purpose beyond entertainment, e.g., education, training, advertising, or supporting social change (Winn, 2009). SGs offer considerable potential that can be used to facilitate formal and informal learning experiences in many contexts. Many studies have pointed to

[1] This chapter is based on Assaf, M. H. A., Spil, T., & Bruinsma, G. W. J. (2020). Supporting Teachers in Adopting Game-based Learning in Formal Education: A Systematic Literature Review. In P. Fotaris (Ed.), Proceedings of the 14th European Conference on Game Based Learning, ECGBL 2020 Dechema e.V..

the beneficial characteristics of SGs, such as their inducement and stimulus appeal, which can support various learning experiences.

Both SGs and DGBL are closely connected concepts within the literature. SGs are specifically designed games extending beyond the intent of pure entertainment, made with the explicit purpose to serve educational objectives through the integration of game content with learning objectives for appropriate user engagement (Connolly et al, 2012). Whereas DGBL, as per (Prensky, 2001), refers to the pedagogical concept of aligning digital games within an education curriculum, taking advantage of the exciting aspects of games to enhance learning experiences.

Successes in informal learning have caused supporters to falsely believe that implementing SGs into the classroom would be a relatively easy transition and have the potential to revolutionize the entire educational system. In fact, despite the constructive properties of SGs, DGBL technologies have been adopted relatively slowly, and the uptake to embed SGs in meaningful ways into the curriculum or into every day classroom practice is beneath aspirations. According to their report about ICT in Education, the European Commission conducted a survey (Wastiau et al., 2013) in 31 countries to benchmark the progress of ICT in European schools. It was reported that between 50% and 80% of the surveyed students have never used digital learning games during lessons. In their final report in 2019, the European Commission conducted another study (Deloitte et al., 2019) in which they concluded that that the percentage of students who use a computer at least once a week for learning purposes has remained stable compared to the 1st survey of schools.

As the hardware, the connectivity and the software are increasingly available in the learning environment, the paucity of DGBL utilization in formal education can no longer be solely attributed to the lack of ICT; we are now facing other factors. Therefore, this study aims at exploring the recent efforts done to advance the utilization for DGBL in formal education and to what extent have these efforts succeeded to support teachers adopting SGs in their classrooms.

2.2 Problem Statement and Objective

The research in this paper starts from the observation that the uptake of DGBL in formal education, despite its anticipated positive effects, is still limited. In order to foster the utilization of DGBL in educational environments, it would be beneficial to classify the various efforts that aimed at promoting teacher adoption of DGBL. Therefore, the study sought using a systematic literature review to explore the related literature and investigate the recent efforts done to enhance the implementation of DGBL in formal education. We analyze ten years of accumulated research to address the following central research question: What themes have been investigated in prior DGBL research?

2.3 Methodology of literature search

In this study, we used systematic literature review and combined it with (Wolfswinkel et al., 2013) grounded theory literature review method. While systematic literature review offers a pre-defined procedure for literature search and refinement, the grounded theory literature review method ensures extraction of linkages between different papers. The two approaches were chosen to achieve a holistic literature coverage, adequate extraction of meanings and associations between studies as well as thorough analysis. In general, the systematic review methodology appears fundamentally different from the narrative approach, as it clearly specifies its "criterion-based selection" process (Cook et al., 1997). It, therefore, seeks to avoid any possibility of partiality or prejudice that may potentially emerge if unrevealed criteria are used for the selection of the literature. The methodology was initially established in the field of medicine, but has spread to various academic disciplines since. A systematic literature review is defined through the usage of a comprehensive search that scans the relevant body of literature with clearly stated and comprehensible search choices and selection criteria. The development of the corresponding search record makes reproduction and "assess[ment] of the exhaustiveness'' of the study possible such that "scholars in the field can more confidently (re) use the results in their own research" (Brocke et al., 2009).

To examine the evidence published in the reports, we adopted a thematic analysis approach because it was appropriate to aid in identifying themes that can serve as guiding principles in designing interventions for helping teachers in adopting games for learning. Thematic analysis includes inductive and deductive analysis of qualitative data that aids researchers in identifying, analyzing, and reporting patterns (themes) embedded throughout the data (Braun and Clarke, 2006). In addition, the technique affords an exploratory orientation, especially since the area of supporting teachers in game-based learning is under-researched, and it is applicable to multiple qualitative data sources (e.g., focus group, interviews, documents). Furthermore, researchers and practitioners interested in this field can benefit from systematic and adaptive principles to strengthen their endeavors in assisting teachers to successfully adopt game-based learning.

In line with these approaches, we followed a five-stage systematic review process (see Figure 2.1): (1) definition of literature inclusion and exclusion criteria, (2) literature search, (3) literature select and refinement, (4) analysis of selected articles and (5) presentation of findings. The discussions below elaborate on each of these stages and their sub components.

2.3.1 Definition of literature inclusion/exclusion criteria

We set out to ensure a quality review. As such, our literature inclusion criteria were targeted at papers from high-quality sources. We agree with (Webster and Watson, 2002) that high-quality contributions in a field are predominantly found in reputable sources such as academic journals and conferences. Therefore, we included only journal and conference

articles and excluded dissertations, books reviews, case studies and books. We defined our search term as "gam* AND teacher" to capture both *game* and *gamification* related articles.

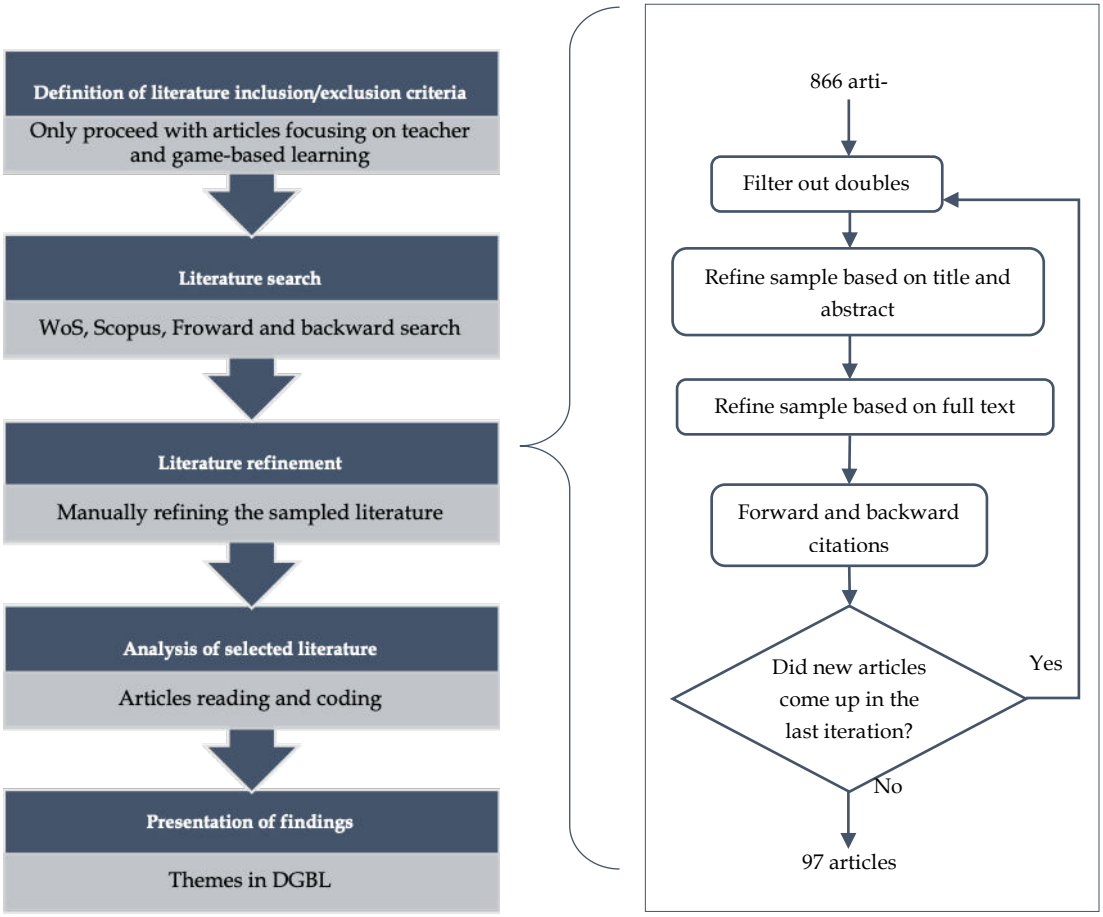


Figure 2. 1 A five stage systematic literature review process

2.3.2 Literature search

To ensure a complete coverage, we started the literature search in two well-known academic databases (Web of Science and Scopus). We chose these databases because they cover a significant range of journals and conference publications. Initial analyses have shown that the addition of further databases would have increased the number of obtained duplicates significantly. The search was temporally bounded for all works between 2011 and 2021. The search query took place on February, 19 (2021) and was updated on March 5 (2021). In the Web of Science, the search was filtered by: Languages = (English), Databases= WOS, KJD, MEDLINE, RSCI, SCIELO, AND Timespan=2011-2021. The search yielded 392 scientific papers. Whereas in the Scopus database, the search was filtered by, Languages = (English) AND Timespan=2011-2021. The search yielded 475 scientific papers.

2.3.3 Literature refinement

After identification of the current body of literature, we exported the results from both searches to Endnote20 and eliminated all duplicate articles and one article with the authors, which gave us a sample of 485 papers for relevancy analysis (see Figure 2.1). The subsequent selection process stage narrowed down the search according to the citation impact to ensure sufficient significance and appropriateness of the research, and to help restrict the focus of interest to a manageable and reputable search for literature. The abstracts, introductions, and conclusions of the remaining papers were analyzed to remove articles that did get through the stage wise selection process but were not significantly meaningful for the review subject. Since the emphasis of this review is on interventions targeting teachers, studies with a purely student focus or on different thematic topics were not considered. We included further relevant articles discovered through a forward and backward tracing of references in the citation index (Webster and Watson, 2002). We performed the literature refinement process by reading the title, abstract and the main text of the sampled articles. We discarded articles that only used GBL as an example, a reference to explain other concepts or listed GBL as a keyword without further discussion in the main text. We also discarded articles that are investigating the aspects of none-digital games like board games. After manually refining the sampled literature, a total of 97 journal and conference articles were selected for analysis in this review.

2.3.4 Analysis of selected literature

At this stage, we assigned codes to the selected articles based on DGBL research themes, theories and gaps for future research. For the DGBL research themes, we applied the tenets of grounded theory literature review method (Wolfswinkel et al., 2013). Specifically, we read individual papers and developed open codes in the first instance. From this analysis, we developed 52 open codes. Next, we analyzed conceptual similarities of the open codes to generate axial codes. As a result, we developed 9 axial codes. Finally, after continuous iterative analysis through mapping and integrating as well as refining of the axial codes (Corbin and Strauss, 1990), we developed 3 selective codes as the main themes in DGBL research.

With regards to analysis on theory, we coded the selected articles based on their underpinning theoretical lens. A master classification table was developed in Microsoft Excel for excerpts, notes and categories from each article. For instance, in coding the article by (Ketelhut and Schifter, 2011), excerpts such as professional development, teacher efficacy, pedagogical issues as well as school culture were derived as the open codes. We also classified the paper under the professional development selective code since the focus of the paper was to address impact of format of the professional development and associated support systems on DGBL acceptance.

2.4 Results

2.4.1 Overview of DGBL research

A comprehensive look at the whole body of literature found, it can be noticed that scientific literature has been giving an increasing focus to DGBL over time (see Figure 2.2). In terms of year of publication, the findings show that the number of articles is increasing in recent years. If we exclude year 2021 - as the search was conducted in February, 2021-, the last three years (2018 - 2020) constitutes about 40% of the published articles. This focus is even expected to be amplified in the coming years as during the COVID-19 pandemic where lockdowns has made a drastic change in school learning paths which have led to home schooling practice and shift to digital learning.

2.4.2 Themes in DGBL research

This subsection addresses the study's central research question. As presented in Table 1, DGBL research can be classified into 3 main themes (see selective codes), namely *Adoption Motivations and Obstacles*, *Teacher Competency*, and *Adoption Strategies*. The Adoption Motivations and Obstacles theme consists of 37 open and 5 axial codes while the Teacher Competency theme contains 10 open and 2 axial codes. Lastly, the Adoption Strategies theme consists of 5 open and 2 axial codes. Each theme identified is further discussed as follows.

2.4.2.1 Adoption Motivations and Obstacles

Understanding the adoption of digital games in school can be framed in the broader context of the adoption of ICT. Studies within the Adoption Motivations and Obstacles theme are considered the first step in any attempt to foster technology adoption by focusing on drivers and barriers of utilization. Specifically, these articles examine the factors that determine why teachers adopt DGBL in classrooms, and the hurdles that impede DGBL acceptance in formal educational settings. By addressing these motivations and obstacles, researchers are trying to underline the critical adoption determinants in order to be tackled in any prospective intervention. The literature here highlights the role of the teacher as the agent of change in the uptake of technological innovations. Therefore, studies in this theme look into the motivations and hurdles mostly from teachers' perspective as teachers' beliefs that digital games will impede rather than facilitate teaching can hinder the uptake of digital games in a classroom

The axial codes under the Adoption Motivations and Obstacles theme as presented in Table 1 are *Personal Factors, Social Influence, Technical Factors, Pedagogical Factors,* and *Administration Issues*.

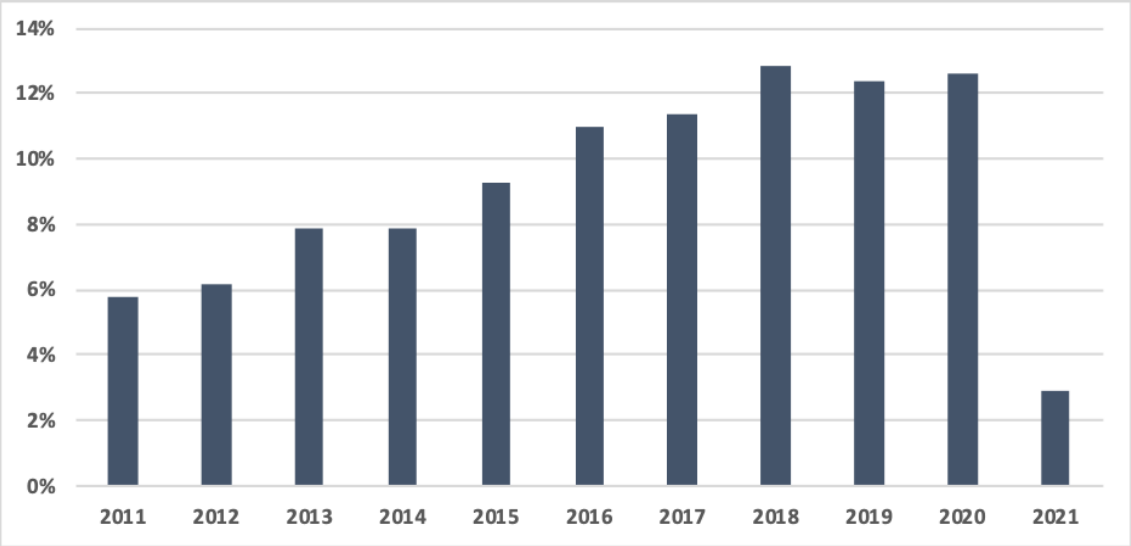


Figure 2. 2 Whole search sample distribution by year of publication

Within the Personal Factors, most of the studies investigated teachers' attitudes and perceptions towards digital games and the factors that influence their technological acceptance. (Bourgonjon et al., 2013) emphasized on the need to understand teachers' perceptions and beliefs that underlie their decision-making processes and to focus on the factors that influence the acceptance of video games as learning tools in the classroom to understand, explain and predict changes in teachers' behavior with regard to adopting these tools. (Hamari and Nousiainen, 2015) also referred to the significance of teachers' attitude in influencing the perceived value of DGBL. Therefore, many studies tried to investigate the factors that can affect teachers' attitudes towards DGBL and highlighted important determinants like; games' complexity (Bourgonjon et al., 2013) (McDaniel and Kenny, 2013), lack of pedagogical evidence (Bourgonjon et al., 2013), and absence of previous games experience (Martin del Pozo et al., 2017) (McDaniel and Kenny, 2013).

A considerable share of the articles also examined teachers' behavioral intention and its relations with different adoption determinants. For this purpose, many studies used the Technology Acceptance Model (TAM) to understand the perceived usefulness and perceived ease of use of digital games. The TAM has proven to be an efficient model and it is widely employed in the field of technology and education (Šumak et al., 2011). It is a robust model that can be extended with additional factors which can be selected based on their specific relevance regarding digital games in a school context. (Sanchez-Mena et al., 2019) used the original TAM to predict teachers' behavioral intention to use educational video games. They found that teachers' perceived usefulness of educational video games is the main antecedent in teachers' attitude formation and behavioral intention. Other studies like (Dele-Ajayi et al., 2017) – who preferred to use a modified version of TAM to suite the particularity of the case study- used TAM to highlight the key areas which require support

and input to ensure teachers are ready to accept and use this technology in their classroom practice.

Regarding teacher's demographics, the literature showed mixed results. For instance, (Marti-Parreno et al., 2016) (Sanchez-Mena et al., 2019) (Noraddin and Kian, 2015) concluded that gender and age were not found to moderate teachers' attitude towards DGBL. (Li and Huang, 2016) suggest that demographics had a moderate effect on DGBL adoption where female and younger teachers are more likely to implement DGBL in their classrooms.

Within the Social Influence, researchers tried to shed the light on the impact of teachers' surroundings on their adoption decisions. One important social factor that influences the uptake of DGBL by teachers is the presence/absence of the models of success. In their studies (Stieler-Hunt and Jones, 2017) (Stieler-Hunt and Jones, 2019), concluded that even teachers who use digital games in the classroom can experience varying degrees of alienation and resistance from their teaching colleagues. For that, it is recommended that teachers need to work together at a single school site rather than alone as small pockets of innovation.

Selective	**Axial**	**Open**
Adoption Motivations and Obstacles	Personal Factors	Technology Acceptance
	Social Influence	Attitude
	Technical Factors	Perceptions/Views
	Pedagogical Factors	Behavioral Intention
	Administration Issues	Beliefs/Opinions
		Reluctance/Discomfort
		Demographics
		Expectation
		Needs
		Lifestyle
		Game Experience
		Confidence
		Self-efficacy
		Openness
		Innovativeness
		Models of Success
		Colleagues Adoption
		Hardware Compatibility
		Classroom Setting
		Availability of Games

Selective	Axial	Open
		Games' Complexity Technology Support
		Teaching Level and Experience Teacher Role Curriculum Highlight Game Benefits Material/Content Time Class Management Student Evaluation/Assessment Lack of Evidence Student Preferences Organizational ICT Culture Costs Community/Parents
Teacher Competency	Professional Development Game Literacy	Technology Integration TPACK Computer Skills Design Learning Activities Efficacy Evaluate and Select Games Re-design games Gameplay Exposure Game Development Tools Constructionist Gaming
Adoption Strategies	Theoretical Model Applied Framework	Identification/Classification Games Review/Rating Repurposing Games Game Design Support Game Customization Tools

Selective	Axial	Open
		Game Simplification Engagement in Game Design

Table 2. 1 DGBL research themes

Several scholars have emphasized on the Pedagogical Issues as a crucial factor for DGBL adoption. The congruency of games with the curriculum plays an important role in the adoption decision. Within Pedagogical issues, scholars investigated the role of the teachers as well as the challenges associated with the implementation of DGBL in classrooms. Several studies have discussed how the new technological tools force the change on teachers and demand new confrontations like limited preparation time (Molin, 2017) (Webb et al., 2015) (Allsop and Jesse, 2015), appropriate assessments (Molin, 2017), choosing appropriate games (Molin, 2017) (Emin-Martinez and Ney, 2013), game-based curriculum (Marklund and Taylor, 2015) (Webb et al., 2015) (Allsop and Jesse, 2015), classroom setup (Webb 2015) (Webb et al., 2015) (Allsop and Jesse, 2015), students' administration (Marklund and Taylor, 2015), maintenance (Webb et al., 2015), skills at using games (Foster and Shah, 2020).

After addressing teacher-related issues, researchers tend to tackle technical and administration factors which are usually discussed within the same context. The initial adoption decision of teachers in the first place resides on the individual level, however, once this initial adoption decision is made, issues on the school level could impede further uptake of digital games (De Grove et al., 2012). On the school level, recurring issues concern infrastructure, technical support, cost and school culture. In order to harness the potential effects of digital games, schools need to acquire access to a functioning technology infrastructure (e.g., computers, high-end graphic cards, memory storage, and/or network connectivity). Hence, when using digital games in the classroom, it can be expected that technical problems emerge. If no or insufficient technical support is anticipated, teachers will be less likely to use digital games. As the hardware, the connectivity and the software are increasingly available in the learning environment, the lack of ICT is not being frequently addressed especially in recent studies. What can be a more technical challenge is the availability of innovative digital games that can meet teachers' needs and expectations. (Jesmin and Rinde, 2018) referred in their study to the lack of high-quality content and resources available as the main obstacle to the teachers' actual use of digital games, suggesting that creating a single repository for educational games and ideas can help overcome this problem. Administration wise, the lack of funding has been repeatedly reported as a big barrier (Watson and Yang, 2016) (Alyaz and Genc, 2016) (Chen et al., 2012). The utilization of digital games demands additional costs for purchasing game licenses and keeping the technology infrastructure in schools up-to-date. Here, limited budgets appear to be the most

crucial inhibiting factor for implement DGBL. Thus, according to teachers' opinion, despite their positive attitudes and their intention to use digital games for teaching, it is assumed that there will be insufficient financial support. To reduce these financial demands, (De Gloria et al., 2014) noted that the use of Commercial Off The Shelf (COTS) games is being considered for instruction, given their popularity, validity and cost-effectiveness. Other researchers (Molnar et al., 2015) (Baldauf et al., 2017) (Marfisi-Schottman and George, 2014) have also offered innovative mobile games that can be inexpensive to produce and run on low-cost computational platforms.

2.4.2.2 Teacher Competency

Studies within Teacher Competency theme focus on improving teachers' skills to enable them adopting DGBL effectively in their classrooms. These studies have either investigated professional development (PD) related to ICT skills, or suggested special tracks for developing teachers' game literacy. For PD, scholars tried to identify the needed skills and competencies for deploying DGBL in schools. As the provision of high-quality teacher training on the educational applications of games is of paramount importance to their effective integration in classroom settings, it is required to help teachers learn both why they should adopt and how to become adept at integrating technologies into their curriculum and instruction.

Different frameworks have been proposed on how to shift the focus from teaching technology to using technology to enhance learning. (Ketelhut and Schifter, 2011) explored (Schifter, 2008) principles for successful technology professional development; (1) Time to practice technology, (2) Technical support in the classroom, (3) social support system, (4) Changes in classroom. (Ketelhut and Schifter, 2011) argued that these principles make a model for innovative technology implementation to ensure teachers are secure in using the technology, knowing they will have technical support when needed either through outside technicians or internal social support.

Another famous framework for PD is the Technological Pedagogical Content Knowledge (TPACK) framework (Mishra and Koehler, 2006). Conducted studies illustrate the usefulness of TPACK as a research framework for facilitating and assessing teachers' professional growth in the use of ICT in education. TPACK has, in recent years, become central to research into technology education and teacher professional development in many different disciplines. Several studies targeting pre-service and/or in-service teachers undertaken during the past decade have been grounded in the TPACK model (Hsu et al., 2014) (Meletiou-Mavrotheris and Prodromou, 2016) (Figg and Jaipal-Jamani, 2018) (Tokmak, 2015). Scholars, though, have shown mixed results on the effectiveness of TPACK. (Meletiou-Mavrotheris and Prodromou, 2016) for example, have stressed on the usefulness of TPACK as a means of studying and facilitating teachers' professional growth in the use of ICT in education, helping them to move beyond their restricted views of digital games as

educational tools, and to improve their confidence and ability to integrate them within the curriculum. (Hsu et al., 2014) from their side, argued that current (TPACK) studies are inclined to treat technology in a general manner, which may not be able to provide adequate guidelines to improve teacher preparation and professional development when teaching with games. Therefore, they suggested a slight variation (TPACK-G) in which they added a game-knowledge dimension in order to promote teachers' knowledge about choosing appropriate games to enhance how and what students learn in the classroom.

While PD frameworks plan to grow teacher's professional digital knowledge on the mid-long terms, other researchers tried to conduct "fast-track" interventions in order to raise teacher game literacy using special courses and workshops. In these case studies, researchers aimed at changing teachers' attitude towards games, inform teachers about the anticipated positive effects of games and the key benefits they can bring to educational settings, and provide teachers with the knowledge and skills for effective DGBL adoption. Scholars have tried in this regard to expose teachers to gameplay (Chen et al., 2012) (Correia and Santos, 2017), help teachers evaluate and select digital games appropriate (An, 2018), support teachers identify game requirements (Saggah et al., 2020), and provide teachers with the skills needed for Constructionist Gaming to engage learners in game design and development (An, 2018) (Sancar Tokmak and Ozgelen, 2013).

2.4.2.3 Adoption Strategies

After investigating the impediments of DGBL, the next step would be to provide solutions to overcome the obstacles that limit DGBL adoption in formal education. Researchers here tried to present innovative solutions that facilitate DGBL implementation using theoretical models and applied frameworks that challenge the previous hurdles. Some scholar tried to help teachers identifying games that can be integrated in school curriculum. As the awareness about SGs and the potential they can bring to the educational environment raised, teachers' decision about the adoption of game-based learning may be now impeded by the availability of suitable games that can match the pedagogical practices. In this regard, few researchers tried to classify SGs to ease teachers' task in identifying appropriate games. Maybe one of the most well-known and recent classifications of SGs is the G/P/S model by (Djaouti et al., 2011), which considers interactions between games and players. The proposed model classifies serious game with three categories; Gameplay, Purpose, and Scope, offering quick overviews for educators to easily identify educational games for their students depending on the desired purpose. Another study by (Wu, 2015) offered a typology of educational digital games in order to support teachers in familiarizing themselves with the selected game(s) before classroom application. Particularly, the typology aims to aid teachers in identifying games based on modern learning theories (behaviorism, cognitive constructivism, social constructivism, and constructionism). According to (Wu, 2015), the typology would allow teachers to identify games along targeted learning

opportunities, target age group and learning objectives, in-game subject area, learning objectives, and the technology and resources needed to use the game.

Many researchers realized the importance of involving teachers in SGs design and how the design experience can positively influence teachers' attitudes regarding the use of digital games in the classroom (Sancar Tokmak and Ozgelen, 2013) (Li et al., 2013) (An and Cao, 2017) (Frossard et al., 2015) (Tobar-Munoz et al., 2016) . (Li et al., 2013) for instance, examined how teachers' perceptions of digital games evolved through the process of designing and building their own educational games. Teachers were first introduced to various online games, and then they were engaged in game design and development using Scratch or any game design software. After developing their own games, the interviewed teachers indicated that the game design process enabled them to use all the 21st century skills. The study revealed that many participants experienced difficulty in translating their design ideas to a game. Some teachers had to completely change their game designs to fit the program they used.

As the game design can be a laborious task, researchers tried to either simplify the design process so that teachers can design their own games, or by creating customization "authoring" tools that help teachers integrate their learning objectives or activities into gameplay. (Van Rosmalen et al., 2015) conducted a study to exemplify that games are not necessarily the exclusive domain of game professionals by providing approaches that teachers themselves can use to build games or make use of existing games. For that, they explored various strategies starting from some very simple games that might be readily included in a lesson, game engines purposed on teachers and, finally, to games purposed on students themselves, intending to inspire teachers to build and use their own games. (Kutay et al., 2013) on the other hand, tried to provide the tools for novice IT users to develop immersive games for teaching which teachers can use to modify content and context, so that they can develop relevant material and generate interactive games that simultaneously challenge the students to think differently. In the same vain, (Romero and Barma, 2015) explored the effectiveness of different adoption strategies like customizing games, repurposing existing games and creating new games on identifying games that could be used in the context of the primary education curriculum in Quebec-Canada. They concluded that customizing and creating new games are generally avoided by teachers due to due to the technological restrictions. Therefore, they pointed out that there is a need to allow teachers to develop the strategies of customization, repurposing and game creations, and limit the expectations of finding a perfect match between the SG and the curricular objectives. Another interesting adoption strategy is used by (Molnar et al., 2015) where they provided teachers with a platform that enable them from personalizing the educational content and integrating learning objectives into gameplay at runtime. This has not only eased the game design for teachers, but also allowed them to customize the game content for their specific needs.

2.5 Conclusion and future work

In this paper, we conducted a systematic literature review to understand the state of DGBL research and highlight potential areas for future research. The study aimed at shedding the light on the most important efforts that support teachers adopting DGBL in their classrooms. For that we conducted a systematic literature review for the academic works within the last decade. As such, one central research question guided the study, namely:

What themes have been investigated in prior DGBL research?

In terms of the issues investigated in prior studies, our study reveals that DGBL research can be categorized into three main themes, namely Adoption Motivations and Obstacles, Teacher Competency, and Adoption Strategies (see Table 2.1). Our findings reveal that the DGBL research is generally increasing over years, this can be attributed to the technological advancement and increasing availability of ICT in school environments. From the three main themes in DGBL research, Adoption Motivations and Obstacles dominated the others. As such, we believe that this theme has been extensively investigated and most of the researchers concluded to very similar adoption determinants. Unless there would be a need to investigate the adoption barriers for a very specific case study, we do not see many potential gaps in this research area.

As the adoption impediments are well defined, overcoming these obstacles requires both a top-down and a bottom-up approach. It would be beneficial to consider the aspects of teacher competency in order to provide recommendations for policy makers to establish professional development programs that empower teachers with the skills and knowledge needed for DGBL adoption. Hence, we argue that future research should consider more focus on providing innovative DGBL adoption solutions that take into account limited time available for teachers, relevance to curriculum and learning objectives, and schools' budgets and limited ICT resources.

By unearthing the findings pointed above, this study makes the following contributions. First, this study serves as a foundation for future DGBL research by revealing knowledge gaps for further investigations. Second, the use of grounded theory literature review method in this study moves our review a step further from some existing ones to enable a holistic literature coverage and thorough analysis for advancing knowledge. Thus, future reviews can follow this study as a guide to operationalize the grounded theory literature review method. Lastly, this study contributes to the understanding of the DGBL concept by clearly delineating its components, properties and characteristics. We envisage the discussions in this article to rekindle debates and draw new researchers to push forward the development of DGBL research. Two key limitations of our review are the subjective approach of deriving the DGBL research themes and our focus on themes. As such, future

studies can employ objective methods such as scientometrics, bibliometrics, or main path analysis to review studies on DGBL to augment our research.

2.6 Summary

This chapter ends, therefore, with an extensive systematic literature review that delineates various strategic solutions to overcome the obstacles that impede the adoption of DGBL in formal education settings. In this chapter, through a comprehensive systematic literature review, it was realized that although several strategies had been discussed and proposed, indeed, there is a need for innovative solutions that could address these challenges. The review identified some of the most critical areas where available tools fail, and underlined the need to design practical, user-friendly, and technologically flexible tools that can make DGBL more easily integrated and accepted within the most varied educational contexts. This gap, therefore, points out the need to develop new methodologies that can overcome the existing bottlenecks of adoption to DGBL in favor of more effective educational outcomes.

Chapter 3 moves from theoretical solutions to practical experiences: the perceptions of Jordanian in-service teachers about DGBL in their environments. This chapter, representing the second part of the problem awareness phase in the DSR framework, now seeks to understand the specific challenges and attitudes that teachers in Jordan face when trying to apply DGBL in their classes. This part of the thesis aims to gather first-hand opinions with regard to practical use of DGBL in relation to infrastructural and pedagogical aspects that influence the adoption of DGBL. The further findings from this study will be contributed toward developing a solution in a way that takes into account the needs and the hurdles that the educators in Jordan are facing, hence enhancing the practical relevance of the sought solution.

Chapter 3

Awareness of the Problem - Teachers' Perceptions[1]

Over the past few years, academics have witnessed an increasing amount of attention being accorded to games as learning tools. According to several researchers, (de Freitas, 2006; Egenfeldt-Nielsen, 2005; Prensky, 2006) SGs can assist learning by emerging as an alternate means of presenting instructions. Whilst SGs are increasingly gaining acceptance as a learning tool, their application in formal education remains rather limited, which underpins the importance about understanding what makes a game effective and how it must be used in classrooms. Given that teachers play a key role in shaping and responding to the intricate contextual factors influencing the manner in which games are experienced across educational settings, their opinions on what SGs can possibly accomplish in educational settings would inexorably impact the decisions relating to when, how, and for what purposes they would be incorporated in classrooms. Against this backdrop, this study administered a survey online and in hardcopy to ascertain teachers' perceptions on SGs and their effect on their contribution as a teacher. It also pinpointed the challenges and impediments of utilizing SGs in classrooms through teachers' perspective, which illuminated the attitudes teachers generally bring to games-based learning environments. According to the findings, teachers are typically open to using SGs in their classrooms. Overall, it can be inferred that the design/development of SGs aimed at formal education can benefit significantly by adopting game features and surmounting the hurdles addressed by teachers.

3.1 Introduction

Both game-based learning and serious games (SGs) can foster student interest and motivation in the subject matter, thereby enhancing the efficacy of learning (Wouters & van Oostendorp, 2023). Making the learning process fun and engaging is not only known to make learning more compelling, but also more efficacious by engaging the participants in an emotional and cognitive manner (Prensky, 2002). To that end, one of the key traits of SGs is their ability to integrate the element of fun whilst delivering informative instructions. Through their ability to engage with students at a deeper level, SGs help increase learners' attention, motivation and in effect, learning. There is credible research that suggests that students today have a gaming-enabled learning style (Clark et al., 2016).

Examining various young professionals, (Beck & Wade, 2005; Jones & Shao, 2021) found that their learning style was deliberately overlooking the format and structure of formal education. Using trial and error extensively, they gladly accepted instruction and

[1] This chapter is based on Assaf, M., Van Hillegersberg, J., Spil, T., & Arikat, N. (2019). Teachers' perceptions about using serious games in formal education in Jordan: Possibilities and limitations. In S. Schreiter, & A. K. Ashmawy (Eds.), Proceedings of 2019 IEEE Global Engineering Education Conference, EDUCON 2019 (pp. 436-441). [8725193] IEEE Computer Society. https://doi.org/10.1109/EDUCON.2019.8725193

contribution from peers; they were amplified on 'just in time' learning to conclude their tasks and meet their needs. All such skills are deemed essential in modern scenarios and SGs can help students develop and practice them.

It is believed that SGs have the potential of being used across schools. However, in order to draw maximum benefits from SGs in classrooms, it is important to acknowledge the influence of context concerning how games are played and understood, as well as to understand the critical role played by teachers in shaping and manipulating such contextual scenarios.

The efforts in the development of serious games and affiliated learning materials concerning schools are primarily focused on chronicling the utilization of games in classrooms and elucidating the learning principles as well as pedagogies. Nevertheless, problems tend to arise when games are specifically designed and introduced for schools with incomplete awareness of the teachers' role in shaping a gaming experience (Stevens et al., 2008). Unfortunately, most of these challenges manifest when the educational advantages of games are spoken about without understanding the role of teachers within games-based classrooms, or when they are deemed complete.

The rising interest in SGs as tools of learning are typically geared towards the benefits of games contributing to students' learning (New Media Consortium, 2012); the rationale behind why games are suited to learning contours of the 21st century; as well as the specific domains of application which could benefit from the utilization of digital games (Young et al., 2012) A large part of this research indicates that games tend to almost always enhance student learning and achievements. In particular, 'black box' notions of games, in the context of learning, underpin the importance of context as well as the manner in which teachers influence what games eventually manage to achieve in classrooms.

According to many researchers, games-based learning in schools is closely linked to the manner in which teachers perceive games. For instance, (Squire, 2002) contends game play's educational value is derived from the creative utilization of educational media along with efficacious pedagogy in order to encourage students to take part in meaningful learning practices. Analogously, (Mehrotra et al., 2012) opines that although games can support a gamut of learning styles, manner in which teachers work with games can directly impact the success or failure of game-driven initiatives.

While there are individual studies that specifically focus on how teachers influence game-based learning outcomes, their role in SGs' design and development has generally been neglected in past researches in the parlance of serious literature on games (Perrotta et al., 2013; Connolly et al., 2012). Therefore, this study aims to bridge this gap by sharpening the focus on understandings, attitudes and expectations about serious games on the part of different primary school teachers across Jordan.

Since not many studies have explored the nuances of game-based learning in the Middle East, this study is aimed at reviewing teachers' perceptions concerning the application of serious games in Jordan's primary schools. It also aims to determine the vital factors that affect teachers' attitudes on integrating digital games in their teaching practice.

3.2 Existing Research

Generally, the literature related to teachers' views on digital technologies and game-based learning has presented conflicting results. For example, (Razak et al., 2012) probed the use of digital game-based learning and the utilization of game creation tools in the Curriculum for Excellence across Scotland's private schools. To that end, a web-based survey was followed by interviews of some teachers. The survey covered 49 primary schools, and as many as 62 responses were received from teachers who were all females, with their mean age being 32.8. Nearly 50% of the teachers conceded that they had never used game creation tools or computer games; 39% had only used computer games, while 3% reported that they had only used creation tools. Meanwhile 8% had used both game making tools and computer games. Teachers were found to largely use free online mathematics along with language games. According to their conclusions, computer games do not eradicate the importance or role of the teacher; however, there is a need to train and expose teachers to game-based learning to help them increase their understanding and ability to use this approach.

In a study on augmenting teachers' use of digital content, (Gaffney, 2010) examined the design principles in technology adoption. He opined that the increasing use of technology is primarily aligned to the action of education and government authorities, which reinforces the importance of collaboration between educational stakeholders. He also concluded that the role of teacher training institutes and universities cannot be ruled out since they provide the in-service training and develop a theoretical framework involving learners, teachers and policy makers.

Similarly, (Allsop & Jesse, 2015) studied the teachers' reflections and experiences on game-based learning in primary classrooms, which evidenced 89 responses across primary school teachers in Italy and England. Close to 70% of teachers in both countries stated that they did not have any previous experience of teaching game design. As per (Allsop & Jesse, 2015), barriers such as limited access to equipment and the curtailed ability of schools' information and communications technology (ICT) capability, coupled with the paucity of relevant games relevant can limit the use of digital games in classrooms.

Correspondingly, (Beavis et al., 2014) examined the data collected for a research project that focused on learning and teaching of digital games across Australian classrooms. This study explicitly focused on different teachers' understanding, attitude and expectations about digital games. This study's central observation was that teachers were very

optimistic about the potential impact of games on learning environments. In addition, it reported data concerning teachers' views on the limitations of digital games. Teachers exhibited some concerns associated with the effect of games on teachers' control of learning as well as the learning environment. They also voiced concerns about the limitation of time and resources.

In the previous related literature, we found that utilizing game-based learning in classrooms is usually associated with some classic impediments like the availability of ICT and action of government authorities, which games' engineers cannot do much about them. This study investigates the hurdles more thoroughly by seeking the opinion of teachers and exploring their attitude about SGs and the actual limitations that hurdle their use. This will provide more accurate input to the design/development process of SGs, and help creating more acceptable and usable SGs.

3.3 Education and ICT in Jordan

Jordan's educational system comprises of a two-year cycle of preschool education followed by 10 years of compulsory basic education as well as 2 years of vocational /secondary academic education after which, students appear for a General Certificate of Secondary Education Exam, also referred to as Tawjihi. Notably, secondary education does not entail any charge in government schools (Education System in Jordan, 2018).

Jordanian schools can be divided into two main categories, private and public. The private sector educates nearly 20%-40% of the nation's student population (UNICEF, 2014). The same textbooks are used by all government schools and most private ones. The School Curricula and Textbooks Division of the Ministry of Education produces and prints textbooks that are distributed free of charge in the compulsory stage, but at a nominal fee during the secondary stage.

While some private schools do provide better educational opportunities than public schools, others are set up in order to bridge the gaps created by public education authorities. In turn, this makes the infrastructure differ between private and public schools. Whilst the Ministry of Education has strung hard to integrate computer laboratories across all schools – almost 93% of primary and secondary schools currently have functional computer laboratories (UNESCO, 2013), the number of learners who share a computer remains relatively high. (UNESCO, 2013) suggests that in public schools, the learner-to-computer ratio is 25, whereas it is 29 in private schools. With regard to connectivity, 61% of computers have Internet connectivity across public schools, as compared to 71% in private schools (UNESCO, 2013). The Ministry of Education is taking proactive steps to make available a sizeable number of computers for pedagogical purposes across all educational levels. When preparing its policy framework, Jordan addresses ICT allocation for both

administrative and pedagogical purposes by directing its efforts to cost-efficient measures in order to acquire resources, as opposed to only depending on education budget (UNESCO, 2011).

With regard to usage, ICT in Jordanian schools is limited and largely reliant on the availability of Internet connectivity and adequate infrastructure. For this reason, Jordan emphasizes Computer Assisted Instruction (CAI) in primary as well as secondary schools. Close to 88% of primary schools currently offer CAI, which is available in 97% of all secondary schools (UNESCO, 2013). Since Jordanian children as well as youth are acquainted with majority of the computer skills informally outside of schools, ICT's integration in primary and secondary curricula at an early stage is paramount since it plays a key role in ensuring the implementation of ICT in school classrooms.

Given that teachers are believed to have the strongest important influence on classroom learning, it is they who play a vital role in making sure that students make effective use of ICT both inside and outside school premises. Consequently, they not only know how to instruct their students to make effective use of ICT, but also require training in using ICT to teach different subjects and integrate ICT across the curriculum in order to elevate the overall learning experience whilst enhancing students' academic achievement.

Meanwhile the integration of digital games in game-based learning is confined to individual initiatives across some schools – (Shahrori and Rimawi, 2011; Saraira, 2011)- and cannot be considered to be a general orientation for government's educational policies. Therefore, this study aims to shed light on the potential use of digital games as educational tool, as well as to create awareness about contribution of SGs in the educational system, whilst exploring the possibilities and limitations for adopting game-based learning in Jordan's formal education curricula.

3.4 Survey

In this study, data were gathered via a survey that was administered both online and in hardcopies. Aimed at primary school teachers in Jordan, it was supplemented using direct contact with school directors and teachers. This survey was shared through email as well as on social media networks, while its hardcopies were delivered for schools that did not have any Internet access.

When teachers were invited to complete the survey online or offline, the participants were specifically informed about consent and right of withdrawal. They were given provided information about the purpose of this investigation and were made aware that this survey was primarily targeted at primary teachers. Originally written in English, the survey was translated to Arabic and formulated into 2 open questions and 20 closed questions.

The responses to survey were indicated by checking one (or more) of the items from a list of answers. Figure 3.1 illustrates a sample question of the survey (English version) used for most of the questions.

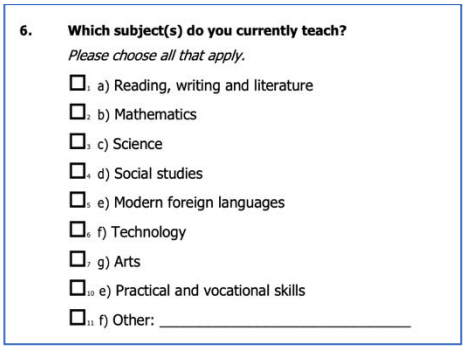

6. **Which subject(s) do you currently teach?**
Please choose all that apply.
☐ a) Reading, writing and literature
☐ b) Mathematics
☐ c) Science
☐ d) Social studies
☐ e) Modern foreign languages
☐ f) Technology
☐ g) Arts
☐ e) Practical and vocational skills
☐ f) Other: _____

Figure 3. 1 Sample question of the survey's English version

The term "Serious Games" is not very commonly used in Jordan, so, a brief introduction about SGs was presented at the beginning of the survey to make sure that teachers are aware about the subject of the study. As we will see in the results later, some teachers had already used games in their classrooms and were more familiar with "Game-based Learning" expression.

Questions were grouped in three categories. Under the background information group, teachers were requested to share some basic data such as age-group and gender, education level, duration of teaching experience, and the subject(s) taught by them. They then indicated the ICT (Information and Communication Technologies) made available in their schools, as well as to estimate the number of hours they put in a typical school week as duties.

The second group meanwhile targeted the teacher's game play experience as a player. In this group, teachers were asked to provide information about what genre of games they play (if any), and the amount of time they spend while playing games every week. In addition, they were asked about the platforms they used to play such games. In addition, information about teachers' thoughts and experiences about SGs was gathered in the survey's third part. They were asked to indicate their acceptance about the idea of using SGs to gain knowledge and to know their willingness to use such games within their classrooms. The survey also intended to investigate teachers' beliefs about the benefits of SGs (if any) in classroom settings, the features which a same must use in education, as well as the obstacle(s) that impeded their usage in school, if any. Teachers were also asked to describe how teaching with games could impact their role in classroom in an open question.

3.5 Findings and Discussion

As many as 76 responses were received, of which were 66 female teachers and 10 were male teachers. Table 3.1 depicts the number as well as each gender's whole percentage falling into different age-groupings.

Age	Female %	Male %	Total %
Less than 25	3.0%	0.0%	2.6%
25 – 29	10.6%	40.0%	14.4%
30 – 39	51.5%	40.0%	50.0%
40 – 49	30.3%	20.0%	29.0%
50 – 59	4.5%	0.0%	3.9%
60 and more	**0.0%**	**0.0%**	**0.0%**

Table 3. 1 Number of teachers for each gender in different age-groupings

More than 86% of all participants were females and the majority of them were aged between 30 and 49 (more than 80%). Meanwhile 80% of male teachers were between the ages of 25 and 39. In this relatively small sample, participants can be considered to represent the overall Jordanian primary teaching populations with regard to both age and gender (The World Bank, 2018). Over 53% of teachers were found to have teaching experience of between 5-15 years (Figure 3.2).

In terms of ICT infrastructure, teachers were asked to choose all the technology tools available for educational purposes in their schools. Nearly 51% of teachers reported using PCs and/or Laptops in teaching their subjects, whereas 50% mentioned the availability of interactive-whiteboards for their students; similarly, 13% of teachers stated that students access smartphones and tablets in the class. Nearly 23% of teachers meanwhile do not use any ICT devices within their schools.

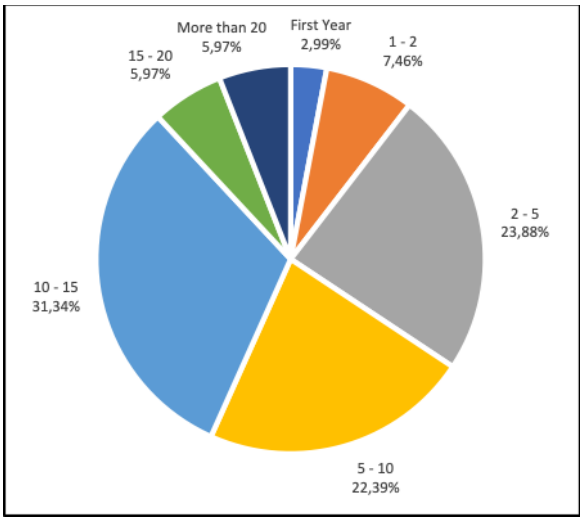


Figure 3. 2 Teachers' experience in years

During the survey's second part, teachers were asked to share their experience with digital games along with the devices they are using to play games. It was found that over 80% of teachers played games for less than one hour per week, whereas 16% spent 1-5 hours weekly on gameplay. Not surprisingly, tablets and smartphones were reported as the preferred devices to play games with 80%, followed by Laptops and PCs with 20%. According to the findings, 68% of teachers preferred puzzle games while nearly 22% opted for strategic games. Figure 3.3 illustrates the most preferable genre of games played by teachers.

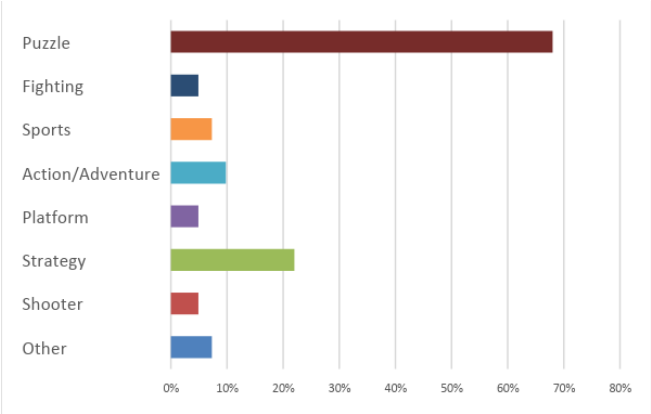


Figure 3. 3 Games Genre Played by Teachers

Meanwhile the last part of this survey encompassed teachers' interest in SGs as well as their features. When they were asked to share their thoughts on using SGs in formal education, 97% of teachers said they did believe that games could be used to acquire knowledge. Teachers also exhibited a strong willingness towards using SGs within their classrooms (Figure 3.4). With regard to the question: Are you ready to use SGs to teach your subject(s)? Over 84% of teachers answered in the affirmative (Yes) and nearly 16% answered Maybe.

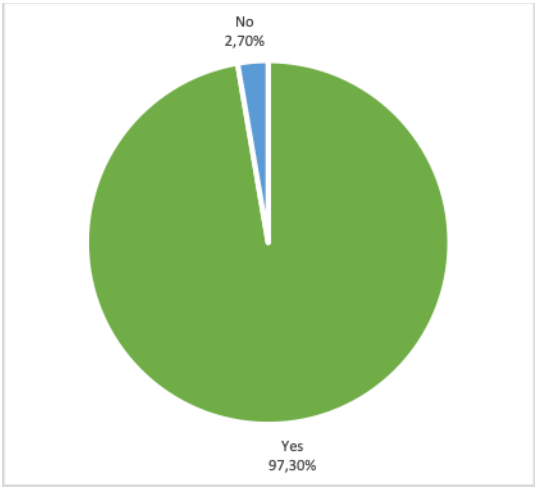


Figure 3. 4 Teachers believes about using SGs to acquire knowledge

Notably, teachers did emphasis on the several potential advantages of SGS in education. Close to 65% of teachers believed that SGs can enhance student engagement in the subject being taught and boost student academic achievement (65%). In addition, 62% of teachers opined that SGs can improve students' skills in using technology, with 58% reporting that SGs can foster creativity.

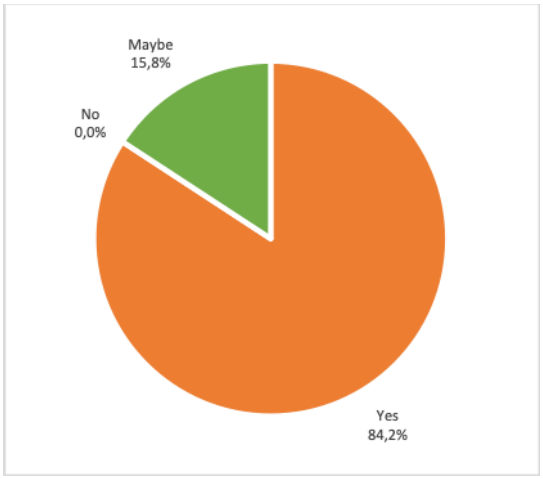


Figure 3. 5 Teachers' Willingness to use SGs in classrooms

When asked about the impediments for using SGs in school, 'Teacher's attitude towards using SGs' was found to be the most reported obstacle. This may seem contradictory given that 84% of teachers expressed willingness to use SGs in the classroom (Figure 3.5). The contradiction can be explained by teachers' genuine interest in the potential of SGs to enhance learning but are concerned about practical issues such as the relevance of available SGs to the curriculum and their own comfort and familiarity with such tools. This suggests that while teachers see the value in using SGs, they may feel hindered by external factors

like the lack of suitable games that align with their teaching objectives or curriculum standards, which was identified as the second most significant obstacle in the survey.

One plausible explanation for this could be that teachers tend to stick to school curriculum in order to make sure that their educational program are completed on time. They also avoid playing games which are not directly related to their plan. According to a considerable number of teachers, Preparation Time could also be deemed as a major barrier against SGs, which is not surprising since the use of games can increase the quantum of workload on teachers. Rather surprisingly, 'Lack of ICT' was the fourth most reported obstacle.

In an open question, teachers were requested to explain the manner in which the use of SGs affected their role as teachers. Most teachers emphasized the positive ramifications of using SGs in classrooms.

In fact, one of the teachers replied, "Using games in classroom will increase teacher-student interaction in an enjoyable environment, which can speed up knowledge delivery with less time and effort." Meanwhile another teacher said: "When using games in classrooms, the student will be the core of the educational process, where teacher role will be only to supervise, coordinate, and encourage the students by providing appropriate educational environment." Additionally, teachers underpinned the significance of using games which are closely associated with the subject: "If the learning tool (the game) is easy to use and closely related to learning contents, this will facilitate student integration in the subject to be learned." Only one teacher expressed some apprehensions about using games in classrooms: "Eventually, students will be tied to the game and deny the role of the teacher."

The last question of the survey sought clarity about the characteristics which a good SG must possess in the context of formal education. Attributes such as availability for different platforms (Web, PCs, smartphones), and including some fun elements were frequently reported. In this regard, one of the most frequently reported characteristics demanded by teachers was their ability to control the game's learning contents and game elements through which they could keep track of the learning objectives and feel a greater degree of confidence about their contribution as class-leaders.

Furthermore, teachers also evinced a strong interest in games that could be attributed to Learning Management Systems (LMS) such as *moodle* and *Sakai*, something that could be justified for teachers already utilizing LMSs within their schools and wanting to have some level of integration between game-based learning and LMS. According to some teachers, a successful SG should be able to provide multi-player mode, which indicated that they appreciated collaborative teamwork.

3.6 Conclusion

This research is premised on the view that SGs can potentially improve student engagement and student learning, and the context within which they are used impacts the final decision of implementing games-based learning. We are also of the view that teachers play a pivotal role in creating and shaping such an environment. For this reason, teachers' understanding and views about SGs affect where, how, why, and when they work with games.

According to the data gathered by Jordanian teachers, they are very interested in integrating SGs into their teaching that a majority of them consider digital games to be an efficacious educational tool. Since Jordanian authorities lack a clear framework on game-based learning in the curriculum guiding the efforts of teachers within the classroom, SGs efficacy in teaching would be very limited. The many challenges faced by teachers exacerbate the problem further: this includes finding SGs that are relevant to the curriculum and the lack of student assessment in SGs, among several others.

Whilst the majority of teachers in the country generally have limited experience in digital games, they were – through their broader pedagogical discourse - aware about the direct as well as indirect gains that SGs can bring to educational processes across many levels. To that end, the impact of games on developing transferable skills like critical thinking, problem solving, creativity and collaboration were frequently mentioned by surveyed teachers.

Due to the absence of specific national policies pertaining to game-based learning, the involvement of digital games in education can vary considerably from school to school, wherein the decision is left to school managers or to individual teachers in many cases. Therefore, we believe it is vital that research institutes that are focused on game-based learning ensure a constant two-way communication with teachers in order to integrate game-based learning into formal education.

In addition, we also argue that SGs must match the needs of teachers in addition to meeting their demands. Given that teachers will be largely pleased to come across feasible games for their curriculum, empowering SGs via dynamic authoring tools which enable teachers from editing learning content could catalyze the integration of SGs in classrooms. Thus, encouraging teachers' control over SG elements and content should improve cross-curricular SG utilization whilst reducing barriers that impede the adoption of game-based learning.

The grounded and optimistic nature of these observations is an important motive towards shaping ongoing research for the purpose of improving SGs development and coming up with flexible models of game-based learning spaces to improve learning outcomes. They also establish the foundation on which intersections can be found between pedagogical decision making and the factors influencing what actually transpires when games are introduced into schools.

3.7 Summary

This chapter concluded the problem awareness stage in the DSR framework and described the barriers to adopting DGBL in schools. Specifically, this chapter has outlined the views and experiences of Jordanian teachers related to the general barriers that teachers face during the process of GBL implementation in their classes. Key barriers include a lack of technical support, resistance from traditional educational frameworks, and scarcity of resources that the curriculum might need. Moreover, the chapter expounded on the important requirements for any potential solution which would handle the critical issues and barriers by setting a clear agenda in the development of the right tool which would address the critical needs that had been identified.

Chapter 4, will shift the focus to the development phase of the DSR, where the first prototype of the FunHomework platform is introduced. This chapter tries to bridge the theoretical and practical parts of the integration of GBL by developing a friendly, flexible, and accessible game authoring tool. FunHomework tries to mitigate these identified barriers by helping educators easily create and incorporate game-based learning into their practice. This prototype represents a key step in the realization of the research goal after the empirical findings on the needs and problems of educators in fostering GBL adoption in formal educational settings and in proposing a workable solution based on both theoretical literature insights.

Chapter 4

Development[1]

Video Games have always been a point of attraction for many people, especially for those in the younger age groups. Recently, the trend of taking advantage of this engaging field in education, to impart learning in some topics, is growing. Whereas Serious Games are generally designed for a specific educational topic with pre-defined and static learning contents and activities, we propose a serious game for children called "FunHomework". The game is based on features in commercial games and obtains its learning material from another application called "TutorApp", where both applications share the same real-time database. The TutorApp can be used for different subjects, giving educators full control over the learning contents of the game, and can also be used to monitor students' performance. With its dynamic contents, FunHomework will maintain its engagement and increase its usability.

4.1 Introduction

The use of games for learning has developed over several years. SGs are considered an interesting tool that combines entertainment with knowledge transfer. They have a purpose beyond entertainment, e.g., education, training, advertising, or supporting social change (Winn, 2009). SGs offer considerable potential that can be used to facilitate formal and informal learning experiences in many contexts. Many studies have pointed to the constructive properties of SGs, such as their inducement and stimulus appeal, which can support various learning experiences.

One of the main advantages of using technology in education is producing a personalized learning experience. SGs can gauge the level of the students/players and cater to their learning style. Some students prefer verbal learning style of using words, both in speech and writing, where others may respond better to logical learning style of using logic, reasoning and systems. Such adaptation in classrooms is governed by the availability of time and resources. Due to the evolving learning styles of the Millennials and the way they learn, SGs can be a favorable vehicle to cater to their needs.

FunHomework is a novel game, affording the teacher control over the learning contents, making the game suitable for various subjects. To maintain its engagement and increase its usability, the game is developed using Procedural Content Generation technique, which generates dynamic contents and unique environment, every time the game is played.

[1] This chapter is based on Assaf, M. (2017). A Platformer Serious Game with Dynamic Learning Contents. In Serious Games: Third Joint International Conference, JCSG 2017, Valencia, Spain, November 23-24, 2017, Proceedings (pp. 138-145). (Lecture notes in computer science; Vol. 10622). Springer. https://doi.org/10.1007/978-3-319-70111-0_13

4.2 Background Work

Many researches have described the positive effects of games on child and teen players' learning (Blumberg and Ismailer, 2009). (Robertson and Miller, 2009) have empirically supported the constructive outcome of digital games, especially for the less-abled children. Using a game in classroom can motivate all the students, including shy pupils, to participate and contribute in class actively. The nature of games boosts diverse crucial skills for deep learning, such as metacognition, selective attention, etc. (Blumberg and Ismailer, 2009; Charsky, 2010). Therefore, SGs can be considered an effective teaching tool that involves various learning principles, not just by virtue of being a game (Mason and Rennie, 2008). SGs have to be supported with educational principles and planned with educators, to guide the student through the learning material. Students should be given the opportunity to explore the games and cooperative learning should be encouraged.

Usage of SGs in formal education is making progress (Barragán-Pulido et al., 2023); however, most games were designed to achieve a specific learning goal. The games were structured in such a way that the learning goals are recognized and specified in the early stages of game design. SGs generally target specific topics (e.g. Math, Science, etc.). A game that is developed for the science subject in elementary schools will have almost static learning contents. As a result, it cannot be used for another subject, or even other topics within the same subject. Once the students master all the details and tackle the game, their motivation to play the game diminishes.

Despite the presence of games in formal education, it is still rarely seen in the regular classroom (Ulicsak and Wright, 2010). We argue that the reason for that is the gap between game developers and school teachers. A SG that is designed for teaching some curriculum, might not fit perfectly in another classroom that uses a completely or partially different curriculum. To have serious games in the classroom, they have to fit into the existing lesson structures and need to provide appropriate assessment. Currently, games are used often based on the criterion whether it makes the teacher's life easier, because the teacher chooses which game they are willing to use (Davidson, 2008). Teachers need to assess whether the game will enhance their students' learning, which can be time consuming. This is also another reason why serious games are not used in the classroom more frequently.

A study by (Husain, 2011) introduced Serious Game design framework and an example of a Math educational game. Her SG targets Math of fourth graders and is made of three components: the game itself, a social network and a teacher reporting tool. She urged that some teachers are reluctant to use serious games in school and that we can increase usage of serious games as a resource, by involving teachers in game design and address their concerns. In her opinion, SGs should be games and not just drill and practice.

Mathbreakers is a 3-D math exploration video game, where kids experiment with numbers and operations by playing with various toys and puzzles. Adventurers can chop numbers in half with a fraction's sword, cast addition spells to zero-out negative enemies, and outsmart swarms of spiky integers, while developing number sense. The first release of Mathbreakers complements the standard math curriculum in San Francisco - USA for grades 1-6, including arithmetic, negatives, fractions, factoring, multiples and powers. The game is also supported by a dashboard, where teachers can assign lessons and track the progress of their students. However, teachers have no access to the learning material, as the curriculum is pre-set.

This paper proposes a serious game for elementary school students, called "FunHomework", where learning contents and questions are set dynamically by another application called "TutorApp", used by teachers. Each time the student plays the game, he/she finds new questions and challenges set by their teacher. Using TutorApp, teachers can add their own learning materials, which are then integrated into FunHomework and can be viewed and tackled by students during gameplay, which puts the game under the full control of teachers.

4.3 Game Components

FunHomework is a framework that consists of two applications; a Game "FunHomework", and a mobile application "TutorApp" for teachers. The basic goal of this framework is to provide for students an encouraging learning environment to submit their homework/activities results, and for teachers a simple and easy tool to manage students' activities and evaluate their performance. Both applications share the same Firebase real-time database to save, retrieve, update and exchange students' data and homework/activity reports. (Firebase, 2017) provides a real-time database and backend as a service. The service provides an API that allows application data "TutorApp" and game data "FunHomework" to be synchronized across clients and stored on Firebase's cloud. Firebase also provides client libraries that enable integration with Android, iOS, as well as Unity3D game engine applications.

4.3.1 TutorApp

TutorApp is a mobile application whose purpose is to assist a teacher in organizing and infusing learning content into the game FunHomework. It is an authoring tool, whereby a teacher can create learning content and objectives that fit into the curriculum. The authoring content created is dynamically integrated into the game at runtime and therefore ensures that pedagogical play is guided by the objectives set by the teacher. This, therefore, means that the teacher can monitor the progress of their students, readjust content in the game as necessary, and get to have a view of the performance of their students. This app is therefore expected to ward off several aforementioned implementation problems that

face teachers, and serve as a possible remedy to realize effective implementation of DGBL into schools.

Using TutorApp, teachers will be able to organize students into groups according to their age/class or subject (Figure 4.1a). They can also assign homework/activity questions to be done by students using FunHomework game (Figure 4.1b). The application will be used by teachers and have the following functionalities:

1. Create a group for students to join, identified by a unique identifier GroupID.
2. Create a homework with a name and a description. Specifying the homework deadline is optional.
3. Add questions to homework, specifying the right answer for each question, as well as the mark associated with that question.
4. View the results of students within each homework and within the group as a whole.

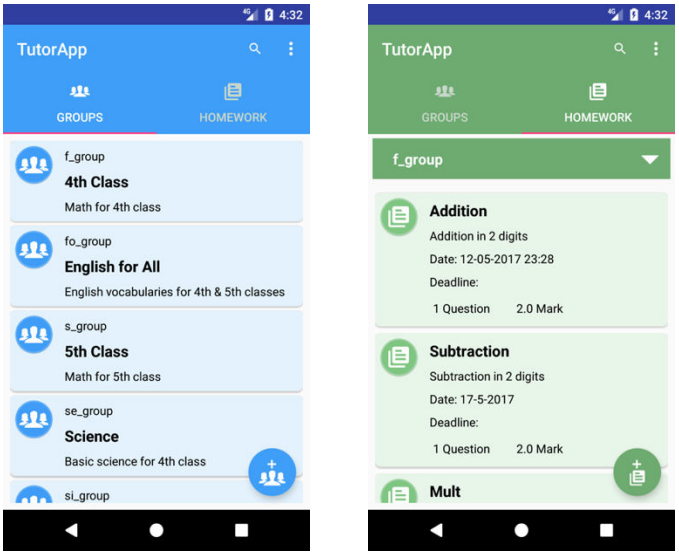


Figure 4. 1 TutorApp application
a) Groups View b) Homework View for group "f_group"

4.3.2 FunHomework

FunHomework is 2D game developed using Unity3D game engine. The game can be classified as a Platformer game - one of most popular genres of video games. Games like Super Mario and Sonic, considered as the best-selling games of all time, are Platform games (Wikipedia, 2017).

In the game's main menu, the players have to fill in their profile with data to be shared with TutorApp, which includes name, age, and student number if available. To view available homework/activities, the player has to join active group(s) created by their teacher. The group can be found by its GroupID as a unique identifier. (Figure 4.2)

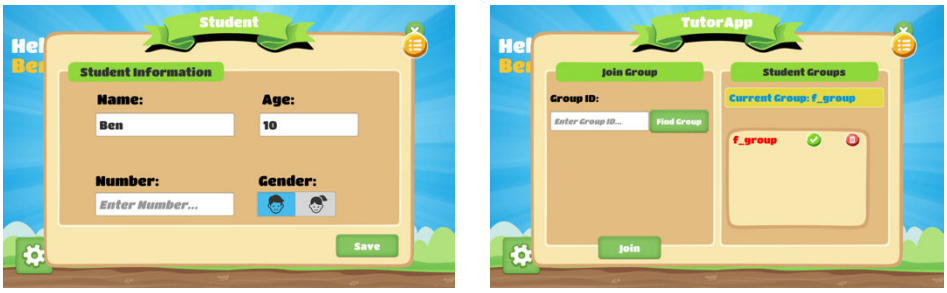


Figure 4. 2 FunHomework game
a) Basic information b) TutorApp details

The teacher shares the GroupID with their students which will enable them to find and join a specific group by that GroupID (Figure 4.2a). Once the student successfully joins their group, he/she will be able to view homework/activities assigned by the teacher (Figure 3.3a). By selecting the "Play" button, the game starts (Figure 4.3b) and the questions of the homework/activity are integrated into gameplay.

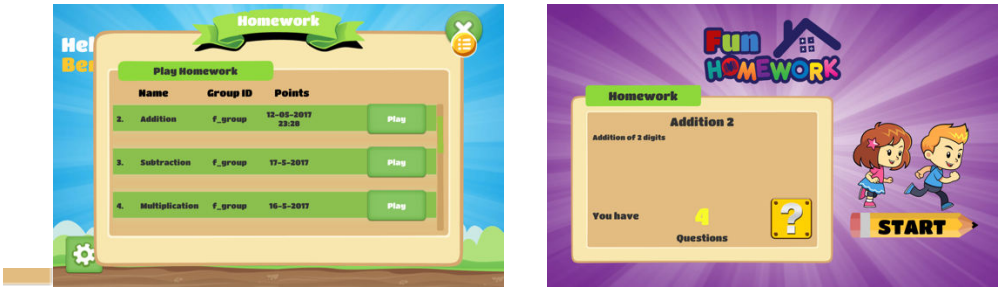


Figure 4. 3 Homework/Activity
a) Available homework for group "f_group" b) Homework "Addition" description

FunHomework involves guiding a player character to jump between suspended platforms and over obstacles to traverse their environment. The player controls the jumps, to avoid letting their character fall to their death or miss necessary jumps. During gameplay, the player has to fight and jump over enemies which launch projectiles. With their pencil weapon, the player can shoot enemies and gain more points. Along the way, the player can collect stars, before reaching a point where he/she is blocked by a wall, asked to hit a question block before he/she can go further (Figure 4.4a). Once the question block is hit, question interface appears and the players can write their answer to the displayed question – which is loaded from TutorApp (Figure 4.4b). Upon completion, the player can view their result which shows right and wrong answered questions accompanied by their marks and percentage out of total possible marks. The result screen also shows the points the player has collected by gathering stars and shooting enemies. The players can also see their position in a standings table of all students within their group, based on the average marks of all attempts. With two different player characters, one for girls and one for boys, the players can choose a character which represents their gender. The game presents the possibility of choice in character selection, which can be considered as a means by which the players could extend themselves into the world of the game.

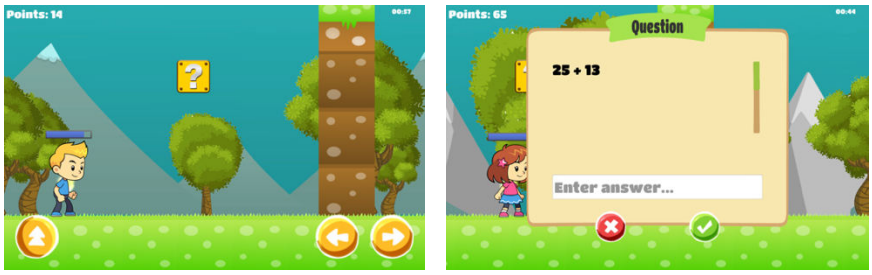


Figure 4. 4 FunHomework Question
a) Question Point b) Question User Interface 4 Procedural Content Generation

Procedural content generation (PCG) is the programmatic generation of game content, using a random or pseudo-random process that results in an unpredictable range of possible game play spaces (Procedural Content Generation Wiki, 2017). Due to the increasing cost of content design, we used PCG technique that can supplement design skills to rapidly populate the environment with randomly generated content. Using dynamic Instancing of In-Game Entities, we varied the parameters of in-game entities, to create a large possible number of entities with a small chance of repetition (Procedural Content Generation Wiki, 2017). The dimensions of the environment depend on the number of questions of the activity/homework to be solved. The building unit we used to generate game contents is the question. Before and after each question, we generated an enemy selected randomly from a set of enemy entities (Figure 4.5). Mountains and trees are also instantiated with Background Parallax effect from a set of entities, and placed with random spacing among question points and according to the dimensions of the environment. The same principle applies to walls, platforms, obstacles and stars to be collected. After generating the environment and its contents procedurally, the players find activity/homework questions spread evenly across their path.

The result of PCG will be an almost completely different play environment, each time the player starts the game. The changing positions of mountains and trees and the different types of enemies settle the player in a new level, by restarting the game. This has not only saved design and development time, but also reduced the chance of player frustration, and maintained game engagement.

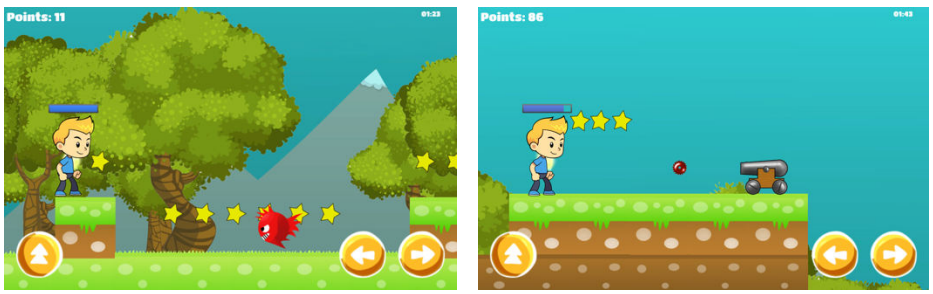


Figure 4. 5 Sample Enemies

4.5 Reward System

The term reward system refers to the structure of rewards and incentives in the game that inspire intrinsic motivation in the player, while also offering extrinsic rewards (Game Reward Systems, 2016). Reward systems can be viewed as player motivators or as compromises for easing disappointment. In modern video games, reward systems also provide a social meaning within and outside of games (Reeves, 2011). In FunHomework, we tried to create a reward system that maintains game engagement and increases the healthy contest among students to play and do more homework. Listing students in a standings table kindles the competitive spirit in them, whereby they are stimulated to keep playing and solving problems, to improve their ranking. The reward system of FunHomework depends on three factors:

1. Number of right/wrong answers that the player make. The final grade of each homework is presented as a percentage and then added to the average of previous attempts.
2. Number of collected points. The player can collect points by grabbing stars, or shooting enemies and projectiles. Points are accumulated in the student's score and then used as a second factor, in case of a tie in the marks.
3. The time needed to finish the homework/quiz. The faster the task is finished, the more are the points to be got.

Once the player reaches the finish point, the result screen shows the outcome (Figure 3.6a), where he/she can also view his/her position in a ranking table (Figure 3.6b). The ranking table displays the players within the same group ordered by a) their average result for all homework in this group b) the sum of points collected during the play of all homework. For more motivation, badges are given to the first 3 players within the group. The first player wins the trophy, while the 2nd and 3rd places enjoy silver and bronze medals respectively.

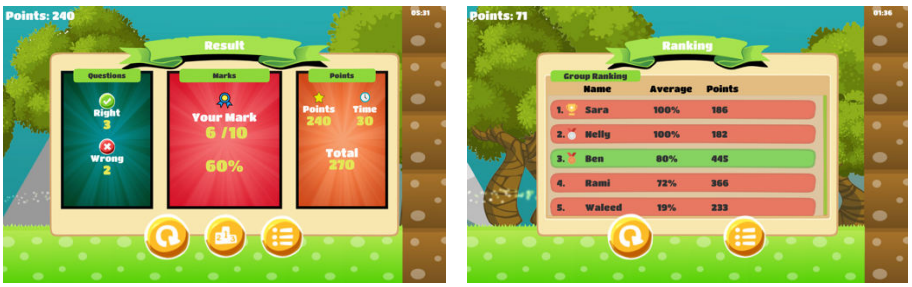


Figure 4. 6 FunHomework End
a) Results Screen b) Students' Ranking

4.5 Conclusion

Serious games are used in various domains; however, in the formal education sector, there are a lot of factors to be considered, as they might change the fundamentals of the current educational process. The teachers play an important role in this process, as they have the authority to choose the learning method. They also have the experience of the current learning process. For using serious games, they need to be able to adapt to a different learning process and be able to manage the reflection of new methods.

In this study, we introduced FunHomework, a platformer game that gets its learning material from another application TutorApp. The game provides full teacher control over the learning contents, making it suitable for various subjects. FunHomework maintains its engagement and increases its usability, by using the Procedural Content Generation technique, which generates dynamic contents and a unique environment, every time the game is played. Providing a healthy, competitive environment, FunHomework can be used in formal education for students within the classroom or at home. The game should be published for personal computers as well as for mobile devices, to be available for students everywhere. While the initial feedback received from students, teachers and parents is promising, the game should be tested in and outside the classroom, to measure its ability to surmount the aforementioned obstacles that hinder DGBL implementation in schools .

As a suggested refinement for future work, Speech Recognition can be employed within the gameplay, to ease user input. This should convert the player's voice into written text and can help the player in submitting the answers with his/her voice more quickly, especially where answers contain long texts.

4.6 Summary

In this chapter, we conducted the development stage of the DSR framework, where the first prototype of the FunHomework platform is introduced as a potential solution to address the challenges hindering the adoption of DGBL in schools. The chapter showed in detail the technical development and validation activities of FunHomework, ensuring that the prototype meets educational needs and technical requirements as elicited from the input of the teachers in previous stages. The identification of pedagogical needs was met by the design of the prototype, which allows the innovative approach to be pedagogically effective and technically feasible for game-based learning platform.

The evaluation stage of DSR framework is the focus of Chapter 5, where a case study will be conducted to test FunHomework platform in actual educational settings. This phase is done with the intent of fundamentally identifying the effectiveness of the platform in addressing the main barriers of DGBL adoption by educators, like being integrated into existing curricula, and ease of use by teachers. From that view, the case study comprises

ongoing feedback mechanisms where teachers give real-time input of how the platform is or will be implemented in their classroom, its functionality, and usability. In this process, FunHomework will take further shape, bringing it closer to the expectations of the teachers. Affirming the potential of FunHomework in facilitating DGBL towards enhancing the wider adoption of DGBL in the real classroom-based educational settings, the next chapter tries to evaluate the influence of the platform.

Chapter 5

Evaluation[1]

Despite the progress made with regard to implementing game-based learning in formal education, many obstacles hinder its integration into classrooms. This research aims to enhance game-based learning adoption by providing a platform that overcomes key hurdles that impede this adoption. The research does so by practically implementing FunHomework – a game-based learning platform with dynamic learning content – in schools and evaluating such a platform's ability to encourage teachers to adopt games in their classrooms. Over a two-month implementation period, twelve (12) teachers, along with their students, participated in the study by incorporating FunHomework into their classroom activities. By the end of the implementation, the ability of FunHomework to enhance the utilization of game-based learning and overcome hurdles associated with embedding it in classrooms was evaluated. The evaluation results demonstrated the applicability of FunHomework in formal education settings with different curricula, schools and countries. Moreover, the implementation of FunHomework positively influenced teachers' decisions to adopt game-based learning by overcoming several key obstacles, such as curriculum alignment, time limitations and students' performance tracking and reducing game production costs. The evaluation of FunHomework revealed considerable satisfaction among educators teaching various subjects, who showed high interest to continue using the platform after the study's conclusion.

5.1 Introduction

The use of games for learning has increased over the past decade. Serious games (SGs) are interesting tools combining entertainment with knowledge transfer (de Freitas, 2006; Prensky, 2006). Successes in informal learning have caused supporters to falsely believe that implementing them into the classroom would be a relatively easy transition and potentially revolutionize the entire educational system (Kenny & McDaniel, 2011). Despite the constructive properties of SGs, Digital Game-based Learning (DGBL) technologies have been adopted relatively slowly, and only a modest number of teachers have incorporated video games into their teaching (Egenfeldt-Nielsen, 2004; Pivec & Pivec, 2008). According to their report about ICT in Education, the European Commission conducted a survey (Wastiau et al., 2013) in 31 countries to benchmark the progress of ICT in European schools. It was reported that between 50 and 80 per cent of the surveyed students have never used digital learning games during lessons. In their final report in 2019, the European Commission conducted another study (Deloitte et al., 2019) in which they concluded that the percentage of

[1] This chapter is based on Assaf, M. H. A., Spil, T., & Bruinsma, G. W. J. (submitted for review). *Implementing Serious Games with Dynamic Learning Contents in Formal Education.*

students who use a computer at least once a week for learning purposes has remained stable compared to the first survey of schools.

In the last few years, software and connectivity have become increasingly available in the context of the learning environment as the requisite hardware. Consequently, the lack of ICT cannot solely justify the teachers' inability to identify certain meaningful applications of technology in their classes, and other factors must also be considered. For instance, the European Commission (2019) attributed the hurdles faced when attempting to adopt digital games and simulations in schools to the lack of existing good quality curriculum-related material, adequate teacher skill-building to use and integrate DGBL into teaching, or the paucity of time to become comprehensively familiar with them and feel comfortable to utilize them in the classroom with the students.

Another important factor that can influence the adoption of DGBL in schools is teachers' attitude towards games. In fact, teachers play a key role in shaping and responding to the intricate contextual factors influencing the manner in which games are experienced across educational settings (Bourgonjon et al., 2013), and a substantial share of the liability for the deficit of adopting DGBL is closely linked to the manner in which teachers perceive games (Squire, 2002; Mehrotra et al., 2012). Many teachers can be informed about the educational value of digital games. However, they are skeptical about the challenges entailed in practically assimilating DGBL in schools.

In their study, Pan et al. (2021) highlighted various difficulties that can hinder the implementation of DGBL in classrooms. In addition to the special infrastructure needed for games, Pan et al. (2021) listed the lack of quality educational game resources as one of the main hurdles that impede teachers from utilizing SGs. This paucity can be associated with the impressively high cost of developing and customizing educational video games. Approximately 40 per cent of the educational game developments actively or recently finished in 2005 were expected to cost more than 100.000$ (Michael & Chen, 2006).

When teachers decide to utilize DGBL, they encounter weak theoretical guidance of frameworks, curriculum, and instructional support (Pan et al., 2021). As the congruence of games with the curriculum plays an important role in the adoption decision, teachers can face difficulties in finding suitable SGs that match their learning objectives and providing adequate feedback about students' performance (Assaf et al., 2019). Moreover, several researchers (Molin, 2017; Webb et al., 2015; Allsop & Jesse, 2015) have argued that the new technological tools could force change on teachers and demand new confrontations such as limited preparation time and appropriate student assessment.

In summary, the utilization of DGBL has encountered serious hurdles within formal education. One of the key impediments to its successful implementation is the scarcity of games that align with specific school curricula. Collaborative efforts with educators, involving them in the game development process, offer a promising avenue for introducing

such tailored games. The upcoming section of this paper delves into various strategies currently being employed to tackle this shortage.

5.2 Background

The important role played by teachers' involvement as designers has been highlighted by contemporary research conducted on classroom-specific technology integration. For several years, this innovation approach has been advocated (Clandinin & Connelly, 1992) as a desirable and feasible approach to securing sustained innovation in practice. In this context, active engagement may have the potential to enhance ownership capabilities, produce material that is more aligned with classroom practice and offer viable professional development opportunities (Ben-Peretz, 1990; Borko, 2004). The yield progression in terms of classroom-oriented technology integration has been indicated by an increasing number of studies wherein teams of teachers acted as designers (Koehler et al., 2007).

One technique to involve teachers as designers encompasses the authoring tools that can provide an uncomplicated premise to abstract the technical aspects of game design. The authoring tools can help customize games according to teachers' requirements at low cost, make them accessible for non-programmers and ease the participation of non-technical SG stakeholders.

The uAdventure project proposed by José et al. (2020) introduced a simplified authoring tool that enables teachers to create SGs that include educational-oriented capabilities such as learning analytics without requiring extensive programming knowledge. In their first pilot study, participants required expert assistance to quickly prototype their game ideas, but almost no participant tried or succeeded in creating their games. Thus, José et al. (2020) concluded that prior narrative experience could be important to be more proficient during the authoring process. In uAdventure, game design can be time-consuming, including producing game narratives and mechanics, not to mention allocating game assets and graphics. In the case of teachers, who are mostly stressed about finishing their educational plans on time, such a laborious and lengthy job might decrease their enthusiasm towards adopting SGs in their schools.

A different level of abstraction of authoring tools in EducaMovil, a game-based mobile learning tool, was presented by Molnar et al. (2015) in a study that aimed to streamline the development of educational games, thereby enabling teachers to either create or customize informative educational content. By leveraging EducaMovil, teachers can create educational content for different subjects and automatically embed it into games while maintaining a low cost, as the platform does not require high-level engineering knowledge or large budgets to function optimally. EducaMovil tried to take advantage of the increasing ownership rates of mobile phones among teachers and students, rendering them a cost-effective solution to complement formal schooling and facilitate the delivery of educational content

anytime and anywhere. Teachers use a PC tool for creating educational content, and a mobile game-based educational application can be installed on Java-enabled cell phones for use by students. While evaluating EducaMovil, Molnar et al. (2015) demonstrated the platform's utilization at a public school in a low-income Peruvian urban area of Lima and assessed teachers' attitudes towards the proposed application's use. Nevertheless, the evaluation neither included comprehensive details about the platform's actual usage nor feedback provided by teachers.

The idea behind EducaMovil is interesting. However, its mobile game-based educational application has been developed only for Java-enabled phones. This can technically limit the tool's implementation because: a) the mobile application couldn't be installed on most modern Android and iOS smartphones; b) the nature of games created with this technology were pretty simple due to the limited hardware available on Java-enabled phones.

We argue that specialized authoring tools, which allow a change in learning content after the game or framework has been created, are a promising way to overcome most of the obstacles mentioned above that hinder the utilization of DGBL in formal education. The aforementioned initiatives have laid a basic foundation for this approach, and we recognize the potential for further research to develop this concept and assessing its effectiveness in real-world educational settings. To that end, this paper introduces FunHomework as a platform designed to streamline the creation of SGs featuring dynamic learning content. Subsequently, we investigate the platform's potential to improve the adoption of DGBL in formal education by addressing the challenges encountered by educators.

FunHomework includes a mobile authoring tool in which teachers only need to create generic learning content integrated into the gameplay at runtime. The mobile games in FunHomework are created with fixed scenarios, but the learning content can be dynamically changed by teachers using the simple authoring tool. An immanent characteristic of games that support generic learning content is that they are loosely based on the close coupling of game and learning scenarios. This can actively enable these games to be used for various subjects and suit different curricula.

In this research, we investigated the validity of such a platform in mitigating challenges that impede the adoption of DGBL in formal educational settings. This examination involved the practical implementation of FunHomework in a real school environment over a two-month period, all aimed at addressing the primary research question:

How can the introduction of simplified game authoring tools facilitate the integration of game-based learning within formal educational environment?

We tried to answer this question by investigating the following:

1. The possibility of adopting FunHomework in real-life educational settings.

2. The utility, quality, and efficacy of FunHomework depending on quantitative and qualitative teachers' reviews.

5.3 Methodology

5.3.1 Material

5.3.1.1 FunHomework

FunHomework is a DGBL platform composed of two mobile apps – an authoring tool for teachers and a 2D game for students. With the help of the authoring tool, the teachers can create their learning content and objectives according to the formal curriculum. These learning contents are integrated into the games at runtime, which renders the game dynamic and aligned with the teacher's learning objectives. The tool also lets teachers observe students' performance and control game elements. This feature keeps teachers informed about students' activity achievement. For the students, the game is used to play and achieve the learning targets set by their teachers. By the end, all students can attain the same learning objectives using their beloved game.

FunHomework consists of a mobile application authoring tool TutorApp, serious mobile games and an open Web API that provides a boundary for communication between the games and the backend. Figure 5.1 depicts the components of FunHomework.

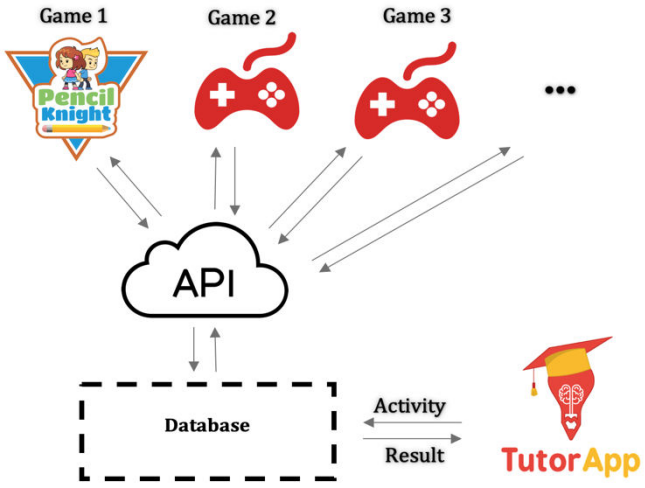


Figure 5. 1 FunHomework components

5.3.1.2 TutorApp – Authoring Tool

TutorApp is a mobile application for teachers to manage student classrooms and control SGs. As an authoring tool, the app enables teachers to control the learning contents of the games without any prior knowledge about programming or game design. TutorApp is

designed for mobile and tablet devices leveraging different platforms – Android and iOS. It is an easy interface to enable teachers to manage students' groups and monitor their activities. The TutorApp was published on the Google Play Store[1] and Apple App Store[2] to streamline testing and debugging by teachers.

When using the app for the first time, the teacher must create an account with their email address. Alternatively, they can sign in with a well-known Single Sign-On (SSO) provider, such as Google. This account creation is essential for maintaining all activities undertaken by the teachers and monitoring students' performance.

TutorApp (Figure 5.2) has three main operations: creating student groups, creating student activities, and observing students' performance. These core functionalities are elucidated in detail as follows:

1. Create a group for students to join, identified by a unique identifier Group ID.
2. Create a homework assignment with a deadline for students within a group.
3. Add multiple choice questions for each activity, for which pictures can be used for illustration.
4. Track individual student results for each activity and view student attempts. The results can also be exported and printed as a PDF file for documentation.

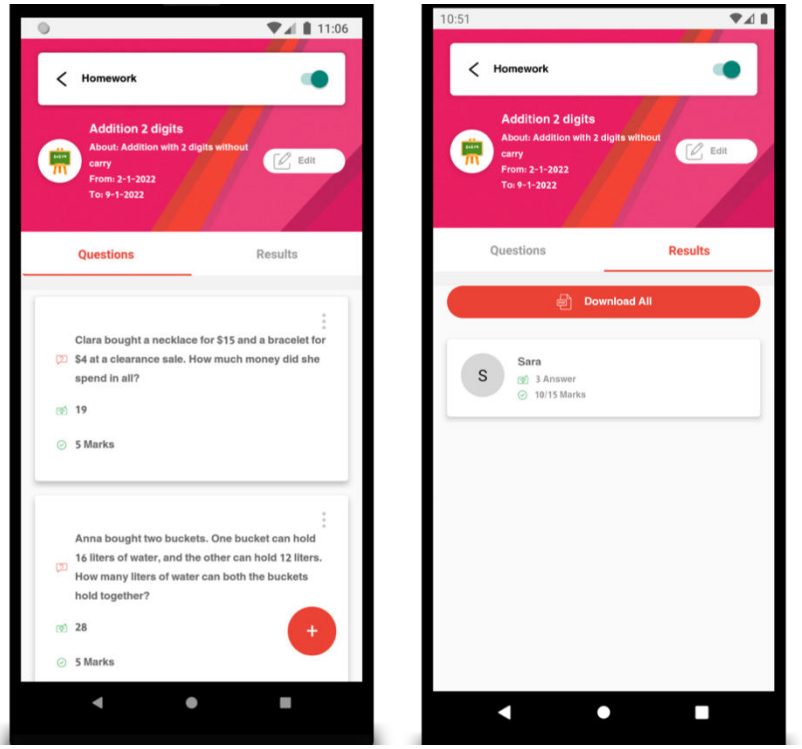


Figure 5. 2 TutorApp - Authoring Tool
a) Homework with multiple questions, b) Students' homework results

[1] https://play.google.com/store/apps/details?id=com.funhomework.android.tutor_app
[2] https://apps.apple.com/us/app/tutorapp-funhomework/id1475411224

5.3.1.3 Pencil Knight – Student Game

The first SG within the FunHomework platform, which is used in the evaluation, is Pencil Knight. The mobile game complies with the dynamic learning content concept and is compatible with TutorApp as an authoring tool. Pencil Knight is a 2D platformer game developed using the Unity3D game engine and designed for primary school students. The first version of the game was created in 2017, and a pilot study (Assaf, 2017) about it was published. Pencil Knight is published in the Google Play Store[1] and Apple App Store[2] to streamline testing and debugging for students.

When playing this game for the first time, the student must create an account to render their data available in case they use the same account on different devices. Account creation is completed by providing basic information about the student, for example, the student's name, age and gender. Thereafter, the game generates a unique username and password that needs to be saved by the student for future login purposes.

After login, the student must join at least one group to access its activities. This GroupID, which identifies the group created by the teacher, can be used to join a specific group. The game enables the user to leave the group and join multiple groups simultaneously. Once the student becomes a part of a group, the available activities created by their teacher for the specific group can be viewed. The desired activity can hence be selected, and the game can be started with dynamic learning contents integrated into the gameplay.

The Pencil Knight platformer game involves guiding a player character to jump between suspended platforms and over obstacles to traverse their environment. The player controls the jumps to prevent their character from falling to death or missing necessary jumps. During gameplay, the player has to fight and jump over enemies, which launches damaging projectiles. Players can shoot enemies to protect themselves and gain more points with their pencil weapon. Along the way, the player can collect stars before reaching the point where a wall blocks them and prompts the user to hit a question block before they can proceed further (Figure. 5.3a). Once the question block has been successfully hit, the question interface appears, and the player needs to select the right answer from the displayed options – which are loaded from TutorApp (Figure 5.3b). If the player selects the right answer, they are surrounded by an aura that protects them from enemy shots for 15 seconds. The player proceeds to the next question facing new obstacles and fighting enemies until they reach the last question of the activity set by the teacher.

[1] https://play.google.com/store/apps/details?id=com.funhomework.android.pencilknight
[2] https://apps.apple.com/us/app/pencil-knight/id1484356278

Upon completion, the player can view their result, which shows the right and wrong answered questions accompanied by their marks and percentage out of the total possible marks. The result screen also shows the points acquired by the player by gathering stars and shooting enemies. The players can also see their position in a standings table of all students within their group, based on the average marks of all attempts. This student's result is then sent to the teacher, who is notified in TutorApp about the activity completion and can view the student's attempt in detail.

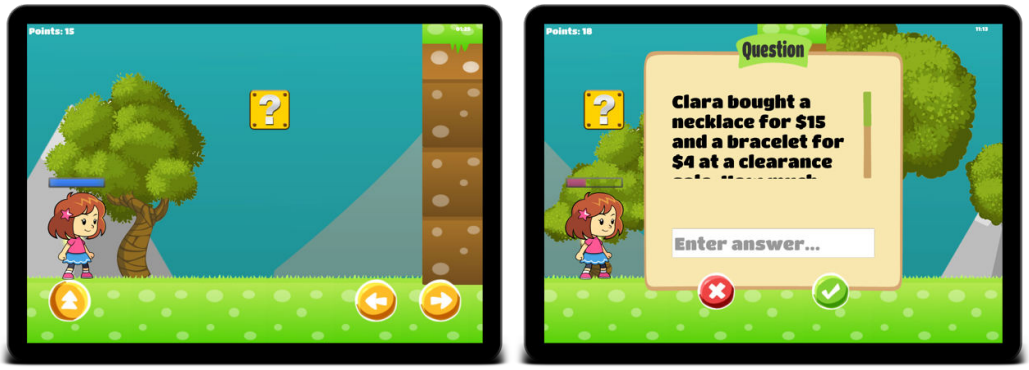


Figure 5. 3 Pencil Knight Game
a) Question point b) Question user interface

5.3.2. Participants

We distributed an open call over Facebook for Arabic-speaking in-practice school teachers in the MENA region to participate in a case study for using and evaluating FunHomework. Given that the first author is from Jordan, conducting and facilitating this research in the MENA region was a logistically advantageous choice. We intended to collect the opinions of teachers with previous experience of using DGBL in their schools. This endeavor helped compare FunHomework with other platforms and determine whether FunHomework can influence teachers' decisions in adopting DGBL. In total, 31 teachers responded to our call, showed first interest in the idea, and tried to install and use the apps. After explaining the requirements and commitments of the two-month implementation period, many teachers experienced doubts about their ability to effectively participate in the evaluation until the end. Eventually, ten teachers volunteered to be a part of the self-selection sample, and another two teachers joined the study with snowball networks. In total, 12 teachers from 6 primary schools in 3 countries (Jordan, Egypt, and UAE) actively tested and evaluated FunHomework until the end of the evaluation. Table 1 depicts more details about the teachers and their classes. Since this study exclusively focuses on the perspectives of teachers, students were instructed to engage with the games while being supervised by their teachers, and their involvement did not extend to the platform evaluation.

Name	Age	Grade(s)	Subject(s)	Total Number of Students	Country
Bayan	23	2nd	Math, Religion, Science	30	Jordan
Dima	23	1st	English	81	Jordan
Ferdous	25	2nd	Math, Science, Social, Religion	26	Jordan
Rana	32	3rd	Arabic, Math, Science, Social	10	Jordan
Ayah	37	8th, 9th	Math	43	UAE
Haifa	46	4th, 5th	Arabic	60	Jordan
Rawan	23	4th	English	90	Jordan
Shorouq	33	4th	English	96	Jordan
Merna	28	3rd, 4th	Social	98	Egypt
Dania	32	4th, 5th	English	93	Jordan
Mona	34	7th, 8th	English	100	Jordan
Amina	24	1st	English	80	Jordan

Table 5. 1 Evaluation - Participant Teachers

All the teachers were women; their ages ranged between 23 and 46. The teachers had the experience of dealing with students from the first to the ninth grades. During the implementation, teachers used FunHomework to create learning activities for various subjects, namely Math, Science and language learning.

The study occurred between February 2022 and April 2022, which matches the start of the second school semester in Jordan. In UAE, on the other hand, the study was conducted in the middle of the second semester, during which schools also enjoyed Spring vacation (from March to April). This explains why most of the participating teachers hailed from Jordan.

5.3.3 Procedure and Evaluation

To evaluate the efficacy of FunHomework against the intended goals, we implemented the platform in practice for 2 months to measure the possibility of incorporating such games in schools. During this evaluation, the platform was subject to refinements and extensive tests on the ground. This evaluation observed and measured how well the platform supports a solution to DGBL adoption hurdles prescribed earlier.

In the first stage, online meetings with teachers were held to explain the study's purpose and demonstrate the framework's usage. To streamline testing and debugging, the apps were published on Google Play Store and Apple App Store to provide a safe means for distribution and installation. Over the period from February 20, 2022, to April 20, 2022, the teachers and their students used TutorApp and Pencil Knight to perform in-class and homework game-based activities.

During the implementation period, the communication between the researchers and teachers occurred over the official website (https://www.funhomework.games) and in a closed Facebook group created for that purpose. Feedback about problems and recommendations was actively collected from teachers. This iterative feedback was used to produce several refined versions of the apps and publish them in the stores.

The implementation required participant teachers to utilize FunHomework in their educational settings for two months, create activities for students and observe their performance, report problems associated with the implementation and recommend features to improve TutorApp and Pencil Knight.

By the end of the 2-month implementation period, satisfaction surveys and structured interviews were used to assess the platform applicability and reuse rates against the research question mentioned above. To accomplish this goal, teachers were first asked to report their opinions about the apps using the User Experience Questionnaire (UEQ) (Hindriks et al., 2019) to acquire a reliable assessment of the user experience. Subsequently, the teachers conducted structured interviews to evaluate the platform's qualitative aspects and features.

5.3.3.1 User Experience Questionnaire (UEQ)

At the conclusion of the 2-month implementation, our objective was to explore the utility and efficacy of FunHomework platform. To that end, we requested each teacher to complete an Arabic version of the UEQ, allowing them to reflect on their individual user experiences. UEQ is a widely used tool to measure user experience and provide quick assessment by end users covering a comprehensive impression of user experience. UEQ allows the end users to express feelings, impressions and attitudes that arise when experiencing the product under investigation in a very simple and immediate way.

The UEQ is appropriate for our evaluation because it asks whether the interaction is usable based on elements such as efficiency, perspicuity, dependability, and User Experience (UX) aspects such as stimulation and novelty. Other than answering whether the solution is usable, we would also like to know if participants are motivated to use it or think it is a novel solution. Furthermore, the survey's authors offer a handbook with helpful information about the survey and spreadsheets, which render the analysis easier because it provides multiple graphs and statistical tests.

The UEQ is a tool designed to measure UX by considering both usability and user experience goals. This questionnaire was empirically constructed, resulting in the identification of six scales that represent essential aspects of UX for a wide range of products (Laugwitz et al., 2008).

The 26 items of the UEQ are grouped into six scales and are semantic differentials with a 7-point answer scale. They consist of a pair of terms with opposite meanings that span a sematic dimension. An example for an item representing the scale stimulation is:

Not understandable o o o o o o o Understandable
Efficient o o o o o o o Inefficient

The 6 scales and the corresponding items are as follows:

1. **Attractiveness**: Reflects the user's overall impression of the product and whether they like it or not. Items include annoying / enjoyable, good / bad, unlikable / pleasing, unpleasant / pleasant, attractive / unattractive, friendly / unfriendly.
2. **Efficiency**: Assesses the user's perception of the speed and efficiency in achieving goals with the product, as well as the clarity of the interface. Items include fast / slow, inefficient / efficient, impractical / practical, organized / cluttered.
3. **Perspicuity**: Focuses on the user's impression of how easily they can understand and use the product. Items include understandable / understandable, easy to learn / difficult to learn, complicated / easy, clear / confusing.
4. **Dependability**: Evaluates the user's feelings about the safety and controllability of their interaction with the product. Items include unpredictable / predictable, obstructive / supportive, secure / not secure, meets expectations / does not meet expectations.
5. **Stimulation**: Gauges the user's impression of whether the product is interesting and enjoyable to use. Items include valuable / inferior, boring / exiting, not interesting / interesting, motivating / demotivating.

6. **Novelty**: Assesses the user's perception of the product's design as innovative, creative, and attention-catching. Items: creative / dull, inventive / conventional, usual / leading edge, conservative / innovative.

Efficiency, Perspicuity, and Dependability primarily address task-related aspects of UX (usability goals), while Stimulation and Novelty focus on non-task-related aspects of UX (user experience goals). Attractiveness is considered a pure valence dimension, with its rating influenced by both task-related and non-task-related aspects.

The format of the questionnaire encourages participants to promptly express their feelings, impressions, and attitudes while using a product. Filling out the questionnaire is a relatively effortless process for participants, making it suitable for online use. The reliability and validity of the UEQ have been confirmed in various studies; further details can be found in (Laugwitz et al., 2008).

To get a better picture of the utility of FunHomework, it was necessary to compare the measured user experience to the results of other established products, for example, from a benchmark data set containing quite different typical products. The UEQ offers such a benchmark, which contains, at the moment, the data of 452 product evaluations with the UEQ. The handbook, data analysis tools, and translations of the UEQ can be seen at www.ueq-online.org.

5.3.3.2 Qualitative Review

Leveraging UEQ, we measured the usability of the apps and the impression of the user experience. However, the quality of the platform may not be directly determined by a quantitative measurement such as UEQ. Therefore, we conducted a qualitative evaluation that was essential to explore specific features and functionalities of FunHomework, comprehend whether the platform can overcome the obstacles stated earlier and encourage teachers to adopt DGBL.

The first author conducted structured interviews consisting of short answers and open-ended questions with teachers in Arabic. In some cases, most of the interviews were conducted over Zoom video calls. However, the meeting could not be personally conducted due to the teachers' examination schedule. In these cases, the interview questions were sent to teachers to be filled out online at the teacher's pace.

In this part of the study, we used Grounded Theory (Wolfswinkel et al., 2013) – an established qualitative method of categorizing and coding empirically collected interview data, building a general theory to fit the data and guiding data collection and analysis.

The first part of the interview focused on teachers' attitudes towards DGBL, the most important features required in a DGBL platform and the problems that hinder the adoption of DGBL in schools. In the second part of the interview, we discussed the implementation

of FunHomework by teachers in their classrooms and evaluated the strengths of the platform and the potential areas of improvement, trying to examine the ability of FunHomework to overcome DGBL practical implementation problems.

Constant comparison analysis was used to interpret the data. The first step, open coding, was completed by deconstructing each interview sentence to identify key categories and concepts. Data collection and analyses were iterative, with new data being used to assess the integrity of the conceptual framework. The concepts identified were reintegrated into themes that reinforced the results' structure.

5.4 Findings

5.4.1 Actual Usage of FunHomework

Over the period from February 20, 2022, to April 20, 2022, the teachers and their students used TutorApp and Pencil Knight to perform in-class and homework game-based activities. The subsequent sections delve deeper into the engagement statistics of the apps published in the Google Play Store and Apple App Store.

5.4.1.1 TutorApp

During the test period, we created three versions of the Tutor app (1.0.8, 1.0.9 and 1.1.0), which were installed 165 times (135 Google Play Store, 30 Apple App Store). The teachers used the app to create 58 student groups and 36 homework-based and miscellaneous activities with 184 questions.

Statistics derived from the Google Play Store about the usage of TutorApp are depicted in Figure 5.4. The graph presents the timeline that reports on user engagement metrics for the app over approximately two months. The metrics displayed are:

Average engagement time: This is the total average time that users spend on the app. The reported average here is 8 minutes and 52 seconds, which suggests users spend a reasonable amount of time on the app per day.

Engaged sessions per user: This metric averages at 1.7 sessions, indicating that users typically return to the app slightly less than twice a day.

Average engagement time per session: At 3 minutes and 20 seconds, this metric shows that each session is relatively brief.

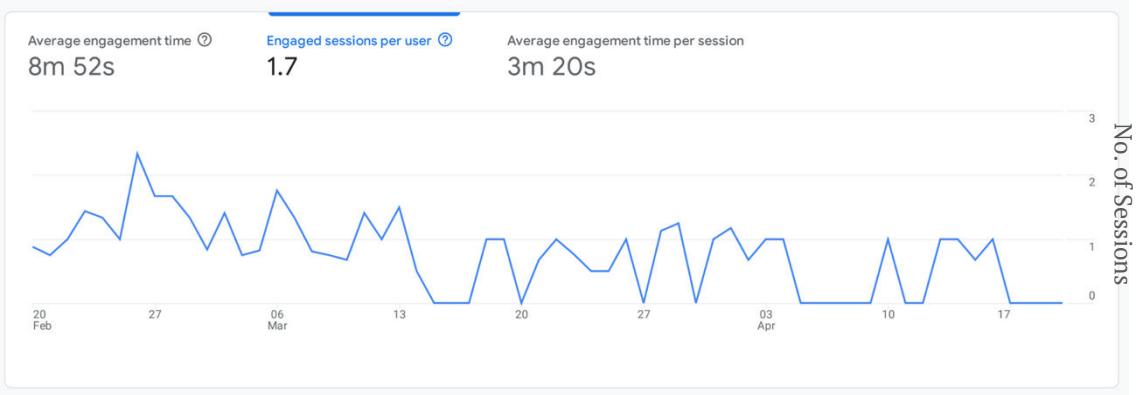


Figure 5. 4 TutorApp engagement overview

5.4.1.2 Pencil Knight

During implementation, five versions (1.15–1.19) were created for the game app. Students installed Pencil Knight 459 times (337 Google, 122 Apple) on different device types (mobile and tablet). As Pencil Knight was developed using Unity 3D Game Engine, we used Unity Analytics to collect the game usage and custom event statistics from both platforms (Android and iOS). The students played the game with a total average of 47.15 sessions daily, 1.3 sessions per user and 7 m 9 s invested per session. In total, 432 activities created by teachers were played with and solved by the students. Figure 5.5 depicts the total daily playtime in seconds per active user of Pencil Knight over approximately two months. The y-axis represents the seconds of playtime, while the x-axis shows the date.

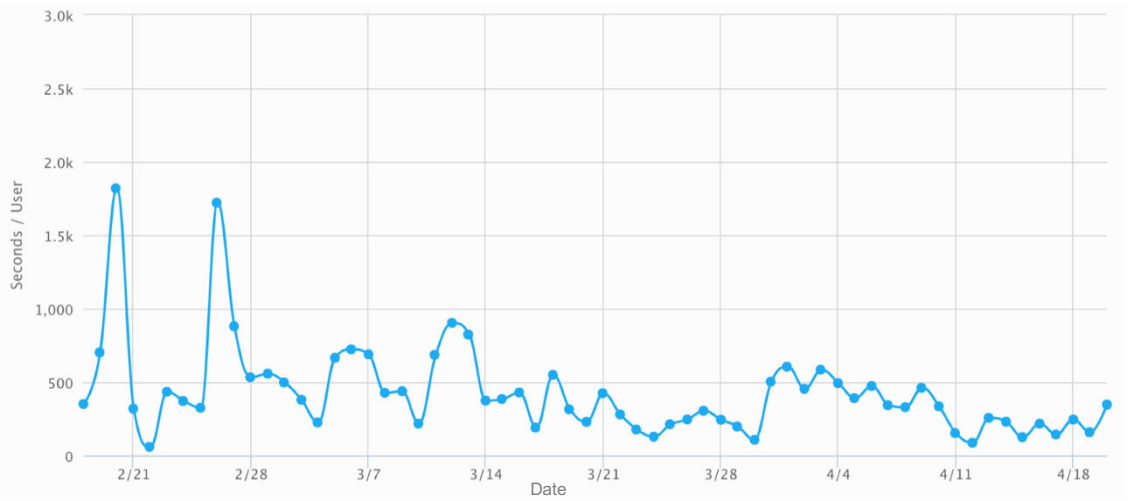


Figure 5. 5 Pencil Knight total daily play time in S per active user

5.4.2 Utility, Efficacy and Quality of FunHomework

5.4.2.1 UEQ

After the 2-month implementation period, the 12 participating teachers completed the Arabic version of the UEQ. The results collected from participants were analyzed using the spreadsheet provided by the authors (Hindriks et al., 2019). Table 5.2 shows the teachers' evaluation results of UEQ. The mean value for each of the six scales was computed by averaging the scores of all items associated with that particular scale.

UEQ Scales	Mean	Variance
Attractiveness	2,067	0,98
Perspicuity	1,625	1,64
Efficiency	1,650	1,60
Dependability	1,875	0,80
Stimulation	2,300	0,90
Novelty	1,425	1,68

Table 5. 2 Results of UEQ scales

The UEQ, by design, does not generate an aggregate score for the overall user experience. The questionnaire's construction precludes the meaningful interpretation of such an overall score, for instance, by computing the mean across all scales. Instead, the individual scale scores are considered. A score on the scale (-3 to +3) falling between -0.8 and 0.8 signifies a relatively neutral assessment of the corresponding scale. Scores exceeding 0.8 indicate a positive evaluation, while scores less than -0.8 indicate a negative evaluation.

In accordance with (Hindriks et al., 2019), positive values indicate a positive evaluation of the quality aspect. However, to better understand the evaluation results, it is necessary to compare the measured user experience of FunHomework with the results of other established products. UEQ offers a benchmark data set containing quite different typical products. The data set contains, at the moment, the data of 452 product evaluations with the UEQ. Figure 6 shows the benchmark of FunHomework.

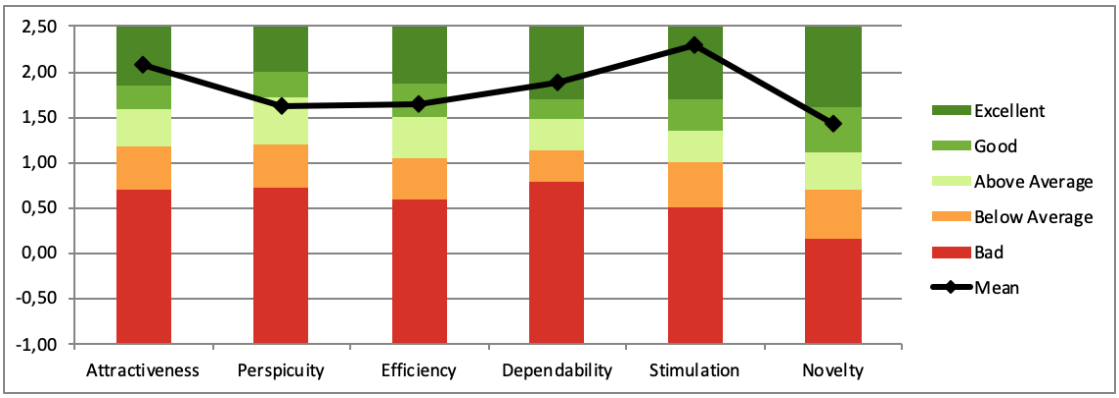


Figure 5. 6 Visualization of the benchmark in the data analysis Excel sheet of the UEQ

As per the UQE benchmark tool, FunHomework's Attractiveness score of 2.067 – for example - is rated as *excellent*, placing it within the top 10% of the 452 benchmarked products.

The scales of FunHomework are presented in the light of UEQ benchmark as follows:

1. Attractiveness (Excellent): In the 10% best results range.
2. Perspicuity (Above Average): 25% of the results in the benchmark are better than FunHomework, and 50% of the results are worse.
3. Efficiency (Good): 10% of the results in the benchmark data set are better, and 75% of the results are worse.
4. Dependability (Excellent): In the 10% best results range.
5. Stimulation (Excellent): In the 10% best results range.
6. Novelty (Good): 10% of the results in the benchmark data set are better, and 75% of the results are worse.

5.4.2.2 Qualitative Review

The analysis of teachers' interviews is presented as two core themes: implementing DGBL in schools and implementing FunHomework in classrooms. Each theme comprises a series of concepts supported by extracts from interviews drawn from the larger data set. Table 3 shows the intermediate open and axial codes, as well as the final selective codes.

Selective	Axial	Open
DGBL in Schools	DGBL platforms	Wordwall
	Adoption Obstacles	Kahoot
	Required Features	Costs
		ICT infrastructure
		School Curriculum
		Time Consuming

Selective	Axial	Open
		Classroom Management Training Complexity Student Performance Feedback Evaluation/Assessment Community/Parents
FunHomework in Classroom	Advantages of FunHomework Recommended Improvements	Real Game Mobile Apps Android/iOS/Web Multiple Subjects Technical Support Easy Setup Customised Content Less Paperwork Shared Activities Using QR Codes for registration Games for other age set Play/Learn ratio

Table 5.3 Qualitative Review Themes

DGBL in schools

Interviewed teachers revealed a positive attitude towards using games in education. They highlighted the advantages of utilizing SGs in school curricula and reported on their previous experience with DGBL. *Wordwall*, *ALEKS*, *Matific*, *Nearpod*, and *Kahoot* are examples of DGBL platforms that teachers tried to incorporate in their schools.

However, teachers mentioned various obstacles that hinder the utilization of games in classrooms. Teachers frequently reported impediments such as ICT Infrastructure and games' availability.

"*Most of the well-known platforms have limited free accessibility and require additional costs for subscriptions, which cannot be afforded by limited school budgets*".

According to Teacher Ayah, the most important factor was the time limitation: "*games are sometimes difficult to adopt in the classroom due to the condensed curriculum and time limitation*".

When asked about the most important feature that needs to be in the game-based framework, teachers highlighted several attributes that should be in any platform to be embedded into everyday classroom practice.

According to Ferdous, the user interface was the most important factor: "*...to have an easy interface not only for teachers but also for students…especially when dealing with primary school students*".

Rana stressed the importance of receiving feedback about students' performance: "*...to give the teacher the needed feedback about mastering the intended skills*".

In addition, many teachers highlighted the importance of incorporating games that suit different genders, age margins and skill levels. Ayah also found it important for the framework to be "compatible with the existing school platform".

FunHomework in classrooms

In this theme, teachers reported on their experience of using FunHomework. They highlighted several strengths that distinguish FunHomework from other platforms that help encourage teachers to utilize FunHomework in their schools. They also noted various areas for improvement that should be considered in future platform revisions.

Teacher Rana was amazed by her students' engagement and used the gameplay as an award for performant students: "*The best thing about Pencil Knight is that it looks like a real game of the kids' favorites, which made my students very attracted to do the learning activities*".

Many teachers liked the availability of FunHomework as a mobile application. Haifa found this application to be very practical and handy. "*It is very nice to have the framework as mobile apps; the teacher can create activities and track students anytime from their handheld device*".

In addition, Teacher Shorouq found the idea of customizing the framework for multiple subjects and different curricula amazing. "*...I used the game with the kids for Math and English activities…. the idea is brilliant*". For Merna, attributes such as easy instructions and direct contact with the developer were very helpful in adopting the platform.

The teachers were also asked to review the individual functionalities of the app. App operations such as installation, registration, activity creation and students' result tracking were rated easy by 83 per cent of the teachers. For improving TutorApp, Ayah suggested that sharing activities among teachers can be a good feature: "*it would be nice if I can share or use activities shared by other teachers, as sometimes I don't have much time*".

With reference to Pencil Knight, teachers found that student registration was a relatively complex task. Although the student had to mostly undertake this process once, almost 70

per cent of the teachers think these steps are a bit complicated for students, especially in primary classes.

Another area of improvement for Pencil Knight, as spotted by Teacher Dania, was to "*...decrease the space between questions….so that the player does not get bored*". In the same vein, Rawan thought that Pencil Knight is designed for primary classes and to "*...disseminate the same interesting principle on other grades…*" and suggested creating another game for older students that suits their age.

The last concept covered in the interviews was the comparison between frameworks with fixed learning content and the dynamic content creation in FunHomework and whether the latter entails an additional burden for the teachers.

More than 66 per cent of the interviewed teachers preferred to customize the activities according to their learning objectives over having ready games that did not match the curriculum, even if this customization led to additional work. According to Teacher Rana, FunHomework was even easier than dealing with the traditional homework, "*...it is not only interesting for the students…even for me it was easier and relieved me from a lot of paperwork*". Teacher Ayah thought, however, that it would be good to enjoy both options with dynamic and fixed contents. "*It is beneficial to have systems that can be customized according to the curriculum, but it is also nice to have ready games that can be used directly as we sometimes don't have much time*".

5.5 Discussion

5.5.1 Usage of FunHomework

The results of the study on the actual usage of FunHomework, encompassing TutorApp and Pencil Knight, shed light on the platform's practicality and the engagement it fostered among teachers and students. Over the two-month implementation period, FunHomework made significant strides in both its availability and usage.

The findings from TutorApp usage illustrated sustained teacher engagement and the app's efficiency in streamlining the process of creating game-based learning activities, requiring only a minimal amount of teachers' time. For Pencil Knight, the results affirm the game's ability to captivate students' interest and encourage active participation in educational activities. Notably, 432 teacher-created activities were completed by the students, further emphasizing the practicality and educational value of Pencil Knight.

The results highlighted in Figures 4 and 5 show that FunHomework apps were continually used by teachers and their students during the implementation period, demonstrating the potentiality of FunHomework to be adopted in everyday classroom activities in formal educational settings.

In summary, the findings indicate that FunHomework, with its components TutorApp and Pencil Knight, not only offers a user-friendly experience but also effectively encourages engagement in game-based learning activities. These results reflect the platform's potential to make a meaningful impact in the field of education, offering innovative and engaging solutions for both teachers and students.

5.5.2 UEQ

The results of the UEQ scales provided a comprehensive evaluation of FunHomework's user experience. To gain deeper insights into the evaluation results, we compared FunHomework with a benchmark dataset of 452 product evaluations conducted using the UEQ. This benchmarking exercise positions FunHomework as a top-performing product in several key aspects:

- **Attractiveness** (Excellent): FunHomework's score of 2.067 places it within the top 10% of the benchmarked products. This highlights its exceptional appeal to users, underlining its strength in capturing user interest.
- **Perspicuity** (Above Average): While falling slightly below the top tier, FunHomework still performs well, with 25% of benchmarked products demonstrating better results. This category pertains to clarity and ease of use, indicating room for potential improvement.
- **Efficiency** (Good): FunHomework's performance is rated as good, with 10% of benchmarked products surpassing it. This suggests that the platform offers an efficient user experience, though there is scope for enhancement to join the upper echelons.
- **Dependability** (Excellent): Similar to Attractiveness, FunHomework shines in Dependability, falling within the top 10%. This indicates the platform's high level of reliability and user trust.
- **Stimulation** (Excellent): FunHomework's score highlights its ability to stimulate and engage users effectively, securing a place within the top 10% of benchmarked products.
- **Novelty** (Good): While performing well, FunHomework is considered good in terms of novelty, indicating that there is potential to further innovate and offer fresh experiences.

These findings demonstrate that FunHomework has succeeded in creating an attractive and dependable user experience, positioning it among the top-performing products in the benchmark. As we continue to refine and enhance the platform, addressing the areas of Perspicuity and Novelty may further elevate the overall user experience. These results reflect a positive trajectory for FunHomework in the realm of user experience and highlight its potential to make a significant impact in the field of DGBL.

5.5.3 Teachers' Interviews

The results of teachers' interviews were presented as two core themes: implementing DGBL in schools and implementing FunHomework in classrooms.

The teachers' interviews revealed a positive disposition toward integrating games into in schools, with a particular emphasis on the benefits of SGs within school curricula. However, they also highlighted challenges, such as ICT infrastructure limitations and the cost associated with many well-known platforms. Time constraints due to a condensed curriculum emerged as a significant obstacle to implementing games in the classroom. Teachers emphasized the importance of user-friendly interfaces, feedback on student performance, gender-age-skill-level inclusivity, and compatibility with existing school platforms. These findings align with challenges reported in the literature, emphasizing the significance of DGBL platform features in teacher adoption decisions.

Enhancing the implementation of DGBL can be effectively achieved by providing solutions to these adoption obstacles that impede effective utilization in schools. Therefore, FunHomework managed to cope with most of these obstacles in the following ways:

- **Congruence of games with the curriculum**: Using authoring tools within the platform can adequately provide games compatible with teachers' learning objectives. This can help teachers integrate the platform into their educational plans without concerns about game compatibility. As teachers completely set the learning content in FunHomework, we managed to utilize the platform in different schools and countries.
- **Platform complexity**: In FunHomework, we limited the role of the authoring tool to create the learning content rather than providing game scenarios and mechanics. This produced a simple authoring tool that does not consume much of teachers' precious time and can be used without previous technical knowledge. During the implementation, teachers could produce activities in TutorApp within a few minutes per session without technical support.
- **Production cost**: Authoring tools can facilitate a cost-effective approach to creating DGBL environments. As FunHomework uses an open API, any game compatible with this API can be easily integrated into the platform and used with the same authoring tool TutorApp. SGs are normally created with high budgets and predefined learning content. Once the player masters all aspects of the game, the latter loses much engagement value. The dynamic nature of FunHomework games can render them suitable for any subject, drastically decreasing the production cost. In addition, this can increase game reusability rates, as more challenges can easily be appended to the game.

- **Student assessment**: To empower teachers to adopt new instructional tools, it is important to receive sufficient feedback about students' performance using these tools. Teachers, while evaluating FunHomework, have precisely denoted this fact. In TutorApp, teachers can track their students' results and export reports to be documented and used in the final evaluation of student performance.

Within the second theme, teachers shared their experiences with FunHomework and identified several strengths that set it apart from other platforms. Notably, teachers praised the mobile application, making it convenient and practical for them to create and track student activities. Customizability for multiple subjects and different curricula was seen as a brilliant feature, enhancing the platform's appeal. Teachers also appreciated the ease of use, direct contact with developers, and easy app operations, which included installation, registration, activity creation, and result tracking. Suggestions for improvement included enhancing the ease of student registration and expanding the game to cater to older students. Almost 90% of the teachers found that the student registration process was complicated for primary school students. Within this process, the student had to first create an account, log in with a username and password and join a specific teacher group. Some teachers suggested simplifying student access, for example, by using scannable QR codes that relieve students from saving login credentials.

A significant finding was the preference for dynamic content creation in FunHomework, allowing teachers to tailor activities to their specific learning objectives. Many teachers expressed a willingness to invest additional effort in customizing content, appreciating the platform's flexibility and the reduced paperwork it entailed. Some even found FunHomework to be a more manageable alternative to traditional homework, indicating its potential to alleviate teachers' burdens.

5.6 Conclusion and Recommendations

We conducted this study to answer a central research question:

Can SGs with dynamic learning contents enhance the utilization of DGBL in formal education?

As teachers play a pivotal role in adopting technological initiatives in their classrooms, we implemented the FunHomework platform in six different schools to explore teachers' views on the ability of a platform with dynamic learning content to overcome most of the implementation obstacles reported in the literature.

Through comprehensive exploration and examination of FunHomework, including TutorApp and Pencil Knight, our findings point towards a positive answer to the research question, revealing promise and potential for utilizing platforms with dynamic learning content in formal educational settings. The empirical evidence presented in this study

offers a glimpse into the practical implementation of FunHomework. The results underscore the practicality and engagement potential of the platform among both teachers and students.

While the limited number of participating teachers may restrict the generalizability of the findings to a wider audience, the focused group of teachers with prior experience in DGBL offered valuable insights and information regarding the advantages and disadvantages of the platform. Moreover, the smaller participant pool facilitated in-depth analyses of each teacher's input, leading to a deeper understanding of the topic under scrutiny. As experts, the teachers were committed to participate and dedicate time to use and test the platform, driven by their motivation to share their knowledge and insights for improving the concept.

The study's exploration of FunHomework's actual usage revealed its transformative impact on both teachers and students. The TutorApp, designed to facilitate the creation of game-based learning activities, witnessed sustained teacher engagement. The app proved to be an efficient tool in streamlining the process of activity creation, saving teachers valuable time while providing a user-friendly experience. Through various versions, TutorApp demonstrated flexibility, and its deployment on different devices was a key feature. Additionally, the detailed engagement statistics displayed in Figure 4 reveal that TutorApp resonated with educators. Teachers engaged in multiple sessions, highlighting its practicality in the everyday classroom environment.

On the student front, Pencil Knight emerged as a captivating and engaging game. The data showed that students actively embraced the game, with frequent daily sessions. Pencil Knight's user statistics indicated not only students' involvement but also a high rate of session completion. This usage pattern demonstrated that FunHomework can effectively engage students, ensuring that learning remains dynamic and interactive.

The UEQ results indicate that FunHomework has succeeded in creating an attractive and dependable user experience. The strengths noted in the UEQ assessment affirm the platform's potential for making a potential impact adopting platforms with dynamic learning content by teachers.

As we conclude our exploration of the potential of SGs with dynamic learning content to enhance DGBL in formal education, it becomes evident that FunHomework, with its TutorApp and Pencil Knight components, holds a reasonable promise. The findings from our study point to significant strengths and opportunities in this innovative concept. To ensure that FunHomework fulfils its potential and continues to improve the landscape of formal education, we present the following recommendations for consideration and implementation. These recommendations are designed to enhance the platform's utility, address specific challenges, and further the cause of engaging and effective learning in the classroom.

- **Mobile Apps**: as an advantage of using mobile apps, distributing several versions of FunHomework was relatively easy. Therefore, we see that providing the platform in the form of mobile apps in the official app stores can increase the chances of adoption in formal settings.
- **Expand Target Age Groups**: it is worth noting that the Pencil Knight game was designed for primary school students aged between five and ten years. This constrained the implementation of older and larger amounts of students. However, FunHomework is based on an open API that enables other games to be easily developed, which is compatible with TutorApp.
- **App Store Guidelines**: we chose to publish and distribute the apps using well-known app stores, therefore, we needed to align our apps to Google and Apple stores' guidelines. As these stores have some strict rules regarding apps targeting children, such as "Age Neutral Screen", that are required for creating and editing child accounts, further complexity was added to the student registration, as directly reflected in teachers' reviews of the apps. It is recommended that developers who publish their apps in app stores consider the store guidelines to avoid production delays and provide a smooth user experience.

Overall, teachers' direct implementation and evaluation of FunHomework revealed considerable satisfaction among educators teaching various subjects in different schools and countries, who showed high interest to continue using the platform after the study concluded. The teachers' interviews underscored the multifaceted nature of implementing DGBL in formal education settings. While challenges persist, the adaptable nature of platforms like FunHomework offers promise. Teachers' willingness to customize content, coupled with their enthusiasm for engaging gameplay, suggests the potential of such platforms to be adopted in the educational landscape. However, ongoing improvements, especially in user experience and game variety, are vital to ensuring the seamless integration of DGBL into classrooms. These insights from teachers illuminate the intricate dynamics between technology, pedagogy, and student engagement, paving the way for future advancements in the field of game-based learning.

5.7 Summary

Chapter 5 of the thesis represented the evaluation phase of the DSR process, at which the FunHomework platform was subjected to a two-month-long case study in a real-world school environment. This chapter offered a broad analysis using both quantitative and qualitative methods in measuring the effectiveness of the platform in addressing the identified major obstacles that acted as barriers toward the adoption of DGBL. These findings establish that FunHomework can make the incorporation of game-based learning into formal education systems easier and more attractive for teachers. This resulted in the demonstrated platform that allows teachers to more easily include their educational content

within the games, and supports the mapping of games to the curriculum, increasing the tendency for adopting DGBL in formal education.

Chapter 6 focuses on the discussion that reflects the findings from the previous four studies. This last chapter will pull together the accumulated insights developed through the research process and critically assess the impact and implications of FunHomework in a broader perspective of educational technology and pedagogy. This will cover what the project has achieved and its limitations; it will discuss how the DSR methodology contributed to answering the research question thoughtfully. Besides, this chapter would mention some future research areas that try to extend this line of work on how the findings can help shape the design of similar tools or strategies to further improve the adoption and effectiveness of DGBL in different educational scenarios.

Chapter 6

Summary and discussion

Throughout this dissertation, the focus was on four works examining ways to enhance the process by which game-based learning is adopted in formal education. These are discussed in this chapter. First, the research is positioned by describing the aim and the context of the studies. Next, each study's results are summarized. Thereafter, the conclusions are formulated with regard to the overarching research question. This is followed by a discussion of the research approach and the outcomes. To conclude the chapter, recommended potential future directions for researchers and practitioners are outlined.

6.1 Overview of The Study

This research was undertaken based on the landscape of the adoption of game-based learning in formal education that reveals problems existed in this research area and hinder teachers from utilizing SGs in their classrooms, even though there are so many research studies have been carried out in this field. Design Science Research (DSR) has been selected as the research methodology for this research study where at the beginning stage, the establishment of awareness towards the problems has been identified by conducting two precursory sub-studies. Key issues that surmount SGs implementation have been discovered and therefore this is believed as the main problem in this research area. The conceptual solution "FunHomework" has been formed to deal with the problems identified, which then was evaluated practically in school settings.

The aim of the study was to explore the ability of serious games featuring dynamic learning content to enhance the adoption of game-based learning in formal education. To that end, a game-based learning platform - FunHomework - was presented, in which teachers could create pedagogical content using an easy mobile authoring tool and integrate the content into a mobile serious game to be used by students.

FunHomework aimed to simplify the authoring tools for games by relieving teachers from the need to dive into the technical aspects of game design and enabling them to focus on creating the in-game pedagogical content. This solution was intended to enable teachers to customize games according to their needs and those of the school curriculum, which in turn retained the teacher as part of the production of the game and maintained their sense of engagement. At the same time, teachers were not pushed from their comfort zone or required to acquaint themselves with the technical aspects of the game. As a result, teachers were attracted to utilize FunHomework practically in their classrooms due to the minimal technical effort and short preparation time needed.

The primary data source in this study was teachers' feedback in the form of interviews and questionnaires. To understand the limitations that hinder the adoption of games in schools, several obstacles were identified and investigated. To enhance the utilization of game-based learning in formal education, the researcher explored recent efforts to promote serious games, as was the extent to which these efforts managed to overcome the implementation impediments. After that, implementation challenges like teachers' attitudes to the games, the availability of curriculum-related games, and the time/effort needed to implement these games, were investigated. Eventually, the findings were reflected in the potential solution - FunHomework - which was embedded in school practice to evaluate and validate its contribution to boosting game-based learning adoption. This research focused on answering the following key research question:

> *How can the introduction of simplified game authoring tools facilitate the integration of game-based learning within formal educational environment?*

This question was answered through four sub-studies, as described in the next section.

6.2 Summary of the Findings

6.2.1 Awareness of the Problem – Literature Review

The first step of this DSR was to establish awareness of the problem, in which the obstacles that limit the adoption of SGs in schools have been identified. For that, a domain analysis study had conducted a systematic literature review using Grounded Theory to understand the state of game-based learning research and further investigate the key requirements of a potential solution. The review of the literature was necessary for various reasons: (a) to identify recently conducted work that supported the in-class adoption of game-based learning by teachers, (b) to highlight the variety of methods employed to augment digital game acceptability among educators, as well as the introduction of such games in formal contexts, and (c) to explore the degree to which such endeavors had facilitated the surmounting of the obstacles outlined in the literature and led to more schools adopting game-based learning.

The study findings indicated how three key themes could be used to categorize research into game-based learning: *Adoption Motivations and Obstacles*, *Teacher Competency*, and *Adoption Strategies*.

- *Adoption Motivations and Obstacles:* Studies within this theme were considered the first step in any attempt to foster technology adoption since they focused on drivers of and barriers to utilization, and they generally examined factors that determine why teachers adopted DGBL in classrooms and the hurdles that impeded DGBL acceptance in formal educational settings. This theme was found to dominate the others and had been extensively investigated, while most researchers concluded

that the adoption determinants were very similar. Unless the need should arise to investigate the adoption barriers linked to a very specific case study, the authors could not identify many potential gaps in this research area.

- *Teacher Competency:* The second theme of the findings was *Teacher Competency*, in which the studies focused on improving teachers' skills to enable them to adopt game-based learning effectively in their classrooms. Some of these studies investigated professional development, which was used to expand teachers' professional digital knowledge in the mid- to long-term. Other studies conducted "fast-track" interventions to enhance teachers' game literacy using special courses and workshops, change teachers' attitudes to games, and inform them about the anticipated positive effects of games.
- *Adoption Strategies* formed the third theme of the findings, which presented solutions to help overcome the obstacles limiting game-based learning adoption in formal education. Researchers in this area tried to present innovative solutions that would facilitate game-based learning implementation using theoretical models and applied frameworks that challenged the aforementioned implementation hurdles. The results of this study highlighted the positive effects of authoring tools for games, which involved teachers as designers and could provide an uncomplicated premise by abstracting the technical aspects of game design. Authoring tools could help to customize games according to the teachers' requirements at low cost, make games accessible to non-programmers, and ease the participation of non-technical SG stakeholders.

By the end of this study, the main research problem was identified. It was concluded that the adoption strategies that have been used so far in game-based learning research could nominally combat the obstacles that face teachers by adopting SGs in their classrooms, which has led to narrow progression in implementing game-based learning in formal education. Therefore, the researcher has encountered room for research to provide innovative solutions that correspond to teachers' needs and enhance the utilization for SGs in educational settings.

6.2.2 Awareness of the Problem - Teachers' Perceptions

To further investigate the key requirements of the potential solution a second study was conducted in cooperation with teachers from Jordan. The goal of this study was to investigate the requirements of Jordanian teachers for the artifact and examine whether they are confronted by a different set of practical implementation problems.

In this study, the artifact design started by investigating the initial requirements deduced from a qualitative pre-study featuring structured interviews. This study was conducted to gain theoretical insights into the educational problem domain. This tentative study explored teachers' views on implementing serious games in Jordanian classrooms and

investigated the hurdles limiting this adoption. To achieve this, the ways teachers perceived SGs and how they affected the teachers' contributions were ascertained by administering online and hard-copy surveys. Obtaining the educators' perceptions also enabled the identification of the difficulties and restrictions linked to the in-class use of SGs, thus illuminating the typical attitude of the educator toward an environment based around games.

The study findings indicated that teachers from Jordan expressed great interest in the integration of SGs into their classroom work. However, the effectiveness by which SGs could be used by teachers appears limited because the official curriculum in Jordan offers no definite game-based learning framework to guide educators' in-class endeavors. This issue is further exacerbated by the numerous difficulties that teachers experience, which include, but are not limited to, identifying a SG that corresponds to the curriculum and lacking ways to assess students through a SG.

Despite the lack of digital games experience of most of the country's teachers, educators tended to recognize with confidence that SGs could benefit, directly and indirectly, many aspects of the procedures within education. Therefore, frequent mention was made by the educators in the survey that games could affect the development of transferable skills such as the capacity to think critically, problem solve, be creative, and collaborate.

With no clear governmental game-based learning policy, great variability exists in the ways schools utilize digital games as part of their educational process, with decisions resting with each school manager or, frequently, each teacher. Thus, it is argued that game-based learning can only become embedded within formal education through continuous dialog between teachers and research establishments whose primary focus is game-based learning.

Moreover, the work revealed various ways in which SG use in schools is impeded. According to the participant teachers, the most frequently encountered hurdle was the attitudes teachers had to SG use, with the second being the unavailability of SGs that corresponded to the curriculum. Another key obstacle to SG use, many educators mentioned, was the need for time to prepare the incorporation of SGs. This was unsurprising as the extensive teaching workload can expand if games are used.

The results of this study had replicated the implementation obstacles that were revealed in the literature in study 1, and highlighted significant teachers' recommendations that were vital for refining FunHomework platform design and re-formulating the problem statement. For example, many educators indicated various attributes of effective SGs that would be essential if the latter were used in formal education settings. These features included multi-platform availability so the SG could be used online, on computers, and on smartphones, as well as the need for elements of fun. A characteristic requested very often by the educators was the capability to manage the learning content and gaming elements

of each game so that learning objectives could be tracked, and teachers would feel more confident in relation to the class-leader contributions they were making.

The findings demonstrated practicality and optimism, which should motivate others to shape future studies so that SG development can improve, and customizable game-based learning space models can be created to enhance the outcomes of learning. Furthermore, the findings establish a basis for finding connections between the ways pedagogical decisions are made and the aspects that affect what occurs in practice when a game is introduced by a school.

At the end of this stage, the research problem was recognized and the foremost prerequisites of the artifact were determined, which laid the groundwork for designing and developing the potential solution.

6.2.3 Development

This study incorporated the development step of the DSR framework, whereby a concept was developed to solve the aforementioned problem based on the requirements in the previous stage. To achieve this, the researcher introduced an initial design for a serious game with dynamic learning content, with a prototype to realize the concept of serious games in which the play scenario was fixed and the learning content can be dynamically controlled from an external authoring tool via a mobile app. The study aimed to examine how various development difficulties associated with such a platform and explore potential aspects related to used technology. In this proof of concept, the researcher presented the first version of FunHomework, which was composed of two mobile apps: TutorApp, an authoring tool with which teachers could create learning content, and a 2D platformer game for students that received the learning content created using TutorApp.

This prototype involved the development of mobile apps, the idea for which was generated by teachers' perquisites in the previous stage. The surveyed Jordanian teachers meant that the mobile phone could be a method of complementing formal education cost-effectively and facilitating the ways educational material could be delivered at any time and place. This decision created the additional challenges of supporting mobile devices that used different platforms and were made by different manufacturers, as well as conforming to their policies and technical requirements. Therefore, it was essential to investigate the available technologies and their ability to support the development of the desired apps. The Unity3D game engine was selected for game development as it can export games for different mobile platforms (i.e., Android or iOS) and PC operating systems (i.e., Windows, macOS) using the same code base. The findings of this study evinced the suitability of Unity3D to build adequate game scenarios and export them to playable formats on various platforms without the extra effort of writing platform-specific code. For the authoring tool in this prototype, it was developed using the Java programming language, which can only be run on Android devices, so the study highlighted the need to re-engineer the authoring tool

and to investigate other technologies that support Apple mobile devices running iOS. To communicate, both apps (the authoring tool and the game) needed to share a common database. Since data in these games had to be handled instantly, the database used to store them needed to be able to deal with real-time data synchronization for every connected game-client. The study revealed how the Firebase database could be used by FunHomework to provide reliable storage that synced teachers' and students' data in real-time and would remain available even when the apps went offline.

The game Pencil Knight was developed using the Procedural Content Generation (PCG) method (see Appendix Snippet 2), which involves game content being generated programmatically. Deriving from a process that is randomized or pseudo-randomized, the result is a set of potential spaces for gameplay that cannot be predicted. Since game content design is becoming increasingly costly, design skills were supplemented in this study using PCG so that game content generated at random could create the environment's population quickly. The in-game entity parameters - such as those of enemies, mountains, and trees - were varied with the use of In-Game Entities being dynamically instanced, which created a possible entity number that was numerous but in which repetition was highly unlikely. Due to PCG, whenever a game was started by a player, the play environment would be nearly unique. If the game was restarted, the player would be settled in a different level in which the weather had changed, mountains and trees were in different positions, and they would face new sorts of enemies. While saving the time needed to design and develop the game, this also meant players would be less likely to become frustrated and more likely to maintain their engagement in the game.

In this study, FunHomework was tested on a small scale to obtain initial feedback from teachers and students, who showed noticeable satisfaction with the idea. They demonstrated particular interest in using mobile devices as convenient tools to facilitate the delivery of educational content inside and outside of classrooms. The promising findings of this study highlighted potential future research scopes and were intended to motivate the researcher to undertake further research and evaluate the platform on a larger scale.

6.2.4 Evaluation

At this stage of the DSR, an *ex-post* evaluation was conducted. The key purpose of this evaluation was to determine how well the designed artifact "FunHomework achieved its expected environmental utility. In addition, the evaluation had intended at demonstrating the design theory in terms of the quality of the knowledge outcomes, and to provide evidence that the utilization of simplified authoring tools and SGs with dynamic learning content can contribute to solving adoption problems or make some improvement in this regard.

To that end, the 4th study entailed the implementation of an updated version of the artifact FunHomework in actual school settings to assess it against the desired goal. This

evaluation was continued throughout the study and was used to guide the development of design principles and improve the artifact to best suit teachers' needs.

In this study, FunHomework was subjected to various refinements and implemented in real environments (schools) to evaluate it against the study objective. This evaluation was performed continuously during the activities to derive the design principles and build the most appropriate artifact. While thus implementing the app, an evaluation was conducted of the capacity of FunHomework to make problem-solving contributions by expanding game-based learning use and surmounting the obstacles linked to its in-class incorporation.

In terms of applicability, the data collected from the official app stores showed that the FunHomework apps were installed by teachers and students, and they were continually used to digitize learning activities in various school subjects. Over a two-month implementation period, teachers could integrate the platform smoothly into their pedagogical curricula and create learning activities without direct support from the researcher. The findings of this study revealed that providing a platform in the form of mobile apps via official app stores could increase the chances of it being adopted in formal settings.

The user experience evaluation showed that teachers found the interface of the TutorApp authoring tool very simple – a factor that might decisively impact teachers' choices. However, teachers also noted that the student registration process was complicated for primary school students and that student access could be simplified, for example, by using scannable QR codes that would alleviate the need for students to save their login credentials.

The study findings illustrated that FunHomework was able to tackle the hurdles that generally limit the efficacy with which such tools are often implemented by a school.

- **Congruence of games with the curriculum**: Using the authoring tool within the platform could produce games compatible with the learning objectives of teachers, which would help them to integrate the platform into their educational plans without concerns about game compatibility. As teachers set the learning content completely in FunHomework, the platform was utilized in different schools and countries.

- **Platform complexity**: In FunHomework, the authoring tool's role was limited to creating the learning content rather than providing game scenarios and mechanics. This led to the production of a simple authoring tool that did not consume much of the teachers' precious time and could be used without previous technical knowledge. During the implementation, teachers were able to produce activities in TutorApp in a few minutes per session without technical support.

- **Production cost**: The Pencil Knight game within FunHomework was used for several school subjects, which reduced the potential costs that schools normally bear when acquiring multiple subject-specific games. As FunHomework used an open API, any game compatible with this API could be easily integrated into the

platform and used with the same TutorApp authoring tool, potentially reducing costs even further.

- **Student assessment**: While evaluating FunHomework, teachers denoted precisely the fact that they can keep track of students' performance. In TutorApp, teachers could track their students' results, as well as export reports to be documented and used in the final student performance evaluation.

This evaluation stage has unveiled the ability of FunHomework platform to address several obstacles that teachers encounter by utilizing SGs in their classrooms. This signifies that the adoption of game-based learning can be enhanced by using platforms with simplified authoring tools and SGs with dynamic learning content.

6.3 Conclusion

The aim of the current research was to enhance games-based learning use in formal educational settings. For that purpose, four sub-studies were conducted within a design science research study to investigate how SGs adoption in schools can be reinforced. Contributing to knowledge is seen as the foremost criterion for the publication of research (Straub et al. 1994). In DSR, the potential research contribution can be verified by asking several questions: Is it true? Is it new? Is it interesting? (Wilson, 2002). It would also be important to identify the DSR outputs as research deliverables. According to (Gregor & Hevner, 2013) there are three maturity levels of DSR artifact types, which are illustrated in Table 6.1. At Level 1, artifacts can be specific instantiations in the form of products and processes. At Level 2, the artifacts' contributions can be in the form of nascent design theory (i.e., design principles, methods, technological rules). The most mature knowledge contributions are in Level 3 artifacts, which can take the form of well-developed design theories about the circumstances under study (Gregor & Hevner, 2013).

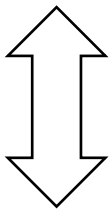
	Contribution	**Types Example Artifacts**
More abstract, complete, and mature knowledge	Level 3. Well-developed design theory about embedded phenomena	Design theories (mid-range and grand theories)
	Level 2. Nascent design theory—knowledge as operational principles / architecture	Constructs, methods, models, design principles, technological rules.
More specific, limited, and less mature knowledge	Level 1. Situated implementation of artifact	Instantiations (software products or implemented processes)

Table 6. 1 DSR Contribution Types
Source: (Gregor & Hevner, 2013)

(Gregor & Hevner, 2013) have also presented a framework for DSR knowledge contribution, which demonstrates the different types and levels of research contributions depending on its starting points in terms of problem maturity and solution maturity. Figure 6.1 shows a matrix of 2 × 2 for research project contexts and potential contributions of DSR research. The x-axis represents the problem context maturity from high to low. The y-axis shows from high to low the current artifacts maturity that exist as potential starting points for solutions to the research question.

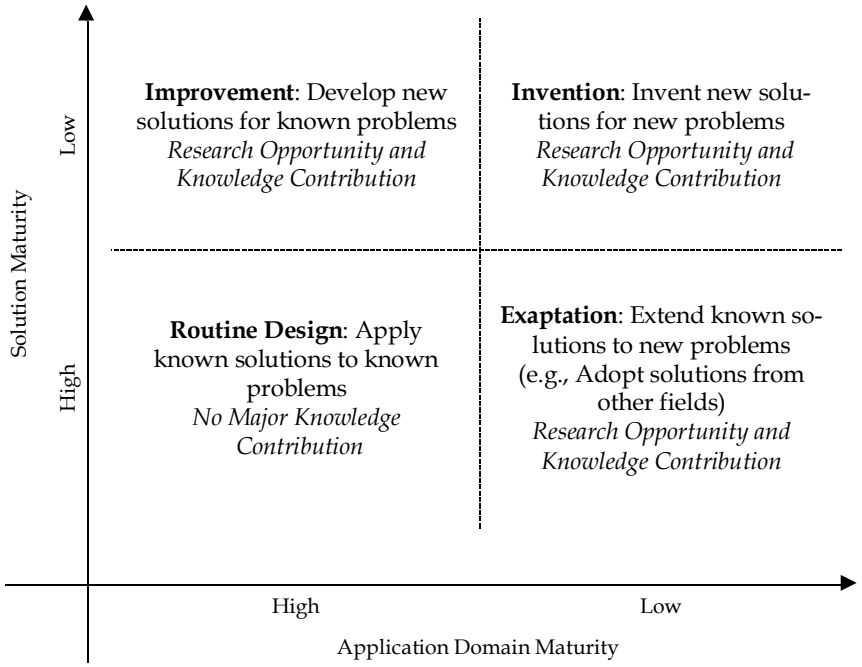


Figure 6. 1 DSR Knowledge Contribution Framework
Source: (*Gregor & Hevner, 2013*)

The artifact in this research has provided an *Improvement DSR* that contributed to knowledge at levels 1 and 2. Next, is a discussion of the research deliverables and their impact on game-based learning knowledge base.

6.3.1 Design Principles

This research presented FunHomework platform as a software product that provides new solutions for known game-based learning adoption problems. The platform was first presented in the study (Assaf, 2017), which was published in the Joint Conference on Serious Games (JCSG). After that, another sub-study was conducted in which the artifact was implemented and evaluated in real educational environments to measure its utility and ability to effectively enhance SGs adoption. Within this sub-study - still under review for publication - the platform was subject to refinements and improvements based on direct feedback from in-service teachers, which helped customizing the platform according to teachers' needs.

These sub-studies contributed to knowledge at maturity level 2 by suggesting several innovative *design principles* that can be applied to game-based learning production:

- **Simplified Authoring Tool**: Based on this study, it was found that teachers often have limited time resources for gaming activities. Consequently, to enhance the acceptance of game-based platforms, it would be crucial for game authoring tools to be user-friendly, accessible even to those who are not technologically inclined. The study suggested simplified authoring tools that focus on creating the learning content instead of designing the mechanics of the game. Generally, game authoring tools require teachers to design the game itself which includes actualizing game scenarios and finding multimedia resources. Within FunHomework, the teacher is relieved from games' technicalities and the associated challenges and needs to only focus on the pedagogical content within the game.
- **Dynamic Learning Content**: Typically, SGs are developed with predetermined and unchanging learning content. As the learner overcomes various obstacles and challenges within the game, they eventually reach a point of mastery. Once this stage is reached, the engagement begins to diminish, resulting in decreased usability of the game. To address this issue, incorporating dynamism into SGs can effectively extend user engagement and improve overall reception. The principle of *Dynamic Learning Content* for SGs design was introduced in this research, in which learning materials are injected in the game at runtime instead of building the SG based on fixed notation. Although this architecture is not totally new, a distinct improvement has been made compared to current counterpart solutions. In EducaMovil (Molnar et al., 2015) for example, the authoring tool could be used to create learning contents for a very simple game that can run only on Java-enables phones. On the other hand, FunHomework incorporated a real platformer game that can be run on Android and iOS phones, as well as on personal computers inside a web browser.

- **Open API**: In order to design a game-based learning platform with the potential for expansion to incorporate multiple games, it would be essential to minimize the workload for teachers. This can be achieved by providing a single authoring tool that can be used across all games, eliminating the need for teachers to handle multiple authoring tools for different games. An interesting *design principle* of FunHomework platform is the compatibility of the authoring tool TutorApp with multiple games and sharing the same learning materials among those games. FunHomework uses an open API that administers the interaction between the TutorApp and the SGs, and defines the standards of communication within the platform. As a result, any new SG that conforms to the API standards can be easily integrated in the platform and perpetually communicate with the authoring tool. Figure 6.2 shows how the authoring tool TutorApp, and the games share a real-time Firebase database. The TutorApp communicates directly with the database, whereas the games use a series of cloud functions to communicate with the

database. These games need to call a specific HTTPS URL to perform any necessary operation, complying with the communication standards and the required data formats of the API to ensure a proper interaction.

The figure features the PencilKnight game as an example, but in practice, any game can utilize the secure URLs to register students, log them in, and place them into specific groups using a unique GroupID. Following this, the game can retrieve the learning activity created for this group and integrate it into the gameplay based on the game's mechanics. Once the activity is completed, the result of the student (Attempt) is uploaded to the database where it can be viewed by the teacher via the TutorApp.

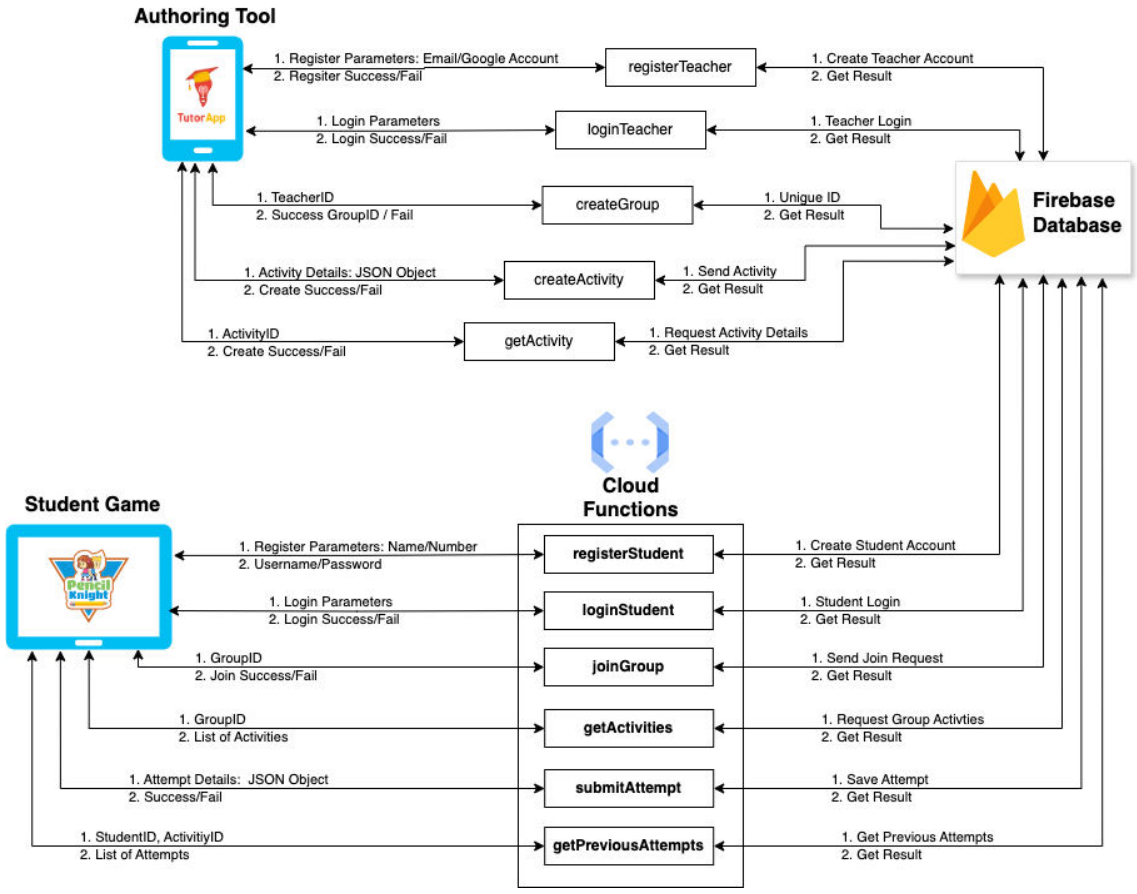


Figure 6. 2 The data flow chart of API for communication within FunHomework

According to (Gregor & Hevner, 2013), a contribution to the design knowledge in the form of *design principles* can be placed at maturity level 2. The research study was concerned in "*how*" the utilization of SGs can be enhanced in formal education. As an *Improvement DSR*, the research has contributed to the *Prescriptive Knowledge* at multiple maturity levels as described in Table 6.1.

6.3.2 Game-based Learning Obstacles

At maturity level 1, the goal of FunHomework platform was to create a better solution in the form of a more efficient and effective technological product. The sub-study (Assaf et al., 2020) which was presented in the 14th European Conference on Game Based Learning, the game-based learning context was well defined, for which solution SGs were mostly not very efficient or suboptimal. Another sub-study (Assaf et al., 2019) was conducted in co-operation with Jordanian teachers to formulate a deep understanding of the problems associated with game-based learning adoption in Jordan, and to build the innovative artifact as a solution to the following key problems.

- **Alignment with the curriculum**: One of the most crucial problems that confront teachers by utilizing SGs in classrooms is the relevance of the games to the school curriculum. The platform's authoring tool allows for the creation of games that align with teachers' learning objectives, enabling seamless integration into their educational plans without worrying about game compatibility issues. FunHomework's versatility was demonstrated as teachers were able to set learning content entirely within the platform, leading to its adoption in various schools and countries.
- **Time consuming games**: creating SGs from scratch using authoring tools can indeed customize games according to teachers' needs, however, this process can be laborious and time consuming for teachers. FunHomework's authoring tool was designed to create learning content rather than game scenarios and mechanics, resulting in a straightforward tool that didn't require much of teachers' time or technical expertise. Teachers found it easy to use, and were able to produce activities in TutorApp quickly and without the need for technical support. In just a few minutes per session, teachers could create activities that were both effective and efficient.
- **Game cost**: game production can be very expensive, and it would not be feasible for schools to afford distinctive games for different subjects/classes. By utilizing the Pencil Knight game in multiple school subjects, FunHomework was able to minimize the costs typically associated with acquiring several subject-specific games. FunHomework's open API allowed for easy integration of any game compatible with the API into the platform, utilizing the same TutorApp authoring tool. This integration capability had the potential to further reduce costs for schools.
- **Tracking student performance**: teachers are skeptical about incorporating games within their educational plans as they are not able to track students' performance during gameplay, and they generally do not get direct feedback about knowledge attainment within the game. In FunHomework, teachers are able to track their students' results and export reports about their performance, which could then be documented and used for the final student attainment evaluation. While

implementing and evaluating FunHomework in schools, teachers esteemed precisely the fact that they can keep track of students' performance and get feedback about results of individual students.

The fourth sub-study - still under review for publication - demonstrated FunHomework's ability to challenge obstacles that hinder teachers from adopting SGs in formal education, by evaluating the platform in different schools and countries.

As FunHomework managed to evince positive changes in the efficiency of utilizing SGs in formal education, we can classify the platform as an *Improvement DSR* that featured a *research opportunity*, and conferred *knowledge contribution*.

6.4 Reflections on the Research Method

6.4.1 Design Science Research

This study focused specifically on providing practical software that would overcome most of the implementation obstacles that hinder the adoption of game-based learning in formal education. To achieve this, the DSR method was used, which is based on solving problems in practical ways and features knowledge that is prescriptive or oriented around solutions, whereby scientifically justified outcomes can be utilized to design a solution to a field problem of complexity and relevance.

The study fits within the characteristics of qualitative research and its design is a result of the DSR methodical choice to stay close to teachers' professional needs and practical conditions of schools. The method is based on the dual objectives of achieving knowledge about the efficacy of design and implementation of SGs with dynamic learning contents, and the development of theories about the utilization of SGs in school settings from a user-perspective.

The method was focused on clarifying the context of game-based learning in schools in an recurring approach that remained close to the requirements in practice and to the obstacles of the intended users. The DSR approach did not impose a final formula of model design and implementation, nor did it set mandatory rules for the utilization of SG in school practices. Instead, the approach focused on a steadily evolving and cooperative practice that suits the school context, the teachers, and the chosen objective.

The design of the artifact appeared to be effective for addressing complex practice problems in a game-based learning environment and the teachers demonstrated their control over aligning the game with their curriculum and students' performance tracking.

We assume that these encouraging results is partly attributable to the constructive DSR method, in which we comprehensively took advantage of the feedback from end-users to

make sure that the artifact would respond to practical needs and requirements. The credibility of research method was promoted by the involvement of in-service teachers in the output sections of the research. In close cooperation with school teachers, we established an appropriate problem situation from a practice viewpoint. As a result, the researcher were able to refine the development of the research and the practical tools that had been created using applicable knowledge and based on actual teacher requirements. By applying Hevner's framework, an information system was built, demonstrating that this process can be effectively transferred to SG design, which is grounded in practical experience and foundational knowledge.

6.4.2 Role of the researcher

The researcher acted as a designer and a developer of the FunHomework platform using the data provided by teachers. From the first exploratory studies to the prototype in the second study, the teachers' input was collected using interviews and questionnaires administered online, after which it was used to refine and improve the platform according to the teachers' requirements.

The implementation phase took place in four countries, and virtual communication occurred between the researcher and the teachers through the official website (https://www.funhomework.games). Before the implementation phase in the fourth study, online meetings were planned with the teachers to explain both the focus of the study and how to utilize the FunHomework platform to create activities and use the game. During the implementation, contact between the researcher and the teachers was essential to monitor the process. The researcher provided the necessary technical support, and the teachers was encouraged to inform the researcher about their progress and critically report the obstacles arising at runtime. Feedback about problems and recommendations was actively collected from the teachers. This iterative feedback was used to produce several refined versions of the apps and publish them in the stores.

After the implementation, the researcher conducted online questionnaires to evaluate the teachers' experiences as users. In addition, the researcher conducted semi-structured interviews with the teachers to evaluate the efficacy of FunHomework in view of the intended goals.

6.5 Reflection on the Findings of this Study

As outlined in the current dissertation, the sub-studies examined offered insightful reflections on game-based learning from the perspectives and outlooks of educators; the hurdles that might impede the ways game-based learning is adopted; the ways in which various implementation-related issues with dynamic serious games could be mitigated; and how schools might be assisted to incorporate game-based learning. The following section uses suitable existing research to reflect on these findings.

6.5.1 Implementation Obstacles

The second study in this dissertation highlighted the attitudes of teachers toward game-based learning in Jordan. It aimed to explore teachers' views about implementing serious games in classrooms and investigate the hurdles that limit this adoption. The study concluded that Jordanian teachers were generally open to incorporating games in their curricula and that implementing games in Jordanian schools was associated with hurdles like preparation time and the availability of SGs that relate to the curriculum.

These findings have been replicated in the literature more than once. It has been noted in other works (Baek et al., 2008; Aljaraideh, 2014) that too much time is needed for the location, preparation, and adaptation of these games. Other authors (McFarlane et al., 2002; Baek et al., 2008) also mentioned that game inflexibility can make teachers unwilling to give educational games a chance in the classroom. Games that suit the required learning cannot be easily found, and even if they can be found, they cannot be easily adapted to the learning objectives. Games are too long and cannot be adapted to the available time, or they cannot be adapted to the way a teacher wants to present a course topic.

Therefore, the intention behind FunHomework was to surmount the numerous hurdles mentioned above so that the integration of game-based learning in formal contexts could be promoted. The platform was validated in the fourth study and the implementation showed highly promising results. The study was conducted with teachers from four countries but on a relatively small sample, so the findings cannot be generalized widely. As teachers in Jordan face the same obstacles mentioned in the literature, the capability of serious games with dynamic content to address the implementation hurdles highlighted in the second study might be encouraging, but any optimism must remain moderate.

6.5.2 Dynamic Serious Games

The studies in this dissertation presented FunHomework, which uses serious games with dynamic learning content to potentially promote the incorporation of game-based learning in formal education by overcoming several of the implementation problems highlighted in the second study. The findings of the fourth study showed the positive implications of the practical utilization of FunHomework in schools. Over the two-month implementation period, the data analytics derived from the app stores showed a satisfying number of users and acceptable teacher interaction rates.

To verify the premise that FunHomework demonstrated utility, it was helpful to examine the app adoption analytics after the implementation period, when participants' engagement usually fades or is found to be impermanent. Figure 6.3 shows the number of TutorApp users over a one-year period until the time of writing in January 2023, which was nine months after the implementation phase.

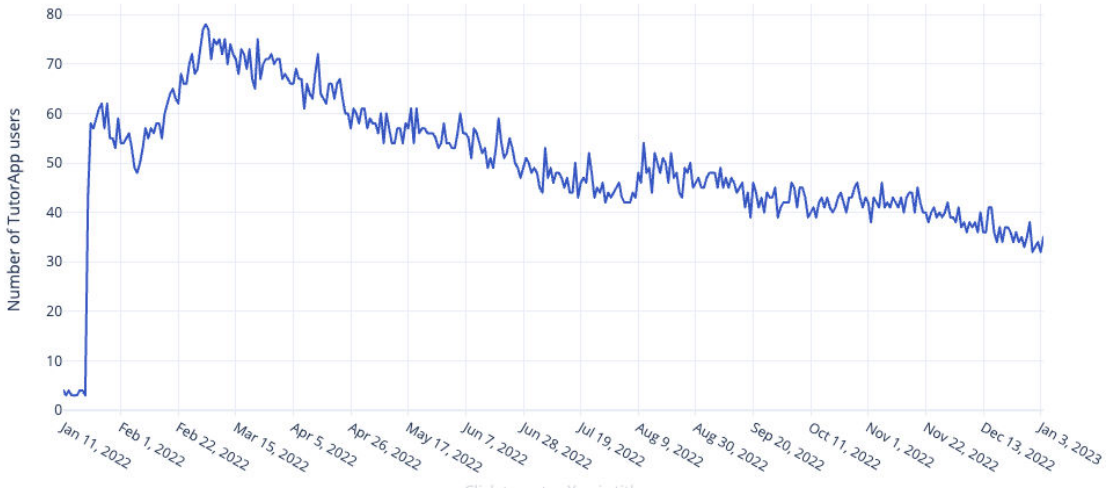


Figure 6. 3 TutorApp users over one year

The implementation phase, which ran from February to April 2022, witnessed the peak in user numbers and interaction; during this period, most teachers started installing and exploring the apps. By the end of the implementation period, a drop in users was evident by the end of April 2022, when teachers started preparing for the final exams towards the end of the semester. After that, most students started a relatively long summer vacation, which lasted about three months in Jordan, for example. The first school semester of 2022/2023 started in September 2022 and ended in January 2023, during which time it was evident that the app was still being used by teachers. During that period, there was no contact between the researcher and the teachers, and, despite using only one simple game like Pencil Knight, the app maintained a reasonable number of users.

Regarding the Pencil Knight game usage, figure 6.2 below shows a similar trend in user numbers, taking into consideration the teacher-student ratio.

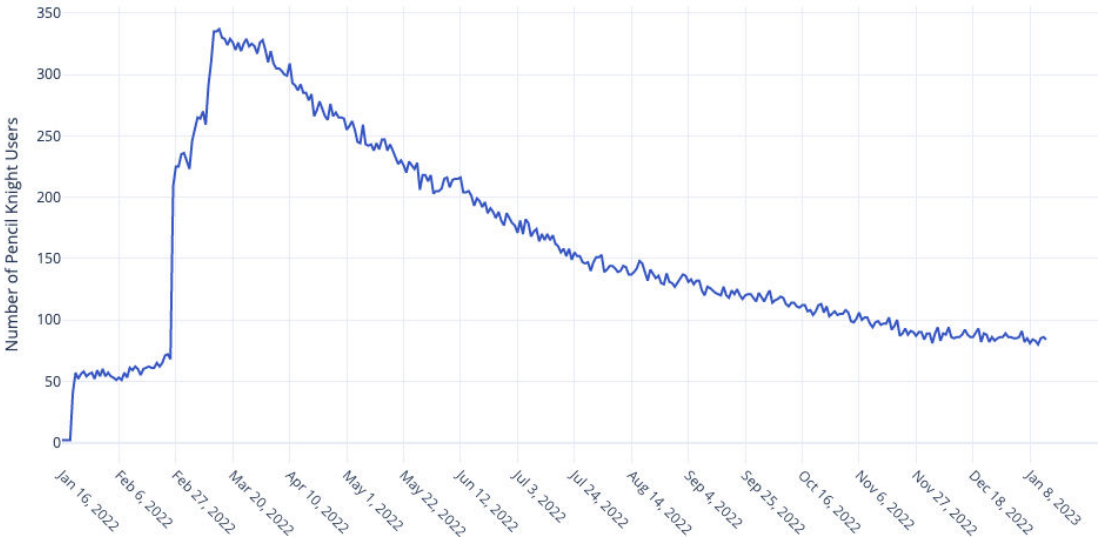


Figure 6. 4 Pencil Knight users over one year

To summarize, after one year of data analytics, it was found that there was ongoing engagement and sustained interest in using FunHomework in schools for educational purposes. The platform demonstrated progress in overcoming implementation obstacles, indicating its potential to improve the utilization of serious games in formal education. However, it should be noted that the current version of the platform only contains one game designed for primary school students, and the results presented in this study reflect the initial implementation of the platform with dynamic learning content. Therefore, teachers and students engagement in FunHomework can be bound to continuing improvements and updates of the platform. There is still a significant amount of work that needs to be done to expand the platform by including other games that can further positively influence teachers' decisions to adopt FunHomework.

6.6 Recommendations & Limitations

6.6.1 Recommendations for practice

According to the current study findings, the researcher recommend that practical steps should be taken to offer procedural and substantive assistance to both facilitators and experts in the topic so that formal education might adopt game-based learning. Overcoming the obstacles that limit the use of game-based learning in schools needs collaborative partnerships between all stakeholders; however, direct support from the education administration is vital for these efforts. The makers of educational policies must regard the distribution and in-school use of ICT as a major potential opening in education. Policy makers must be encouraged to recognize that through ICT, students achieve more, school accessibility improves, efficiency is enhanced, expenses are reduced, student's capacity to learn and opportunities for lifelong learning are enhanced, and students become better prepared to enter a labor force in which competition is on a global level. After that, it is possible to imagine other factors that hinder game-based learning from having an active role in the educational process and fostering 21st-century skills for students.

On the other hand, as the impediments of game-based learning adoption are well defined, experts on the topic should consider focusing more on providing innovative adoption solutions that are aligned with teachers' needs, accommodate their limited time, are relevant to the curriculum and learning objectives, and adhere to schools' limited budgets and ICT resources. The current work illustrated the important role played by teachers in the in-class adoption of technology and showed that a teacher's willingness to use solutions involving educational games increases with their engagement in the creation of such games.

In developing a platform that can be safely used by a wide range of teachers and students, it would be essential to distribute the software using well-known and trusted sources like official app stores. However, this can create uncalculated challenges that severely affect adoption and usage of these apps. For example, to publish and distribute apps using

mobile app stores, the apps needed to be aligned to the store guidelines of both Google and Apple. As these have certain strict rules regarding apps targeting children, such as the "Age Neutral Screen" required for creating and editing child accounts (see Appendix Snippet 1), further complexity was added to the student registration, which was directly reflected in the teachers' reviews of the apps. It is recommended that developers who publish their apps in app stores consider the store guidelines to avoid production delays and provide a smooth user experience. In addition, using third-party distributors can raise data privacy issues and questions over the eligibility to collect and store users' data, as well as the geographical location/s in which the data will be stored and/or processed.

6.6.2 Recommendations for future research

The experiences outlined in the current research study led to various recommended directions for future researchers so that game-based learning in formal educational settings could continue to be investigated and enhanced.

As mentioned earlier, the implementation of the FunHomework platform was conducted with a relatively small sample of teachers and students in the MENA region. The second research study, which examined the views of teachers on using games in schools, was carried out in partnership with teachers in Jordan. The study included 76 teachers who participated in interviews and completed questionnaires. However, the fourth study involved a 2-month implementation period of the platform and entailed collecting rich, in-depth, and detailed qualitative data, which impacted the number of teachers who were willing to devote significant time and effort to this case study.

The researcher attempted to conduct the study in Germany (where they reside) and the Netherlands but encountered various legal and managerial barriers that prevented they from conducting research in schools within those countries.

Given the qualitative nature of the results, the discussion on generalizability must consider the cultural differences that are implicated in the uptake and outcomes of FunHomework as a DGBL platform. Although the present research tried to investigate micro-level obstacles for teachers around the world in using DGBL, it is correct to recognize that the majority of the literature sources under consideration are in English-speaking environments. This center of interest raises concerns in terms of the generalizability of findings to regions outside the Anglophone world, mainly the Arab-speaking countries. This is mainly because of the cultural, educational, and technological differences, which could lead to teachers in these regions viewing and adopting GBL differently in their practices. Therefore, as much as the research is informative on the potential barriers and facilitators to DGBL, one has to be cautious in extending the findings of the study to such a cultural setting. This implies the necessary further research related to the influence of cultural contexts on the effectiveness of DGBL innovations like FunHomework platform.

Moreover, to generalize the results on a wider scale, it would be also essential to consider a larger and more diverse sample. To gain a more complete picture of the ability of such a platform to enhance game-based learning in schools, it would be helpful to investigate the implications of such a platform on a larger sample and/or in other countries.

It is also worth noting that the Pencil Knight game was designed for primary school students aged between five and ten years old, so future researchers might also be interested in exploring the validity with different age groups.

The FunHomework platform was only a starting point for introducing SGs with dynamic learning content. The platform provided a solution that aligned with teachers' needs and overcame many of the key obstacles confronting teachers during the implementation of game-based learning in their schools. However, several other teacher recommendations still could not be met during this research, and these could be addressed in future research. For example, the option to share learning content could offer a major advantage by easing knowledge sharing and distribution among teachers of the same level. Furthermore, providing ready curriculum-oriented content templates might also smoothen the integration of the platform and save teachers' time.

6.6.3 Closing comments

This study described how SGs with dynamic learning content can enhance the adoption of game-based learning in regular education. It showed the kinds of impediments that can hinder teachers from using games in their classrooms. The researcher outlined the practical and future research implications. A teacher's view on game playing in an educational setting clearly influences their decisions regarding the in-class implementation of such games in terms of the approaches, timing, and particular reasons for doing so. The current study also revealed that game-based learning in a formal context is more likely to be adopted if the games correspond to the teaching requirements and provide feasible solutions.

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Appendices

Code Snippets

Snippet 1:

C# Code Snippet from adult verification in Pencil Knight game that enables the player to register and edit account details:

```
public void ValidateDate(){
        var OkDialog = (GameObject)Instantiate(okDialog);
        var txtMsg = (Text)OkDialog.transform.Find("txt_msg")
                    .GetComponent<Text>();
        var okButton = (Button)OkDialog.transform.Find("btn_ok")
                      .GetComponent<Button>();
        okButton.onClick.AddListener(delegate {
            Destroy(OkDialog);
        });
        OkDialog.transform
          .SetParent(mainCanvas.transform, false);

        if (string.IsNullOrEmpty(dayInput.text.Trim()) ||
            string.IsNullOrEmpty(monthInput.text.Trim()) ||
            string.IsNullOrEmpty(yearInput.text.Trim())){
            txtMsg.text = "Please enter a valid birthday!";
            OkDialog.SetActive(true);
            return;
        }

        string dateStr = String.Format("{0:00}",
                          Int32.Parse(dayInput.text)) + "/"
                          + String.Format("{0:00}",
                          Int32.Parse(monthInput.text)) + "/"
                          + String.Format("{0:00}",
                          Int32.Parse(yearInput.text));

        DateTime inputDate = new DateTime();

        if (DateTime.TryParseExact(dateStr, "dd/MM/yyyy",
                        CultureInfo.InvariantCulture,
                        DateTimeStyles.None, out inputDate)){
            DateTime dateCurrent = DateTime.Now;
            DateTime zeroTime = new DateTime(1, 1, 1);

            TimeSpan span = dateCurrent - inputDate;
            int years = (zeroTime + span).Year - 1;
```

```
            if(years >= 18){
                parentConfirmed = true;
                parentalConrol.SetActive(false);
                string stdPushID = PlayerPrefs
                                    .GetString("studentPushID");
                if (stdPushID == null ||
                    stdPushID == String.Empty){
                    mainContentPanel.SetBool("isHidden", true);
                    startButton.SetBool("isHidden", true);
                    settingsButton.SetBool("isHidden", true);
                    moodle_dialog.SetBool("isHidden", true);
                    login_dialog.SetBool("isHidden", false);
                } else {
                    ShowStudentParent();
                }
            } else {
                txtMsg.text = "This is not an adult birthday,
                               please contact yout parents.";
                OkDialog.SetActive(true);
            }
        } else {
            txtMsg.text = "Please enter a valid birthday!";
            OkDialog.SetActive(true);
            return;
        }
    }
```

Snippet 2:

Procedural Content Generation technique was used in Pencil Knight game to generate dynamic contents and unique environment, every time the game is played. Below is a C# code snippet used to generate parts of the environment.

```
//random enemy from the enemies list
int typeOfEnemy = Random.Range(0,Enemies.Length);
float enimeXpos = currentXpos + spaceBetweenQuestions / 2;
GameObject enim = Instantiate(Enemies[typeOfEnemy],
                  new Vector3(enimeXpos,3.7f,0),
                  transform.rotation) as GameObject;

GameObject smallBadFish = Instantiate (SmallBadFish,
                          new Vector3 (enimeXpos - 30f, 10f, 0),
```

```
                            transform.rotation) as GameObject;
//health packs
float healthpackXpos = currentXpos +
                        ((3 * spaceBetweenQuestions) / 4);
GameObject healthPack = Instantiate (HealthPack,
                         new Vector3 (healthpackXpos, 13f, 0),
                         transform.rotation) as GameObject;

//random weather, clear, rain, snow
int weather = Random.Range(0, 3);

if (weather == 1){
   SnowSystem.SetActive(true);
   SnowSystem.transform.position = new Vector3(backgroundWidth /
                              2f, SnowSystem.transform.position.y,
                              SnowSystem.transform.position.z);
   ParticleSystem particleSystem = SnowSystem
                                 .GetComponent<ParticleSystem>();
   var sh = particleSystem.shape;
   sh.scale = new Vector3(backgroundWidth, 1f, 1f);
}else if(weather == 2){
     RainSystem.SetActive(true);
     RainSystem.transform.position = new Vector3(
          backgroundWidth / 2f, RainSystem.transform.position.y,
          RainSystem.transform.position.z);
     ParticleSystem particleSystem = RainSystem
                               .GetComponent<ParticleSystem>();
     var sh = particleSystem.shape;
     var rainScale = backgroundWidth * (1f / RainSystem
                    .transform.localScale.x);
     sh.scale = new Vector3(rainScale, 1f, 1f);
}
```

Snippet 3:

Within TutorApp, teachers were able to sign-up using Google Account and also with email and password. Below is a snippet of React Native code used in TutorApp to perform registration of teacher using email and password:

```
signUpWithEmailAndPassword = async() => {
        let altText = "";
        if(this.state.strFName == "") {
            altText = i18n.t('validEnterFname');
```

```
            alert(altText);
            return;
        }
        if(this.state.strLName == "") {
            altText = i18n.t('validEnterLname');
            alert(altText);
            return;
        }
        if(this.state.strEmail == "") {
            altText = i18n.t('validEnterEmail');
            alert(altText);
            return;
        }
        if(this.state.strPwd == "") {
            altText = i18n.t('validEnterPassword');
            alert(altText);
            return;
        }
        let pwd = this.state.strPwd;
        let confirmPwd = this.state.strConfirmPwd;
        if(pwd !== confirmPwd) {
            altText = i18n.t('pwdNotMatch');
            alert(altText);
        } else {
            this.setState({isLoading: true});
            let credential = {
                email: this.state.strEmail,
                password: pwd
            };

            try {
                const signUpResult = await api
                   .signUpWithEmailAndPassword(credential);
                Analytics.logEvent('signup_email');
                let userData = {
                    id: signUpResult.user.uid,
                    data: {
                        dob: this.state.strBirthday,
                        email: this.state.strEmail,
                        id: signUpResult.user.uid,
                        name: this.state.strFName + " "
                              + this.state.strLName,
                        password: "",
                        photoUrl: "",
```

```
                    fname: this.state.strFName,
                    lname: this.state.strLName,
                    isfirst: true
                }
            };
            await api.updateUserProfile(userData);
            this.setState({isLoading: false});
            let toastMessage = i18n.t('completedRegist');
            this.refs.toast.show(toastMessage, DURATION
                                .LENGTH_SHORT);
            this.props.navigation.navigate('Login');
        } catch(error) {
            console.log(error);
            this.setState({isLoading: false});
            this.refs.toast.show(error.message,
                                DURATION.LENGTH_SHORT);
        }
    }
}
```

FunHomework Evaluation Interview

Date:

Time:

Audio File Name:

Introduction

Get consent for audio recording

Introduce the study

Introduce yourself

Inform interviewee of confidentiality

Inform interviewee of right not to answer a question if they do not wish to

Inform interviewee of right to stop the interview at any time without jeopardy

Questions

Broad questions

1. What do you think about Game-based Learning?
2. Did you try using games in your classroom before?
3. What obstacles do you think can hinder implementing GBL in schools?
4. In your opinion, what are the characteristics of a good GBL platform?

In-depth questions

1. How often did you use FunHomework weekly? N<2, 2<N< 5, N>5
2. How did you find the implementation of FunHomework in your classroom?
3. What features you like in FunHomework?
4. What features you dislike in FunHomework?
5. How do you evaluate these operations:

	Easy	Normal	Difficult
Install the apps			
Register teacher			
Register student			

Create Group/Homework			
Track Students results			

6. Which platforms can be easier and more attractive for you; games with learning content that is close to your curriculum? Or games that have learning content that can be set by teacher to match the curriculum?

Collect demographic information

1. Number of students
2. Subjects
3. Age

Closing

Concluding statement

Thank the respondent

Inform them of what will happen after the interview

Provide contact information if they need to contact the organization about the study