Design, Development and Evaluation of an Educator-Oriented Serious Role-Playing Game Authoring Platform

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Design, Development and Evaluation of an Educator-Oriented Serious Role-Playing Game Authoring Platform

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Abstract

Creating Serious Games (SG) involves a complicated and expensive process. Various stakeholders are commonly included in the process, each with their own specific roles. Several initiatives have been proposed to improve the creation process, in particular devising design methods to guide the design of SGs, and authoring tools to simplify and expedite the development of these games. One of the main drawbacks of these initiatives is the non-existent role of educators in the creation process apart from supplying learning materials. Empowering educators to design how learning tasks should be presented in games and implement their desired designs into finished games as they see fit would improve the accessibility and long-term maintainability of SGs without requiring input from game experts. This could further improve the adoption of SGs in the classroom. Additionally, students would not only benefit from the proven potential of game-based learning, but also from tailor-made SGs. The motivation to address the gap motivated the research in this thesis that investigated the design, development and evaluation of ARQS (Authentic Role-playing-game Quest System), an educator-oriented Serious Role-Playing Game (SRPG) authoring platform. ARQS consists of a design method and an authoring tool devised specifically for educators as target users, and as such possessed processes, workflow and features that was identified to be suitable for educators. Evaluation of the platform included participatory studies with educators. The design method was evaluated through focus group and case studies, and the authoring tool was evaluated in several usability studies. Findings from these studies showed the general suitability of the platform for educators. The output of the platform was also evaluated to identify the potential effectiveness of the SRPGs designed by educators. Experimental studies conducted in the research found that the SRPGs were comparable to non-gaming learning activity but could also be a more effective form of learning tool.

Declaration

The work in this thesis is based on research carried out at the Department of Computer Science, Durham University, United Kingdom. No part of this thesis has been submitted elsewhere for any other degree or qualification and it is all my own work unless referenced to the contrary in the text.

List of Publications

The works presented in this thesis have been published in conferences. The relevant publications are listed below:

- (Chapter 2, Section 2.6.3) Published a paper at NordiCHI 2020.

  Ahmad, A., Law, E. L., & Moseley, A. (2020, October).

  In Proceedings of the 11th Nordic Conference on Human-Computer Interaction: Shaping Experiences, Shaping Society (pp. 1-12).

- (Chapter 3) Published a paper at CIIS 2022.

  Ahmad, A. and Law, E. L. (2022, October).

  In Proceedings of the 5th International Conference on Computational Intelligence in Information Systems

- (Chapter 5, Section 5.4) Published a paper at CHI Play 2021.

  Ahmad, A. and Law, E. L. (2021, September).

  In Proceedings of the ACM on Human-Computer Interaction 5.CHI PLAY (2021): 1-29.

- (Chapter 5, Section 5.5) Published a paper at ICWL 2022.

  Ahmad, A., & Law, E. L. C. (2022, November).

In International Conference on Web-Based Learning (pp. 135-147). Cham: Springer International Publishing.

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List of Acronyms

AL	Authentic Learning
AR	Augmented Reality
ARQS	Authentic Role-playing-game Quest System
BBP	Block-Based Programming
BOTW	Breath Of The Wild
CC	Complexity Capacity
CK	Content Knowledge
COTS	Commercially-Off-The-Shelf
DG	Digital Games
DV	Dependent Variable
EGF	EGameFLow
GBL	Game-Based Learning
HOTS	Higher Order Thinking Skills
IDP	Instructional Design Principles
ILS	Index of Learning Style
IMI	Intrinsic Motivation Inventory
IP	Intellectual Property
IT	Information Technology
LOTS	Lower Order Thinking Skills
LQ	Learning Quest
LS	Learning Style

MCQ	Multiple Choice Questions
NPC	Non-Player Characters
PA	Player Action
PCK	Pedagogical Content Knowledge
PUEU	Perceived Usefulness and Ease of Use
QDD	Quest Design Document
QP	Quest Pattern
RCT	Random Control Trial
RPG	Role-Playing Game
RQ	Research Question
SAM	Self-Assessment Manikin
SEQ	Single Ease Question
SG	Serious Games
SME	Subject-Matter-Experts
SRPG	Serious Role-playing Game
TAM	Technology Acceptance Model
USE	Usefulness, Satisfaction and Ease-of-Use
UTB	Universiti Teknologi Brunei
VPL	Visual Programming Language

CHAPTER 1
INTRODUCTION

This chapter presents the motivation for the research described in the thesis by highlighting gaps in the current research literature on digital educational games with regards to educators' involvement in the creation of these games. The overview leads to the research questions, methodology and empirical work for the research, followed by the main contributions to the field of game-based learning, and concluded with the outline of the thesis.

1.1 MOTIVATION

In the past few decades, there has been a growing interest on the use of digital games (DG) in a non-entertainment context such as education (Boyle et al., 2016). DGs used in these "serious" contexts are identified as Serious Games (SG). Many studies have shown that SGs as learning tools can improve different psychological abilities, including cognitive, affective, and psychomotor. Despite the evidence on the benefits of SGs, such a tool is yet to be widely adopted in the classroom (Wu, 2015). Several of the major barriers contributing to the low adoption rate are related to the lack of suitable SGs (Fokides, 2018; Wu, 2015) and the complicated process in their creation (Laurent et al., 2022).

The common workflow in creating SGs typically involves various stakeholders specialising in different aspects, such as subject matter experts (SMEs) to manage the content to be incorporated in a game, game designers to design the gameplay, and various other experts, such as programmers and various asset designers (e.g., graphic designers, sound engineers), to implement the game design into a finished game. This

leads to a time-consuming and expensive endeavour, which can be out of reach for educational institutions, especially individual educators. Another limitation is related to the long-term use of these games, where modifying games such as to add new content or activities, is difficult and necessitates another iteration of the creation process. On the other hand, COTS (Commercially-Off-The-Shelf) entertainment-based DGs or SGs can be used by educators, although these games might not fully align with the educators' intended curricula, syllabi or learning objectives. Furthermore, there is a lack in the availability of suitable SGs that educators can make use of (Wu, 2015).

Initiatives can be found in the literature that are intended to reduce the complexity of creating SGs by addressing the design and development phases in the creation process. Several design methodologies have been proposed, aiming to systematically guide the design of gameplay, and at the same time ensuring the appropriateness of the gameplay with regard to addressing students' intended learning outcomes (e.g., Arnab et al., 2015; Nadolski et al., 2008). Several authoring tools have also been proposed that aim to simplify and expedite the development of SGs (e.g., Perez-Colado et al., 2019; Torres et al., 2022). While these initiatives can improve the creation of SGs, there is an apparent lack of emphasis on educators' role within the creation process.

The role of educators in creating SGs is currently limited to the capacity of SMEs as content provider of relevant learning materials that is to be incorporated in the games (Ahmad et al., 2020). Beyond this, they generally have no control in the design of gameplay and building the game. This is understandably due to the knowledge and skills required in the field of game design and development, which educators are not expected to possess. However, there is a strong body of evidence suggesting that the lack of educators' role in the creation of SGs affects the successful integration of games in the classroom (Molin, 2017). By providing an educator-oriented SG creation tools, educators could create custom-tailored games that suit their needs, such as meeting specific learning objectives, addressing cultural values, and adapting to student abilities.

The points addressed so far have motivated this research, which aims to enable the creation of SGs accessible to educators, primarily by bypassing the existing dependence on the various game experts (Figure 1.1). This involves identifying a design methodology that can guide educators in designing and converting learning

instructions into gameplay, and an authoring tool with workflow and interfaces suitable for the capabilities of an average educator to implement designs into finished games. The thesis introduces *ARQS* (Authentic Role-playing-game Quest System), an educator-oriented platform for the creation of a Serious Role-Playing Game (SRPG). The platform consists of two main components towards the creation of this type of game (Figure 1.2): a design method (Chapter 3), and an authoring tool (Chapter 5).

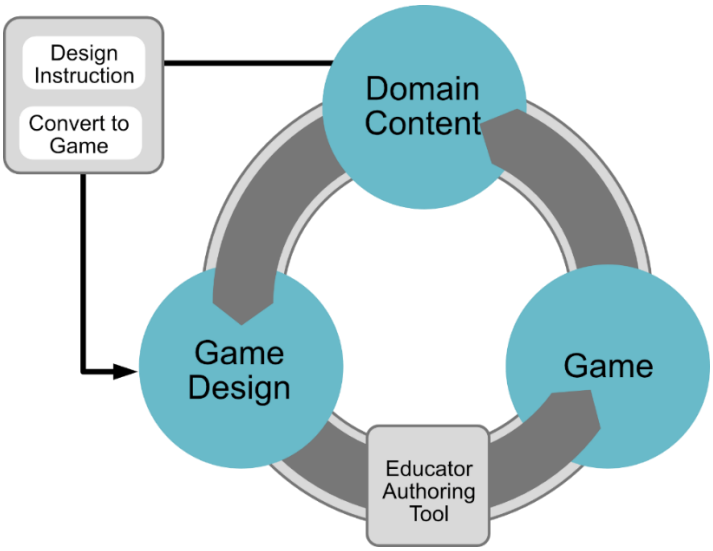


Figure 1.1. Educator-oriented Target workflow.

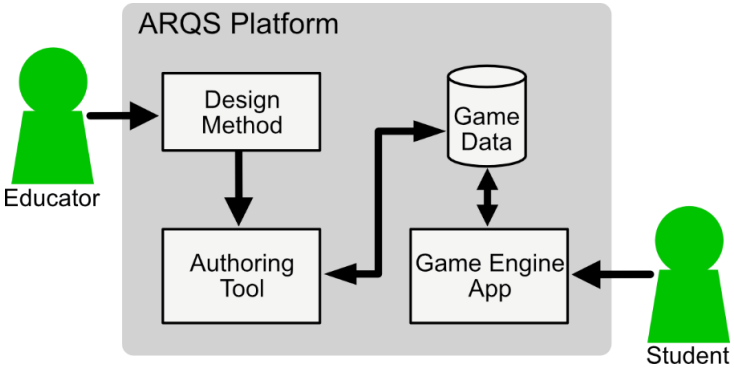


Figure 1.2. Overview of ARQS Architecture.

1.2 RESEARCH QUESTIONS

The research questions presented in this section have been developed based on the research gaps observed in the literature (Chapter 2). The main research question is "*How can educators be more actively involved in the creation of SGs as a teaching and learning tool*", which requires exploring and adapting common DGs creation

processes specifically for educators as target users. Educators' existing knowledge in designing instructions is central to the concept proposed in the research, where concepts of Instruction Design Principles (IDPs) are incorporated into game-specific aspects, providing a process that is mostly familiar to educators.

A major consideration that needs to be addressed at this point is related to the variety of game genre. Reducing the complexity of SG authoring tools is possible by focusing on one genre (Section 2.6.4). The thesis focuses on the "*Role-Playing*" game (RPG) genre, based on the rich educational potentials it possesses (Section 2.5).

To address the main research questions, the following sub-research questions (RQ) need to be answered:

1. **Instruction-Focused SG Design Method**

   RQ 1A: How can instructional activities be incorporated in RPG?

   RQ 1B: How are concepts of Instructional Design Principles (IDP) used in existing SG design methods?

   RQ 1C: How can concepts of IDP be adapted in designing SRPG?

2. **SRPG Design Method**

   RQ 2A: What is educators' experience when using a design method that focuses on instructional design?

   RQ 2B: Is using game patterns to represent instructional activities usable for educators?

   RQ 2C: Can a design method that focuses on instructional design guide educators in designing SRPG?

3. **SRPG Authoring Tool**

   RQ 3A: What are the possible interfaces and workflow suitable for an educator-oriented SRPG authoring tool?

   RQ 3B: Are the interfaces and workflow usable for educators?

4. **Effectiveness of SRPG as Learning Instructions**

   RQ 4A: How effective are educator-authored SRPGs as learning instructions in terms of learning improvement?

RQ 4B: What are students' perceptions of learning with educator-authored SRPG?

1.3 RESEARCH APPROACH

To answer the above RQs, several objectives are addressed in this thesis (Figure 1.3 for the flowchart of the research):

1. *Conduct literature review on existing SG design methods* (RQ1A-1B). This is the preliminary stage of the research, involving literature reviews on how learning can be incorporated in RPG (Chapter 2, Section 2.5). Existing SG design methods are also reviewed to identify how concepts of IDP are used in designing SGs (Chapter 2, Section 2.6.3).

2. *Devise an educator-oriented design method for the design of SRPG* (RQ 1C). Findings from the literature reviews helped in shaping the design method, which is introduced and further explained in Chapter 3.

3. *Evaluate the proposed SRPG design method with regard to its suitability for educators* (RQ 2A-2C). The design method has been evaluated by educators in order to explore their experience, and the games produced, with the method's initial concept through a focus group (Chapter 3) and a case study (Chapter 4) respectively.

4. *Devise an educator-oriented authoring tool for the development of SRPG* (RQ 3A). Another component in the educator-oriented SRPG platform is the authoring tool intended to implement SG designs into finished games. A literature review has been conducted to identify common interfaces and workflow used in existing game authoring tools (Chapter 2, Sections 2.6.4, 2.6.5 and 2.6.6) and its suitability to be incorporated in the SRPG authoring tool. Prototypes of the tool have been built, which are introduced and further explained in Chapter 5.

5. *Evaluate the proposed SRPG authoring tool with regard to its usability* (RQ 3B). The authoring tool has been evaluated by educators in order to establish

its usability. This involved conducting a formative (Chapter 5, Section 5.4) and summative (Chapter 5, Section 5.5) usability studies.

6. *Evaluate the effectiveness of SRPGs authored by educators* (RQ 4A – 4B). Experimental research has been conducted to evaluate the effectiveness of learning instructions presented as RPG, in relation to improving learning performance and affective aspects (Chapter 6).

English language was used in the studies. However, there were instances during the studies where participants and I discussed in Malay language. Occurrences of Malay in the recorded data (e.g., video or audio recordings) were translated into English prior to data analysis.

Since the study involved human participants, ethics approval (Appendix A1) was also granted by the ethics committee of *Universiti Teknologi Brunei* (UTB). Output from the research is expected to be implemented in Brunei Darussalam, as such it was deemed appropriate to conduct the studies within the context of the country's educational system and stakeholders.

1.3.1 Studies in the research

Below is the summary of the studies conducted in this thesis:

1. A *Focus Group Study* was carried out in the initial phase of the research (Chapter 3). In this study, three groups of six educators, explored the initial concept of the proposed SRPG design method. Findings from the study were used to revise the design method.
2. A *Case Study* was carried out to explore how two lecturers would use the revised design method to design SRPG in the real-world (Chapter 4).
3. A *Formative Usability Study* was carried out to explore the initial concept of the low-fidelity prototype of the SRPG authoring tool (Chapter 5, Section 5.4), where ten educators were involved. The findings from this study were used in the development of a high-fidelity prototype.
4. A *Summative Usability Study* was carried out to evaluate the usability of the high-fidelity authoring tool (Chapter 5, Section 5.5), where ten educators were recruited in the study.

5. An *Experimental Study* was carried out where games designed by the lecturers in the case study were used in order to evaluate the effectiveness of these games (Chapter 6).

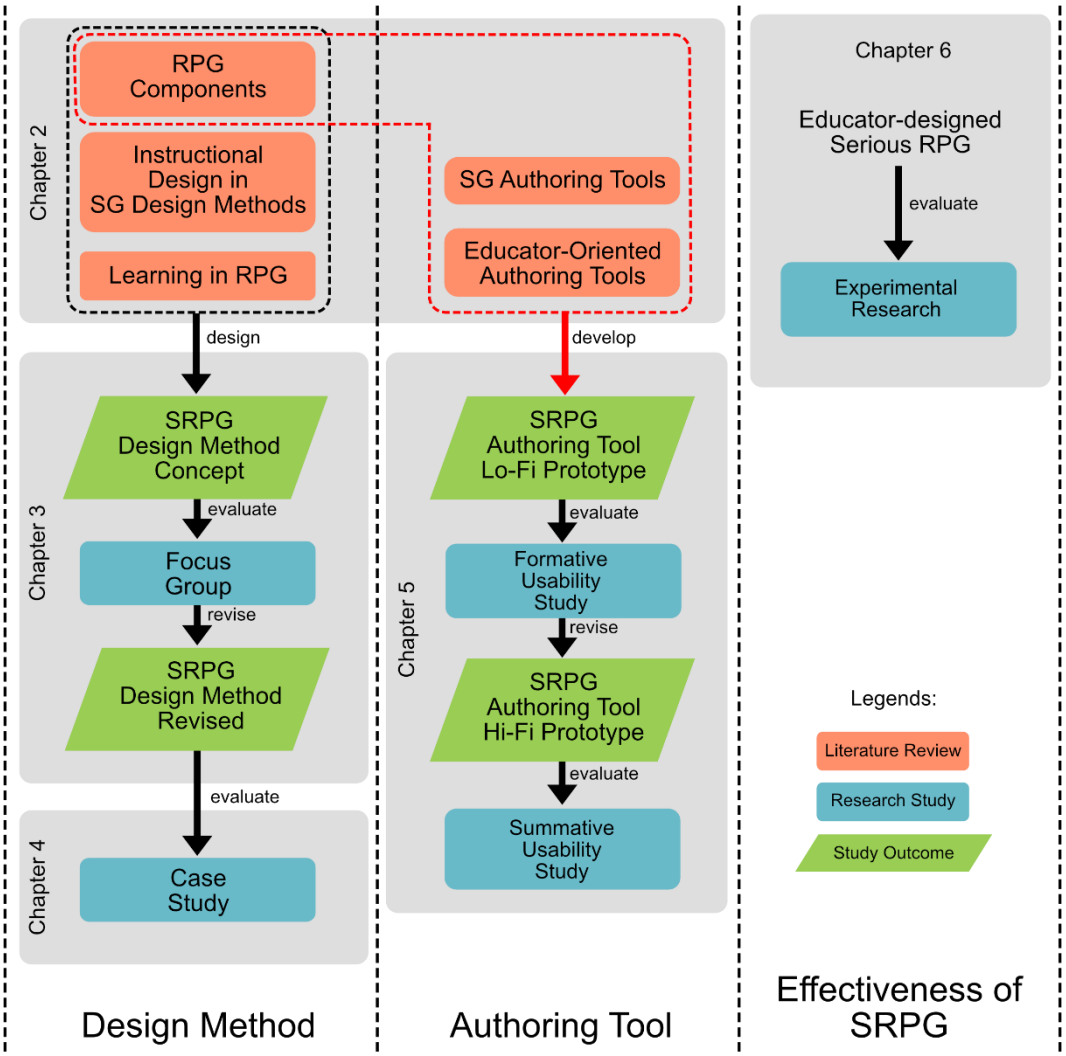


Figure 1.3. Research Flowchart

1.4 RESEARCH CONTRIBUTIONS

The thesis has three contributions to the field of SG research, which are elaborated as follows:

- *Reviewed existing methodologies and tools for the creation of SGs.* The literature reviews identified the state-of-the-art in design methods and authoring tools for the creation of SGs.

- *Implemented a novel platform for the creation of SGs.* A novel design method to design SRPGs was produced, with a workflow that draws on educators' existing knowledge in designing learning instructions, thus enabling this target user to design SGs without knowledge in game design.

  A novel game authoring tool to develop SRPGs was also produced, with features designed to enable educators to develop SRPGs without knowledge in the different aspects of game development (e.g., graphic design, programming). One key component in this authoring tool is the use of Block-Based Programming (BBP), a visual programming language incorporated to program the gameplay logics of an SRPG. A novel blocks programming language has been specifically designed for the specific area of game programming.

- *Investigated the effectiveness of educator-authored SGs in terms of higher-order thinking skills.* Studies in SGs have mostly focused on lower-order thinking skills (LOTS; Boyle et al., 2016; Clark et al., 2016). The thesis addresses this limitation and aims to progress the effort on the use of SGs forward, specifically by providing evidence on the effects of SGs, and recommendations on the design of experimental research, in relation to engaging students' higher-order thinking skills (HOTS).

1.5 THESIS OUTLINE

The thesis is organised into seven chapters as follows:

- *Chapter 2 (Literature Review)* describes the current state-of-the-art in the field of SGs. The term SGs is further elaborated to establish the context of the thesis. Related work on the effectiveness of SGs as learning tools, its design and development, and educators' current role within the creation process is discussed.

- *Chapter 3 (Designing Serious Role-Playing Game: Methodology and Output)* introduces ARQS design method. This is followed with a focus group study conducted with educators to evaluate the suitability of the initial concept of the design method.

- *Chapter 4 (Using the Design Method: A Case Study)* presents a case study where two lecturers used the design method to design SRPGs based on their specialised domain. This includes an extensive discussion and analysis on the game designs.
- *Chapter 5 (Developing Serious Role-Playing Game: Methodology and Output)* introduces the ARQS authoring tool. This is followed by presenting two usability studies conducted with educators to evaluate the usability of the authoring tool.
- *Chapter 6 (Effectiveness of Educator-Authored Games)* presents an extensive discussion of the experimental research carried out to evaluate the effectiveness of SGs designed by educators using the ARQS design method.
- *Chapter 7 (General Discussion)* presents the summary of the findings from the research in this thesis and provide a discussion on the implications of these findings, as well as limitations within the research.
- *Chapter 8 (Conclusion)* concludes the thesis by providing a summary of its key contributions and future enhancements.

CHAPTER 2
LITERATURE REVIEW

This chapter aims to establish the context of RPG and SGs relevant to the thesis. The construct of RPG is described to establish its key components. To clarify the use of the term SG, the concept of game-based learning is also discussed. This is followed by a discussion on how instructional activities can be incorporated in RPG. Processes typically involved in the creation (i.e., design and development) of SGs are also introduced and discussed, highlighting the current SG creation paradigm and the limitations that are stalling the effort on the widespread implementation of SGs in the classroom. Further emphasis on educators' current role in the SG creation process is discussed.

2.1 WHAT ARE GAMES?

According to the significant work in games by Tekinbas and Zimmerman (2003, p.80), "*a game is a system in which players engage in artificial conflict, defined by rules, that results in a quantifiable outcome*". This definition established four core components found in games: *player* (participants in a game), *artificial conflict* (contest or challenges), *rules* (actions or events that can take place), and *quantifiable outcome* (goals achieved after completing challenges). Other game components: game mechanics, story, viewpoint, mode, and gameplay, were also identified, which serves as the basis of games in this thesis (Figure 2.1).

Game mechanic is the low-level implementation of how actions and events set in the rules of game can be carried out (Adams & Dormans, 2012; Hunicke et al., 2004; Sicart, 2008). *Story* is used to lay out the foundation of a game, told using narratives

(i.e., sequence of events). *Viewpoint* establishes the settings (i.e., game world), perspective (i.e., view of the game from players' perspective such as third-person or first-person view) and realism (i.e., modelling of the virtual world such as in terms of the visual rendering and physics simulation). *Mode* refers to a "scene" in a game (e.g., menu and main game scenes). *Gameplay* defines the overall experience felt by players, such as experiencing the story, completing challenges, and performing actions through the game mechanics (Tekinbas & Zimmerman, 2003).

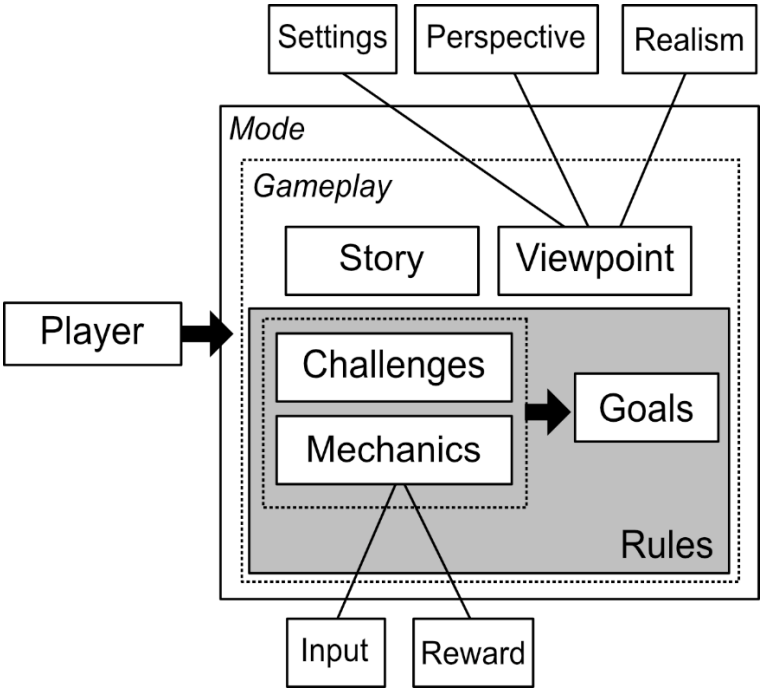


Figure 2.1. General Game Model
(Rollings & Adams, 2003; Tekinbas & Zimmerman, 2003)

Another significant aspect is the media of games. The above definition represents all forms of games: digital, analogue, or hybrid. *Digital* games are presented through digital screens and can be interacted with using devices such as touch screen or mouse. *Analogue* games are presented or interacted with using non-digital media such as paper and cardboard. *Hybrid* games consist of multimodal interactions and displays, a mixture of digital and analogue, such as *Augmented Reality* (AR) games. Digital games will be the focus of this thesis.

2.2 ROLE-PLAYING GAME

There are generally seven genres commonly used in the literature and widely adopted by the gaming community, which include Mini-Games, Action, Adventure, Strategy, RPG, Sports and Simulation (e.g., Rollings & Adams, 2003; Wolf, 2001). RPG is the focus of this thesis, and it is a complicated genre to be succinctly defined (Zagal & Deterding, 2018), where different attributes such as character development (Rollings & Adams, 2003) or story (Fullerton, 2014) were primarily focused on to define RPG. Level of gameplay attributes (i.e., character progression, story, mechanics and challenges) possessed by games were used to classify genres (Heintz & Law, 2015), which resulted in the characteristics of RPG used as the foundation for the work presented in this thesis (Figure 2.2).

An RPG consists of all the gameplay attributes possessed by action, adventure, simulation and strategy genres, as well as the RPG-specific "character personalisation and progression" (Heintz & Law, 2015). The extent to how much these attributes should be present is uncertain in their work. Although some non-RPGs include character personalisation and progression (e.g., BOTW[1]), it is less complex compared to full-fledged RPGs (e.g., Final Fantasy VII[2]). Another aspect associated to RPG is player agency. In typical adventure games (e.g., Tomb Raider[3]), players are immersed in a storyline and completing challenges in a predetermined order of sequence, by performing the required predefined actions. RPGs differ in that players can explore the world completing quests in any order and using any actions. Although there are still elements of pre-scripted narratives in RPGs, players can still engage in an open-ended gameplay e.g., completing side-quests (Heintz & Law, 2015; Zagal & Deterding, 2018), which can lead to continuous and emerging (i.e., non-scripted) narratives that does not end in reaching the fixed end-goal (Krishna, 2021).

[1] https://en.wikipedia.org/wiki/The_Legend_of_Zelda:_Breath_of_the_Wild

[2] https://en.wikipedia.org/wiki/Final_Fantasy_VII

[3] https://en.wikipedia.org/wiki/Tomb_Raider

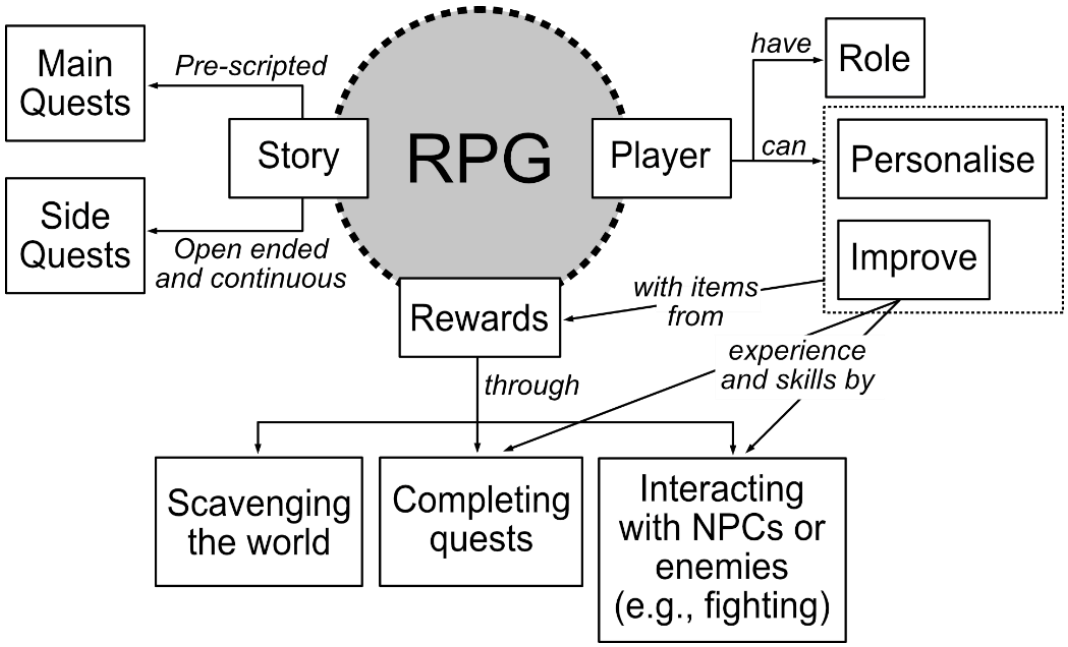


Figure 2.2. Characteristics of Role-Playing Game

One possible reason why certain games are rated as non-RPG, even when they possess all the necessary characteristics, could be due to the simplistic nature of some of these characteristics. As such, certain games could essentially be considered as an RPG or any of the other genres that shares the same gameplay (e.g., action, adventure). The attributes of RPG also suggests that its gameplay is potentially more complex and richer than other genres, giving more opportunities to include a wide variety of activities, targeting various cognitive learning domains and problem-solving types (O'Brien et al., 2010). This is the main reason why RPG is focused in this thesis. Despite the potential strength of RPGs, its use in SG research is still limited compared to other genres (Boyle et al., 2016; Gorbanev et al., 2018).

2.3 SERIOUS GAMES

The use of games in learning has been widely explored within the past few decades with the belief that games can potentially improve learning better than using traditional learning. Multiple definitions are associated with the term SG found in the literature. The seminal work by Abt (1987) defines it as games primarily intended for educational purposes, which would discount games used for non-educational purposes (e.g., awareness). Susi et al. (2007) defined it as the application of gaming technology

and development processes in a non-game market (e.g., marketing), which can also apply to non-game applications (e.g., 3D tools) that make use of gaming technologies. Laamarti et al. (2014) defined it as multimedia digital applications that is entertaining. This would reject non-digital games, and also consider any interactive applications, with or without gameplay, as SGs.

Djaouti et al. (2011) introduced the term "Serious Gaming" to refer to the action of playing video games for serious purposes, which will include games intentionally created, or existing games adopted for these purposes. The term "Serious gaming" shares the same concept with "Game-based Learning" (GBL), which refers to the general use of gameplay for learning with some defined learning outcomes (Plass et al., 2015). The terms GBL and SG have been used interchangeably (Corti, 2006). GBL, however, should be treated as a verb (i.e., learning), an action using a specific form of tool (i.e., games), which can include any type of games such as entertainment or serious games.

The definition of SG adopted in this thesis is "*Games primarily created for purposes other than entertainment*". This is related to any form of games that are specifically designed to help target users achieve some goals other than for mere enjoyment. Emphasis in this thesis, however, is put on formal education (i.e., learning in schools or academic institutions).

To get a general idea about the prevailing research landscape of SG, a targeted literature review was conducted. The search key "effects AND digital education games" was entered in the databases Scopus and IEEE. The publication years were restricted to 2017-2023 when advanced game technologies emerged. 475 records were returned. The initial phase involved reviewing the abstract and discussion section of the publications to identify whether a digital education game was developed and evaluated. Only 23 publications satisfied these criteria and were further analysed. Table 2.1 shows the summary of SGs that have been developed between 2017 and 2023, detailing the genre of the games, targeted domain and academic level. Most of the SGs were implemented as Mini games (n=12) and followed by Adventure (n=5). Only a few SGs were implemented as Action (n=2), RPG (n=2), Simulation (n=2) and Strategic (n=1). Figure 2.3 shows example screenshots of these games.

2.4 EFFECTS OF SERIOUS GAMES

The purpose of SGs is usually associated to some predefined learning outcomes, and their effectiveness is measured on how well it can help players achieve these outcomes. Over the past few decades, numerous studies have looked into the effects of SGs in terms of several learning outcomes: Knowledge acquisition (i.e., acquiring new information), Skills acquisition (i.e., acquiring skills), Cognitive outcomes (i.e., higher order thinking skills), and Affective outcomes (i.e., changes in emotional aspects). Boyle et al. (2016), Clark et al. (2016), and De Freitas (2018) have reviewed multiple studies on the use of SGs, with the conclusion that games significantly result in better improvement in these various aspects compared to learning with non-game activities.

Figure 2.3. Examples of different SG genre.
A) Mini game (Yang et al., 2017), B) Adventure (Stuchlíková et al., 2017), C) Action (Kamaruddin et al., 2022), D) RPG (Wang et al., 2020), E) Simulation (Novoseltseva et al., 2022), and F) Strategic (Luh et al., 2022).

Table 2.1. Summary of SGs proposed between 2017-2023.

Categories	**# of SGs**	**References**
Genre		
Mini games	12	(Goumas et al., 2020; Guo et al., 2020; Hananto & Panjaburee, 2019; Lertlapnon et al., 2022; Mosquera et al., 2020; Polat et al., 2022; Priyadarshini et al., 2021; Speth et al., 2023; Xiong et al., 2022; Yang et al., 2017)
Action	2	(Kamaruddin et al., 2022; Nobnop et al., 2023)
Adventure	5	(Chang et al., 2021; Huang et al., 2021; Ibrahim et al., 2019; Stuchlíková et al., 2017; Tapingkae et al., 2018)
Role-Playing Game (RPG)	2	(Cezar et al., 2019; Wang et al., 2020)
Simulation	2	(Calderón et al., 2017; Novoseltseva et al., 2022)
Strategic	1	(Luh et al., 2022)
Domain		
Language and creativity	3	(Babaie, 2022; Goumas et al., 2020; Xiong et al., 2022)
Health Awareness	2	(Guo et al., 2020; Yang et al., 2017)
Medical	2	(Chang et al., 2021; Novoseltseva et al., 2022)
Mathematics	2	(Kamaruddin et al., 2022; Polat et al., 2022)
Computing	10	(Calderón et al., 2017; Hananto & Panjaburee, 2019; Ibrahim et al., 2019; Lertlapnon et al., 2022; Luh et al., 2022; Mosquera et al., 2020; Nobnop et al., 2023; Speth et al., 2023; Tapingkae et al., 2018; Wang et al., 2020)
Engineering	1	(Stuchlíková et al., 2017)
Environmental Studies	1	(Priyadarshini et al., 2021)
History	1	(Huang et al., 2021)
Academic Level		
General	2	(Guo et al., 2020; Yang et al., 2017)
Pre-school	1	(Xiong et al., 2022)

Categories	**# of SGs**	**References**
Primary (K-12)	6	(Goumas et al., 2020; Kamaruddin et al., 2022; Mosquera et al., 2020; Polat et al., 2022; Stuchlíková et al., 2017; Tapingkae et al., 2018)
Secondary (High school)	2	(Hananto & Panjaburee, 2019; Priyadarshini et al., 2021)
Higher Education	12	(Babaie, 2022; Calderón et al., 2017; Cezar et al., 2019; Chang et al., 2021; Huang et al., 2021; Ibrahim et al., 2019; Lertlapnon et al., 2022; Luh et al., 2022; Nobnop et al., 2023; Novoseltseva et al., 2022; Speth et al., 2023; Wang et al., 2020)
Effectiveness		
Improved learning performance	9	(Babaie, 2022; Calderón et al., 2017; Hananto & Panjaburee, 2019; Ibrahim et al., 2019; Kamaruddin et al., 2022; Lertlapnon et al., 2022; Luh et al., 2022; Wang et al., 2020; Xiong et al., 2022)
Increased motivation	5	(Calderón et al., 2017; Goumas et al., 2020; Guo et al., 2020; Nobnop et al., 2023; Tapingkae et al., 2018)

However, there are studies that showed no differences between SG and non-game learning activities (e.g., Lopez-Fernandez et al., 2021; McKenzie, 2013). This should lead to the realisation that SGs would not always result in better learning compared to non-game-based learning, as advised by Mayer (2019). Training learners in HOTS is also still lacking in the field of SGs, where the implementation of SGs is predominantly for knowledge acquisition involving LOTS such as remembering and understanding (Clark et al., 2016). However, there is positive potential in the effect of SGs in improving HOTS such as problem solving skills amongst students (Yang, 2012).

Another aspect commonly associated with SGs is motivation. Motivation is important during learning activities, as it drives learners' desire to approach and engage with the activities, and is linked to successful learning (Lepper et al., 2005). Garris et al. (2017) identified six important characteristics that can improve learner motivation and engagement in SGs: fantasy, goals, sensory stimuli, challenge, mystery, and learner control. *Fantasy* (e.g., fictional story) and *sensory stimuli* (e.g., animations) are characteristics commonly found in games. *Challenges* found in SGs should be

optimally designed (i.e., not too easy or difficult), which can be done by ensuring that completing challenges are uncertain (e.g., failed attempt is expected) and require effort (Garris et al., 2017). *Goals* of challenges should also be clearly stated and meaningful in the context of the activities, and feedback given for players to gauge their current performance (Locke & Latham, 1990). *Mystery* can evoke curiosity in learners (i.e., the desire to acquire knowledge), caused by discrepancies or inconsistencies in players' existing knowledge (Garris et al., 2017). This is accomplished when players start off in a game with minimal or non-existent knowledge within a new fictional world. *Learner control* relates to what players can do to complete a learning activity (e.g., deciding on strategy), which can be addressed by enabling the use of various approaches that can give players a sense of more control.

The last aspect relevant to the thesis is emotion, which can influence learners' motivation, use of learning strategies and self-regulation (Pekrun et al., 2011). The design of SGs can affect players' emotions (Lei et al., 2022), which points to the importance in the design of challenges. Enjoyment, anger, frustration, and boredom are emotions experienced when engaging in learning activities (Pekrun, 2006). *Enjoyment* is a positive emotion that can be instigated when game challenges are highly valued and sufficiently manageable by players. *Anger* is a negative emotion experienced when challenges are manageable but negatively valued by learners. Challenges that is not manageable on the other hand can cause *frustration* in learners, even when the challenges are positively or negatively valued. *Boredom* is felt when players do not value a challenge. Certain positive emotions have been shown to affect learning performance (Giannakos, 2013).

2.5 LEARNING IN ROLE-PLAYING GAMES

Quests and mechanics are the main outlets where instructions can be integrated in RPG. Bellotti et al. (2011) proposed that a game's user interface, method of interaction (e.g., question-answering or exploration), feedback, and player evaluation are integral mechanics for presenting instructional content to learners. Story in RPG can also be used to contextualise the quests. Using stories in learning (i.e., *storification*) has been shown to improve learners' comprehension, engagement and

retention (Aura et al., 2021). Narratives used in SGs, however, should be optimally aligned with the learning outcomes. The use of rich and irrelevant narratives could in fact impede and distract learners from the actual learning (Clark et al., 2016). Lastly, graphics can be used to present visualisation of instructional events or environment, which would be important for certain learning activities (e.g., medical training) that requires the simulation of real-world environments, scenarios or situations (e.g., Creutzfeldt et al., 2012; Knight et al., 2010).

RPG gameplay can also take cues from established learning theories, which can inform the possible ways learning can be implemented in SRPGs. *Behaviourism* theory focuses on repetition and reinforcement (Schunk, 2012), typically implemented using drill-and-practice gameplay found in most games. *Social Cognitive* theory focuses on learning through observing model behaviours (Schunk, 1998). Simulations and role-playing is a form of modelling (Schunk, 2012), suggesting the relevance of RPG in the context of observational learning. *Cognitivism* theory considers the internal cognitive process that takes place in learning (Clark, 2018), which is mainly concerned with how learners receive information (e.g., listening, watching), process it (i.e., making sense of information), and storing in memory. Too much cognitive effort spent by learners during the processing phase can negatively affect learning (Sweller, 2010a). This can be minimised by properly structuring information that is to be learned, such as breaking into smaller units and using worked examples rather than through discovery or problem-based learning. This concept is typically found in games, where players are presented with guided tutorials focusing on the mastery of specific skills, and hints given to players for completing challenges (e.g., BOTW, Plants vs Zombies[4]).

Constructivism theory concerns with knowledge that is formed based on learners' subjective beliefs and experiences in situations (Cobb & Bowers, 1999), thus requiring learning situated in context (Bredo, 2006). Learners then develop knowledge for themselves as active learners (Geary, 1995). The concept of

[4] https://en.wikipedia.org/wiki/Plants_vs._Zombies

Constructivism can be incorporated in RPGs, where learners can engage in a simulated real-world situations that relates to learned knowledge (Lainema, 2009).

Authentic Learning (AL) is a form of constructivism, a learning approach which situates learners in real-world situations or scenarios (*authentic context*) and engaged in typical activities where learned knowledge is expected to be used (*authentic activities*; Herrington & Oliver, 2000). The two characteristics of AL (i.e., authentic context and activity), along with others, were described by Herrington and Oliver (2000). In AL, learners should also be exposed to *expert models* on how the activities are normally addressed by experts. This approach agrees with social cognitive theory. Learners should also address the authentic activities from *various perspectives*, again sharing the same concept with constructivism. Learners are also encouraged to *collaborate* with other learners, *reflect* on their actions by comparing it with the expert models, and *articulate* (e.g., discuss or present) their understanding and experience with the authentic activities. The last two characteristics of AL include external input. *Scaffolding* involves providing coaching (e.g., from teachers) to learners during the authentic activity, while *integrated assessment* involves assessing the outcomes produced by learners throughout the whole process of engaging with the activity.

The components of AL can be incorporated through the various RPG components. Authentic context and activities can be presented to players through the settings, quests and narratives. Virtual characters (or Non-Player Characters; NPC) can be used to represent expert models. Scaffolding and reflection can be provided through various components such as NPCs or narratives. Players can also be provided with different perspectives through the narratives, quests and player roles. Collaboration can be implemented through multi-player features or allowing collaborative play amongst learners. Authentic assessment can be implemented by tracking players' completion of quests. Articulation, on the other hand, can take place outside of gameplay, such as having players discuss their experience.

Experiential Learning Theory (ELT) is another form of constructivism which describes learning in relation to grasping and transforming learners' experience (McCarthy, 2010). According to ELT, a learner can go through four learning cycles: Concrete Experience (CE), Reflective Observation (RO), Abstract Conceptualisation (AC), and Active Experimentation (AE). CE and AC both relate to grasping the meaning of experience but with opposite learning style, with CE being more on

perceiving new information through experiencing reality (i.e., actually taking part in the experience), while AC is being more on grasping information by thinking (e.g., through symbolic representation). RO and AE, on the other hand, both relate to transforming the experience. RO favours a learning style that focuses on observing others and reflecting on what happens, while AE focuses on actually doing things. These learning cycles can also be incorporated into various RPG components. Completing RPG quest activities can be used to allow learners to experience AE (e.g., when carrying out actions to solve a problem), CE (e.g., experiencing problem faced by the player avatar) and AC (e.g., thinking on solving the problem). Interacting with NPCs on the other hand can allow learners to experience RO (e.g., reflecting on others' experiences).

By identifying the theoretical points where learning can be incorporated in RPG, the points presented above have answered RQ 1A (i.e., *How can learning instructions be incorporated in RPG?*).

2.6 CREATING SERIOUS GAMES

The definition of SGs was established earlier (See Section 2.3), referring to games specifically designed for serious purposes. This includes COTS and custom SGs. COTS games are readily available in the game market (Van Eck, 2009) designed based on some predefined learning structure which might not meet the teaching and learning requirements of certain institutions or educators. Custom SGs, on the other hand, are tailored specifically for the intended learner-target users and instructional intentions.

Creating games generally consists of *design* and *development* phases, and involves a multidisciplinary team with different responsibilities throughout the creation process (e.g., Bethke, 2003; Ramadan and Widyani, 2013). Creating SGs involves additional personnel addressing the learning aspect, such as SMEs, instructional designers or educators, to provide input with regards to the content (Strzalkowski & Symborski, 2017). Game designers are then tasked with designing the game based on the content, which involves tasks such as designing the gameplay and artistic components. The design is then implemented in the development phase by various other stakeholders such as programmers and graphic designers. The overall process entails a complex,

time-consuming and expensive endeavour. Figure 2.4 shows the current SG creation workflow.

2.6.1 Alignment of Gameplay and Learning

A key consideration when designing SGs is to ensure that the gameplay are aligned with the learning outcomes, where instructional activities during gameplay are meaningful or relevant to the instructional goals (Ke, 2016; Shelton & Scoresby, 2011). The gameplay found in "Angry Birds" for example is relevant in the context of learning "projectile motion" (de Aldama & Pozo, 2020), even if the story is not relevant or realistic. Presenting learners with activities that relate to what is to be learned would improve the chances of learning to take place, since learners will focus more on the relevant tasks rather than on extraneous ones that do not contribute to the learning (Sweller, 2010b). Gameplay that is not aligned to the learning goals (e.g., Lopez-Fernandez et al., 2021) would only serve as a short-term motivational factor, and could even be a distraction away from the actual goals or result in less engagement from learners (Asgari & Kaufman, 2004). Any occurrences of substantial learning through this type of SGs would happen unintentionally (Shelton & Scoresby, 2011).

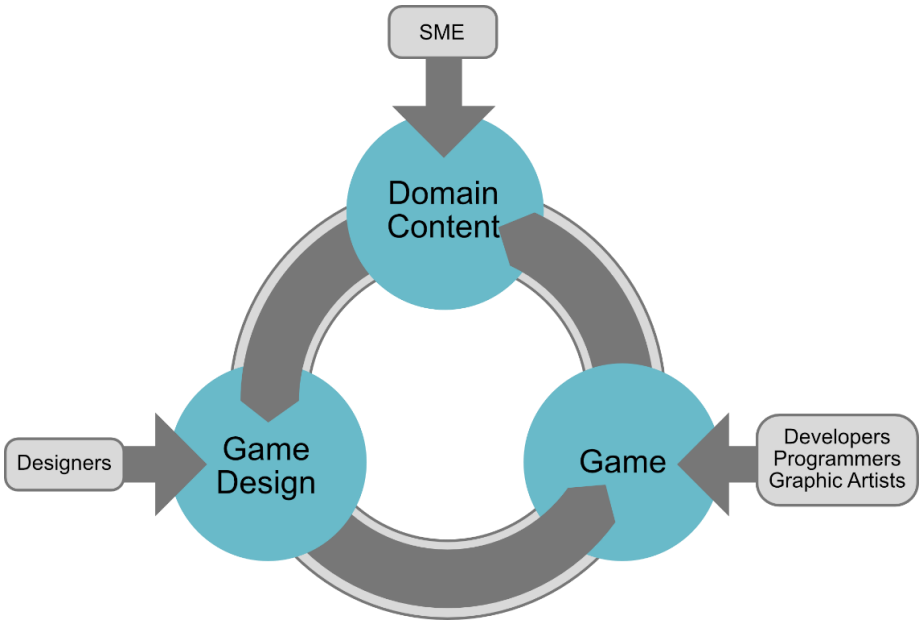


Figure 2.4. Serious Game Project Workflow

2.6.2 Guiding the Design of Serious Games

Several design approaches were proposed as guidelines intended for collaborative effort between the stakeholders involved in the design phase. The *Four-Dimensional Framework* (4DF) is one of the earlier works on supporting the design of SGs (De Freitas & Jarvis, 2006), which emphasises on establishing aspects of learners (e.g., age group, preferences) and learning (i.e., what is to be learned) as the foundation for SGs designs. The "*Relevance, Embedding, Translation, Adaptation, Immersion and Naturalization"* model (RETAIN; Gunter et al., 2008) is another model which starts by identifying activities that are relevant to the learning goal, and intrinsically embedding it within the story of a game. Both models are focused on a high-level design process, giving creative freedoms to game designers to produce SG designs based on the identified learning prerequisites.

The *EMERGO* methodology (Nadolski et al., 2008) on the other hand is a low-level structured method aimed to guide the design of scenario-based simulation SGs intended for acquiring complex cognitive skills (e.g., problem solving, decision making), through activities where learners circumvent real-life problem situations. Other low-level structured approaches focus on identifying game mechanics based on the required learning tasks. The *Learning Mechanics-Game Mechanics* (LM-GM) model (Arnab et al., 2015) provides a mechanism to match learning actions (e.g., find information) to suitable game mechanics (e.g., cut scenes). The model, however, does not provide concrete connections between the learning and game mechanics with the overall learning objectives an SG is expected to address. This limitation was addressed in the *Activity Theory-based Model of Serious Games* (ATMSG; Carvalho et al., 2015). In this model, the "instructional" component was added to define the instructional objectives of the relationship between learning and game mechanics. For example, the learning action "find information" can be mapped to the game mechanics "cut scenes", with the instructional objective being "to inform learners of the activity's objective".

Almost all these approaches require input from game and instructional design. Only the EMERGO methodology is used without requiring input from game designers, as the gameplay produced through the methodology is driven by designing activities based on real-world scenarios and does not require common entertainment-based gameplay elements.

2.6.3 Instructional Design Principles and Game Design

The design methods in the previous section does not explicitly incorporate concepts of existing Instructional Design Principles (IDP). IDP is a systematic approach in planning how intended learning can be achieved in non-game-based instructions (Gagne et al., 2005), skills which educators should already possess. It stands to reason that applying IDPs in designing SGs can further enhance the chance of effective learning to take place during gameplay. A systematic literature review was recently conducted as part of an initial exploratory work for this thesis (Ahmad et al., 2020), with the objectives: 1) to review existing SG design methods that explicitly incorporates processes of existing IDPs, and 2) to establish educators roles in the use of these methods. Only eight design methods were identified.

The concepts of IDP were mainly adopted and used in the capacity of structuring the gameplay. The first aspect relates to *identifying the knowledge* to be taught. Several design methods (Aleven et al., 2010; Bril & Degens, 2016; Jeuring et al., 2014; Kalloo et al., 2015; Linehan et al., 2011; Wouters et al., 2010) adopted general procedures of IDPs with regards to identifying the knowledge, which involves identifying the learning outcomes and the relevant knowledge or skills to be learned.

The second aspect relates to *designing the learning tasks*. One approach involves breaking down knowledge content into smaller units and building a game based on one of these units (Kalloo et al., 2015). The intention is to allow students to focus on individual concepts separately through different games, but this approach can cause learners to fail to understand the relationships between several concepts (Lim et al., 2009). Several methods (Bril & Degens, 2016; Jeuring et al., 2014) adopted the *Four-Component Instructional-Design* (4C/ID) model (Van Merriënboer et al., 1992), which emphasise on identifying authentic whole scenarios to promote the application of various skills together as a whole rather than separately, suitable for learning skills in authentic situations. Learning tasks should also include supportive information (i.e., feedback), which is important in SGs and learning in general (Garris et al., 2017). Few methods (Bril & Degens, 2016; Jeuring et al., 2014) explicitly focus in identifying these supportive information by drawing on the concepts of the 4C/ID model. Several design methods (Bril & Degens, 2016; Jeuring et al., 2014; Van Eck et al., 2009; Wouters et al., 2010) also focused on using authentic scenarios to reflect future or

contextualised environments where learners are expected to apply their learnt knowledge, for example an emergency room for nurse training.

While IDPs coordinate the design of learning instructions, existing game patterns are used to *integrate gameplay into the instructions*. The approach generally involves matching suitable gameplay to instructional tasks (Aleven et al., 2010; Kalloo et al., 2015; Wouters et al., 2010).

The last aspect in structuring gameplay relates to *evaluating the instructional-aspect* of SG designs. The method proposed by Aleven et al. (2010) includes an analytical phase where designs are validated against established learning principles, in order to ensure that the designs can effectively support the intended learning. This process provides a high-level checklist that informs the potential learning effectiveness of the game components incorporated in an SG.

Only two design methods explicitly reported on the specific role for educators (Bril & Degens, 2016; Jeuring et al., 2014), where they are involved in the identification of the required learning outcomes and suitable instructional activities. Educators should already possess the necessary skills to address the aspects of identifying the knowledge, designing the learning tasks, and evaluating the instructional designs. The only aspect in structuring SG gameplay that is currently beyond the capabilities of the average educators relates to integrating gameplay into the instructions. The concept of matching suitable game mechanics to learning tasks (e.g., Kalloo et al., 2015; Wouters et al., 2010), however, could be adopted and further refined to enable this aspect to be fully manageable by educators.

The points presented have answered RQ 1B (i.e., *How are concepts of Instructional Design Principles (IDP) being used in existing SG design methods?*).

2.6.4 Serious Game Authoring Tools

During the development phase, SG design is built into a finished game by various experts in game development (e.g., graphic artists, programmers), which requires different specific tools (e.g., graphics and game development software). With regard to game development software, Cowan and Kapralos (2017) identified the most used tools for developing SGs were software for general games. The most utilised platform

is *Unity*[5], which exemplifies the standards of game development tools, providing an integrated platform with a multitude of features to create the various aspect of games (e.g., adding user interface, programming gameplay). Due to the complex and extensive features available, these platforms can create any type of games. Using these platforms also requires a great understanding of the building block of games, and how components (e.g., game controller, physics) and objects (e.g., player character, interactive door) within games are interconnected.

The complexity of the development tools such as Unity means that experts well-versed in these tools are needed. Reducing, or even eliminating dependency on these experts would improve SG creation in terms of reducing time, effort, and financial constraints. Interest in this area has only started receiving attention recently, where several SG-specific authoring tools have been proposed (**Error! Reference source not found.**). These tools (Figure 2.5) aim to make SG development more rapid and accessible to non-technical experts by addressing several key issues relating to SG development: reducing authoring complexity, reducing the complexity of programming, integrating learning components, and integrating the design phase.

Reducing Authoring Complexity

By reducing the authoring complexity in SG authoring tools, developers could rapidly create SGs as compared to general game platforms. An authoring tool's usability is affected by its flexibility, the diversity of target output that can be produced (Murray, 2016). The more flexible an authoring tool is, the more complicated it is to use (i.e., low usability) due to its many components and features. In terms of SG authoring tools, this meant limiting the type of game genres produced. All of the existing SG authoring tools are able to produce only one genre (Figure 2.6**Error! Reference source not found.**), mostly focusing on adventure (Mehm et al., 2012; Perez-Colado et al., 2019), simulation (Slootmaker et al., 2014; Torres et al., 2022), and mini-games (Gordillo et al., 2021; Tornero et al., 2010; Torrente et al., 2015). Game components that can be configured in these tools are limited to common functionalities found in their target genre, thus reducing the complexity in terms of managing the game

[5] https://unity.com/

components and gameplay. As mentioned in Section 2.2, RPG has richer gameplay, yet its use in the field of SG is lagging behind simulation genre (Boyle et al., 2016), which I postulate is due to the complexity of creating this genre.

Several tools such as Moirai (Torres et al., 2022), Mokap (Torrente et al., 2015) and e-Training DS (Tornero et al., 2010) also simplified the creation of graphical assets, by making use of predefined graphics. Moirai, for instance, comes with a pre-made 3D world environment, and only requires educators to set the gameobjects they want to be shown in a particular scenario. This allows educators to create certain aspect of the visual aspect without involving visual artists.

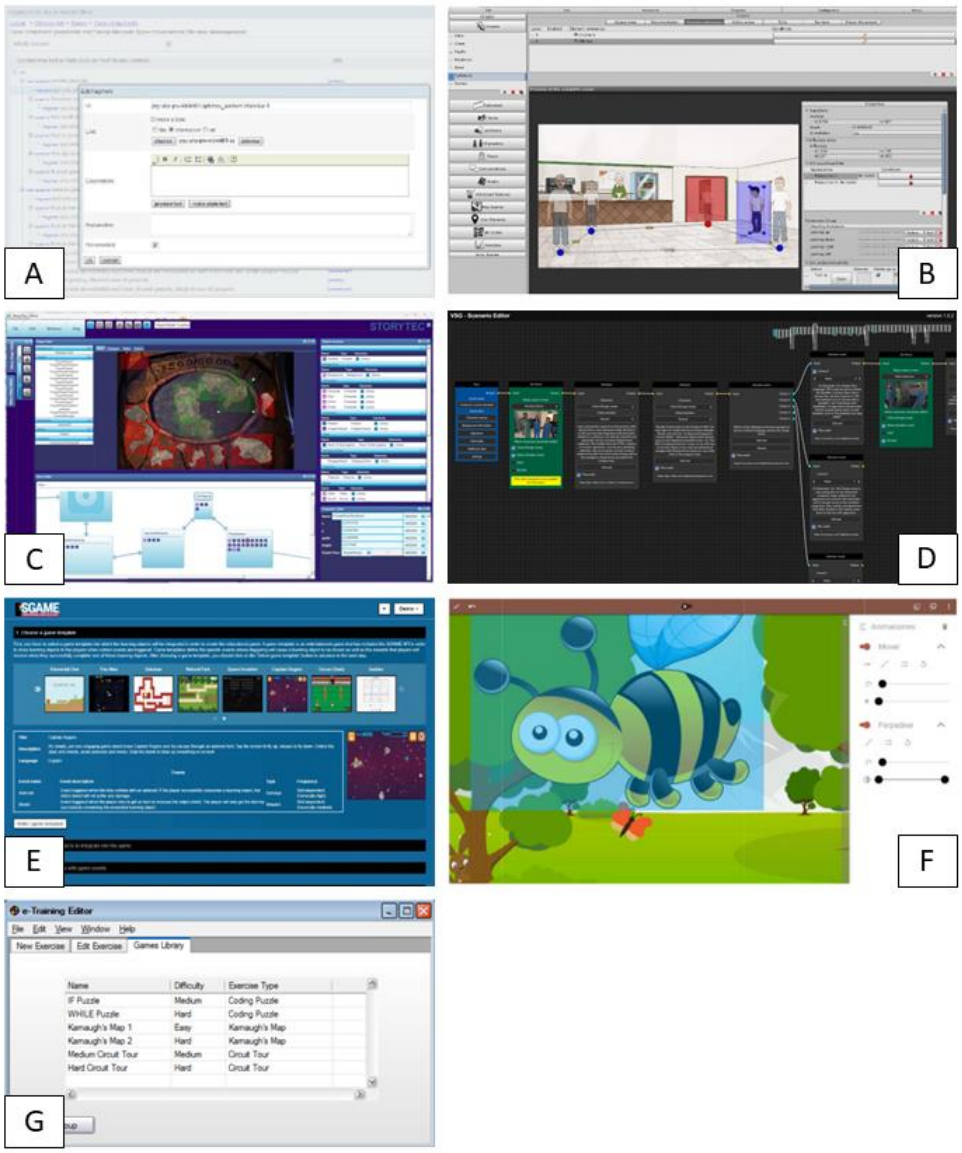


Figure 2.5. SG authoring tools screenshots.
EMERGO (A), uAdventure (B), StoryTec (C), Moirai (D), SGame (E), Mokap (F), and e-Training DS (G).

Authoring tools should also consider the target users' "*Complexity Capacity*" (CC), their ability to handle complex processes within an authoring tool (Murray, 2016). Structuring and simplifying the authoring process workflow is one way to improve the usability of SG authoring tools. Tools such as U-Adventure (Perez-Colado et al., 2019) and StoryTec (Mehm et al., 2012) provide several component editors to address the tasks in creating adventure games, which explicitly exposes the tasks, workflow and associated tools required to create adventure games to the users. This helps non-expert users to create and maintain the correct mental models of the tool and its authoring processes (Murray, 2016).

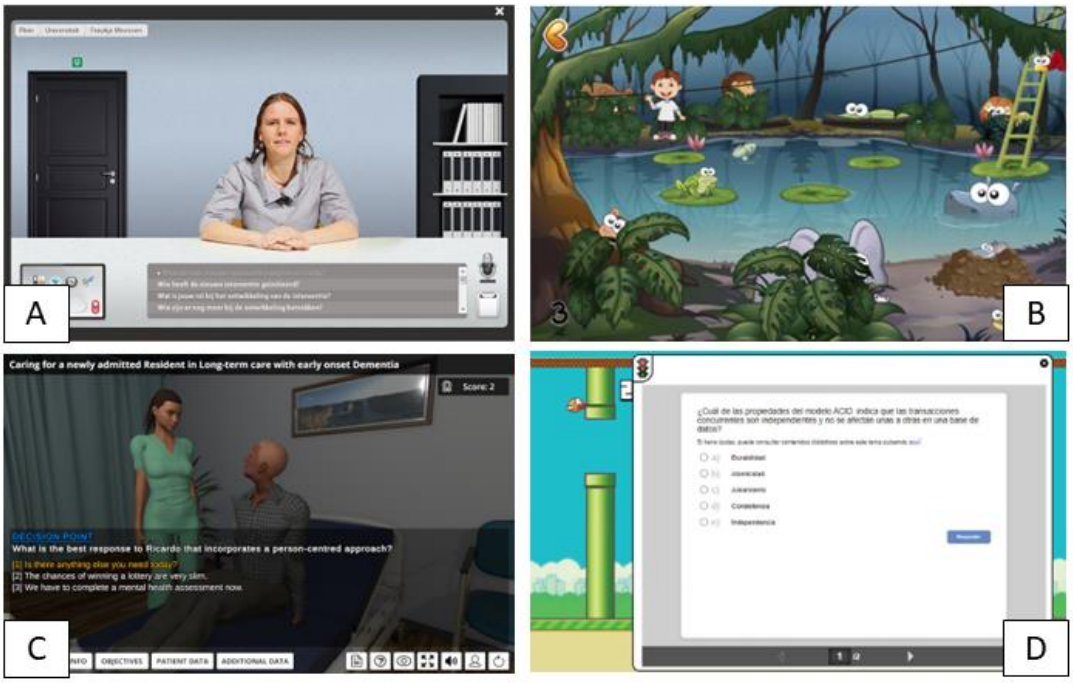


Figure 2.6. Games produced by existing SG authoring tools.
Simulation scenario games with EMERGO (A), Point-and-click Adventure games with Mokap (B), Simulation games with Moirai (C), and Mini-games with SGame (D)

Reducing the Complexity of Programming

Another key approach in authoring tools is to match the complexity of tools and tasks with the target users CC. Creating gameplay involves configuring the logics within a game through programming, typically using text-based programming or scripting languages such as C# and JavaScript, and thus requires experts in programming. To make SG development more accessible especially to non-expert target users, tasks relating to programming should employ interfaces and processes that are suitable for non-programmers or non-experts. Reducing the complexity of programming is a

common theme shared by most of the SG authoring tools. The tools SGame (Gordillo et al., 2021) and e-Training DS do not need to be programmed, as the games are pre-built and only require users to input learning activities as content. Other tools such as U-Adventure, StoryTec and Moirai utilised visual programming languages (VPL), which makes use of visual objects to code, as opposed to using text-based programming languages.

Integration of Learning Components

The next issue addressed by SG authoring tools is the *integration of learning components*. One major learning-related aspects commonly integrated in these authoring tools is tracking learners' progress (e.g., correct and wrong answers), where this feature is built right from the box in the SGs produced. Some of the tools also enable the configuration of the instructional properties (e.g., learning objectives) when creating the gameplay (Torres et al., 2022), and provide explicit outlet where instructional activities are incorporated in the game (Gordillo et al., 2021; Mehm et al., 2012).

Integration of a Design Method

The last consideration relates to the integration of a dedicated design phase. Only the EMERGO toolkit (Slootmaker et al., 2014) is used in conjunction with a specific design method (i.e., the EMERGO methodology in Section 2.6.2) that aims to guide educators in designing an SG. By integrating a design method, the authoring tool can be used primarily as a point of data entry, further streamlining the creation process.

2.6.5 Educator-Oriented Authoring Tools

The tools presented above are intended to simplify the development process, and only few of these tools (i.e., Moirai, SGame, E-Training DS) provide complete control to educators in the creation of SGs. However, only Moirai allowed educators to configure gameplay through the use of a VPL specifically designed to be manageable by educators. Giving educators creative control is also found in educator-oriented authoring tools for the creation of other forms of educational technology. Most of these tools implement standard form controls (e.g., text fields, drop-down menu) for educators to enter learning content to be embedded in various target output such as AR (Blattgerste et al., 2019), comic strips (Suh et al., 2022), and web e-learning

(Xiberta & Boada, 2016). Few tools also incorporate other forms of interface to address other aspects such as graphic creation and programming. PrivacyToon (Suh et al., 2022) provides a drawing editor, with simple drawing tools and the use of image templates, for educators to create artwork for an educational comic strip. This feature was found usable by educators, even by those who were not confident in their drawing abilities. This concept is a viable approach in the design of an SRPG game world and gameobjects (e.g., game characters). VEDILS (Mota et al., 2018) is an AR authoring tool which allowed educators to program the behaviour of the AR app using Block-based programming (BBP), a feature found easy by educators even without programming knowledge.

2.6.6 Visual Programming for Non-Expert Programmers

One of the important aspects in developing SGs is programming the gameplay. The SG authoring tools presented earlier (Section 2.6.4) mostly implemented diagram-based VPL (Figure 2.7B). BBP (Figure 2.7A) is another form of VPL, and is widely used in other areas such as education and application development (Kuhail et al., 2021). Comparative evaluation between diagram-based and BBP is still lacking. Huang et al. (2020) found that diagram-based VPL is more efficient than BBP in terms of time spent completing programming tasks. Giordano and Maiorana (2015) on the other hand found no significant differences between these two VPLs in terms of errors and time spent, but BBP was found simpler to use than diagram-based VPL. Considering the use of BBP is quite prevalent in the other areas of application development (Kuhail et al., 2021), its use in SG development could be promising and warrant further investigation.

2.7 SUMMARY

Educators' active involvement in the creation process can be significant in terms of ensuring SGs suitability as learning tools. One of the shortcomings for the use of existing SGs for teaching is educators' unfamiliarity with the game and any potential instructional characteristics it possesses. This can lead to difficulties in educators identifying "teachable moments" in the game (Molin, 2017). The use of SGs would be more effective in this context if games are created based on educators' individual

instructional intentions rather than requiring educators to adapt their teaching practices to the instructional constraints of unfamiliar SGs. Enabling educators to create SGs would also give a sense of ownership and enable them to identify with the innovation, where ownership is assumed to be an important concept in ensuring the successful and continued integration of an innovation (Ketelaar et al., 2012). The current creation process described in the previous sections shows that educators' roles within the process are still limited.

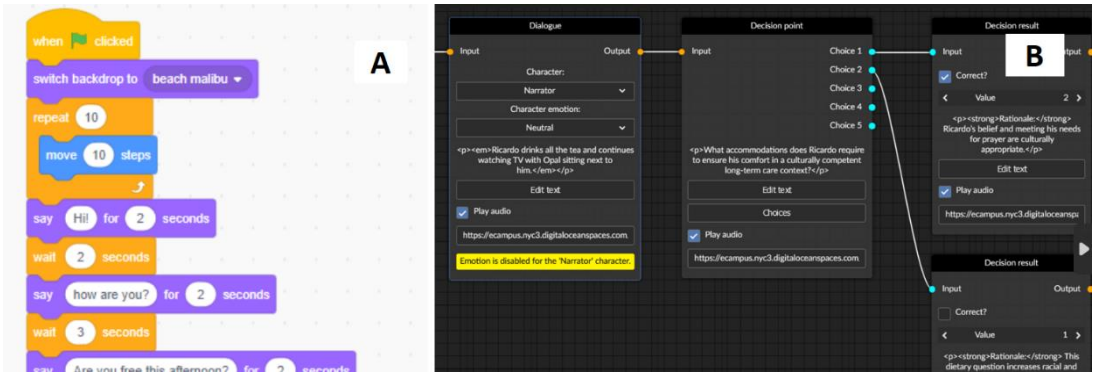


Figure 2.7. Visual Programming Language.
Block-based (A[6]) and Diagram-based (B; Torres et al., 2022) Visual Programming.

In terms of designing SGs, educators are mostly only involved in tasks concerning the instructional attributes of SGs such as providing content materials and instructional activities. However, design methods that incorporates concepts of IDPs (Section 2.6.3) identified areas that could be addressed by educators existing knowledge in designing instructions. The relationship between RPG and learning was also discussed in Section 2.5, where RPG components that could potentially be used to incorporate instructional learning components were identified. This knowledge was used in devising an SRPG design method which is presented in Chapter 3.

Similarly in the development of SGs (Sections 2.6.4), the tasks generally involved expertise in areas that average educators would not possess (e.g., graphic design, programming). In terms of SG authoring tools, only a few are intended to be used by educators, while others provide few features not applicable for the level of technical skills possessed by average educators. Some of the mechanisms implemented in tools

[6] https://en.wikipedia.org/wiki/Scratch_(programming_language)

for SG and other forms of educational technology (Section 2.6.5) shows potential in allowing educators to configure aspects of SRPGs that would typically require game experts such as simple editors to configure the visual aspect (e.g., game world), and the use of BBP to program the gameplay. This has answered RQ 4A (i.e., *What are the possible interfaces and workflow suitable for an educator-oriented SRPG authoring tool?*), where these concepts were adopted in the proposed SRPG authoring tool, which is presented in Chapter 5.

Table 2.2. SG Authoring Tools

Authoring Tool	Target Game Genre / Platform	Component Editors	Target Users	Programming / Configured by	Assets Creation	Game World / Configured by
EMERGO (Slootmaker et al., 2014)	Simulation/Web	Case/Scenario; Scripting	Educators; Programmers; Artists	Text-based Scripting / Programmer	Externally sourced	**Multimedia (images, video) / Educators**
u-Adventure (Perez-Colado et al., 2019)	Adventure/Multi-Platform	Narrative; Scene	Game developer	Diagram-based visual scripting / Game developer	Externally sourced	**2D graphics / Game developer**
StoryTec (Mehm et al., 2012)	Adventure/PC	Story; Stage; Action; Property; Knowledge Space;	Educators; Programmers; Artists	Diagram-based visual scripting / Programmer	Externally sourced	**3D world / Artists**
Moirai (Torres et al., 2022)	Simulation/Web	Scenario	Educators	Diagram-based visual scripting / Educator	Predefined Library	**3D world / Educators**
SGame (Gordillo et al., 2021)	Mini Games/Web	Template selection; Learning Objects;	Educators	None	Externally sourced	**2D graphics / non-configurable**
Mokap (Torrente et al., 2015)	Mini Games/Multi-Platform	Scene; Programming Editor	Game developer	GUI; Text-based programming / Game developer	Externally sourced; Predefined Library	**2D graphics / Game developer**
e-Training DS (Tornero et al., 2010)	Mini Games/Portable Gaming Console	Template Selection	Educators	None	Externally sourced; Predefined template	**2D graphics (Predefined Template) / Educator**

CHAPTER 3

DESIGNING SERIOUS ROLE-PLAYING GAME: METHODOLOGY AND OUTPUT

SGs' primary function is to cause learning to take place during gameplay. This involves imparting knowledge or skills through gameplay. SG design methods discussed in Section 2.6.2 identified how gameplay can be aligned with learning instructions. The workflow of these methods is iterative, requiring first to design the gameplay, and then identify whether it can address the learning intentions. The use of these methods also requires prior knowledge of game design, a task that is to be addressed by game designers.

To devise a method appropriate for educators, emphasis should be more on the design of learning instructions, coupled with a systematic guide on converting these instructions into game activities. This concept was addressed by few SG design methods, which primarily focus on designing instructions using concepts from existing instructional design principles (Section 2.6.3). Based on the approaches found in these design methods, a novel design method specifically for designing SRPG, which are presented in this chapter, was conceived and evaluated by educators in a focus group study to establish the suitability of the method with educators being target users.

3.1 EMBEDDING LEARNING IN RPG

O'Brien et al. (2010) argued on the theoretical potentials of RPG in terms of learning, which merit further exploration. As mentioned in Section 2.2, RPG has the richest game characteristics, but has yet to receive much attention in SG research compared to the other genres such as simulation and adventure (Boyle et al., 2016; Gorbanev et al., 2018), perhaps due to the difficulty in its implementation compared to the other genres. In Section 2.5, RPG components that can be used to incorporate AL were introduced: settings, player role, quests, narratives, and NPCs. This section presents the concept of embedding learning into RPG, using an example SRPG (Table 3.1) to better illustrate the concept.

Table 3.1. "Fire Prevention" Serious Role-Playing Game Example.

RPG Components		**Details**
Theme Settings	Location	A town
	Overarching Story	Help improve fire safety in the town
Player Role		Junior Fire Department Officer
Quests	Quest 1	Players must identify and eliminate fire hazards from a household.
	Quest 2	Players must identify important fire equipment that should be present in a household.

Settings establishes the overall theme of an RPG, such as the world where the game takes place (e.g., a fictional magical world), and the overarching story (e.g., saving the world from evil). In the context of SRPGs, the settings can be set to a relevant authentic context. Using a "Fire Prevention" domain as an example (Table 3.1), the game can be set in a town with the overarching story to "help improve fire safety in the town". Player characters in RPG have specific roles relevant to the settings. In the context of SRPGs, the roles can be set to a real-world role relevant to a learned domain (e.g., a fire department officer for the fire prevention domain). Associating real-world roles to player characters can be used to provide learners with the required perspectives (i.e., point of view) in accordance with AL.

Quests is the main component where instructional activities can be embedded. Quests are initiated when players interact with NPCs (i.e., a quest starts when player accepts a quest from an NPC). Doran & Parberry (2010) classified quests based on the quests' overarching *motivation* (i.e., outcomes to be achieved). These motivations are basically "owned" by the NPCs initiating the quests, and players are tasked with helping the NPCs realise them. According to Doran & Parberry (2010), there are nine common quest motivations found in various RPGs (Table 3.2). Each of the motivations can be approached by players using various *strategies*, where a strategy is a sequence of player *actions* (Table 3.3). For example, the motivation "Gain Knowledge" relates to quests where an NPC wants to get information about something. There are several strategies that can be employed for this motivation, such as "interviewing another NPC" or "spying another NPC". Each of these strategies requires players to carry out certain related actions. For "interviewing another NPC", this might involve going to some NPC, talking to it to get the requested information, and returning to the initiating NPC with the newly acquired information (Table 3.2). Quests in the context of SRPG can be used to present authentic activities, which involve players performing tasks related to the learned knowledge or skills. For the example SRPG (Table 3.1), the quests involve activities where players must exhibit and exercise the required knowledge in terms of fire prevention.

Quest is the outlet where narratives are given to players. The narratives are aligned to the overarching story of an RPG and completing them leads to overcoming the main problem associated to the story. In SRPGs, authentic activities in quests should relate to authentic scenarios, which in turn should be relevant to the story. In the example SRPG (Table 3.1), the quests involve scenarios that could take place within the context of fire prevention domain and the theme of a fire department.

Another important gameplay in RPGs is interacting with NPCs such as to gather information (i.e., hints) for completing quests. NPCs can be used to provide expert model and feedback. In the example SRPG (Table 3.1), players could interact with NPC acting as "Senior Fire Officer" to get advice when completing quests. Other mechanics can also be used in this capacity, such as using messages presented to players during gameplay.

Table 3.2. RPG Quest Pattern.
(The complete Quest Pattern is shown in Appendix A2)

Quest Motivations	**Example Strategies**	**Example Action Sequence**
Gain Knowledge	Interviewing another NPC	Go To NPC B, Talk to NPC B, Go To NPC A, Talk to NPC A
Gain Comfort	Destroying something or removing obstacles	Go To Location A, Destroy Something
Gain Reputation	Obtaining rare items	Go to Location A, Take item A, Go To NPC A, Give Item A to NPC A
Achieve Serenity	Recovering lost or stolen items	Go To NPC B, Sneak Up On NPC B, Take item A, Go To NPC A, Give Item A to NPC A
Gain Protection	Treating or repairing something	Go To location A, Repair Prop A
Conquer	Attacking an enemy	Go To NPC B, Destroy NPC B
Gain Wealth	Gathering raw materials	Go To Location A, Gather Items A, Go To NPC A, Give Items A to NPC A
Obtain Ability	Assembling tool for a new skill	Explore Location A, Repair Item A, Use Item A
Obtain Equipment	Assembling an equipment	Go to Location A, Repair Item A, Go To NPC A, Give Item A to NPC A

Table 3.3. RPG Player Actions.

Player Actions	**Description**
Attack	Fight some enemies
Capture	Catch an NPC who did something (i.e., a culprit)
Examine	Examine/inspect an item or prop or read a readable item.
Experiment	Find out what an item is used for
Explore	Explore a location to find something
Escort	Escort/guide an NPC to some location
Follow	Follow an NPC to some location

Player Actions	Description
Fix	Turn a prop into a desirable state (e.g., fix, install, upgrade, setup, etc.)
Go to	Go to an NPC or a location
Gather	Gather several units of the same item
Give	Give an item/readable item to an NPC
Make	Create an item by combining several other items together
Protect	Improve an NPC, location or prop from an undesirable state to a desirable state
Read	Read a readable item
Sneak Up	Sneak up on some NPC
Talk	Converse with an NPC
Wait At	Wait at some location for some events to happen

3.2 COMPONENTS OF A QUEST

Based on the components of a quest presented in the previous section, several key components of a *learning quest* (LQ; i.e., quests in an SRPG) were identified (Table 3.4). *Player action* consists of common RPG player actions that can be used to carry out tasks in a quest. *Initiator* defines the NPC who owns a quest, which players must interact with before a quest can be started. Quests involve players interacting with various *gameobjects* such as NPCs, props (e.g., furniture) and items (i.e., virtual objects that can be collected). *Rules* define requirements that players must meet for completing quests. Common rules include specific items to use, quota requirements (e.g., number of items to be collected), and time limit to complete tasks in a quest. During a quest, player, and computer-triggered actions (e.g., timer countdown) will trigger some form of *events* (e.g., talking to an NPC will start a conversational dialog or item given to players). The last component is *sub-tasks*, which refers to the tasks that players must perform during a quest. The LQ components presented served as the foundation for the SRPG design method proposed in this thesis, which will be presented in the next section.

Table 3.4. Structure of a Learning Quest.

Quest Component	
Player Action	Common RPG player actions (Table 3.3) associated with a task.
Initiator	The NPC that players need to interact with to start a quest.
Initial Gameobjects	Gameobjects that need to be created when a quest has started.
Rules	Requirements (i.e., items that must be used, number of items/enemies that must be gathered/defeated, and time limit), if any, to complete a task.
Events	Events (e.g., interacting with NPCs, etc.) that will be processed during a quest. When an event is triggered, actions set for the event will be executed (e.g., create dialog with NPCs, etc.).
Sub-Tasks	Append sub-tasks to a quest.

3.3 ARQS DESIGN METHOD

The proposed ARQS design method (Figure 3.1) was conceptualised by drawing on the components of RPG presented earlier in the chapter, and the concepts of IDP in existing SG design methods (Section 2.6.3). The relevant concepts presented earlier were identifying knowledge to be taught, designing the learning tasks, and integrating gameplay into the instructions. This section aims to address RQ 1C (i.e., *How can concepts of IDP be adapted in designing SRPG?*)

The proposed method consists of six general steps. Steps 1, 2 and 3 are tasks educators should be able to perform based on their experience in instructional design. The tasks involve identifying learning outcomes, authentic context and authentic activities. The first two steps correspond with *identifying the knowledge* to be integrated in an SRPG, while the third step with *designing the learning tasks*.

The third step corresponds to the well-established 4C/ID instructional design model (Van Merriënboer et al., 1992). The 4C/ID design model includes analysis of knowledge and design of tasks. The analysis of knowledge essentially involves identifying knowledge (i.e., concepts and facts) required to perform some skill and identifying required skills to be learned (e.g., procedural tasks). Data from the analysis

phase will then inform the design phase, which includes selecting appropriate activities that enable learners to acquire the pre-identified knowledge and skills.

Converting the authentic activities into RPG quests are done in Steps 4-6, which correspond with *integrating gameplay into the instructions*. Educators are provided with an RPG game pattern based on (Doran & Parberry, 2010) that is used as a library, in which learning tasks in the activities can be matched to RPG quest components. The game pattern consists of *Player Actions (PA)* and *Quest Pattern (QP)*. PA provides a list of common game actions players can perform in an RPG (Table 3.3), while the QP provides an extensive list of quest motivations, and their associated strategies, commonly found in RPGs (Table 3.2). The last step involves adding in all the gameobjects involved in a quest. This step is akin to setting up a scenario in a play, which includes identifying actors (game characters), props, items and locations. A Quest Design Document (QDD) is the output of the design process, containing the completed structure of an LQ. Table 3.5 shows the items that needs to be completed in the QDD. Further detail of using the design method is presented in Section 3.3.1.

Table 3.5. Components in a Quest Design Document.

Component	
Initiator	An NPC whom players must interact with to start the quest.
Actors	Other NPCs or enemies that players interact with in the quest.
Items	Items that players can interact with or required to use in the quest.
Props	Props that players can interact with in the quest.
Locations	Locations involved in the quest.
Rewards	Rewards that are given to players during the completion of the quest.
Tasks	Tasks that players can or must complete in the quest. Each task consists of rules that must be met to complete the task, events that are triggered, and actions that are executed within these events.

3.3.1 Designing an SRPG

In this section, a demonstration on designing an SRPG will be given as an example usage of the proposed design method. Table 3.6 shows the outcome for each step of

the design method when designing the example SRPG (Table 3.1). Designing an SRPG starts by identifying the learning outcome (Step 1). The next step involves identifying an overarching theme and student (i.e., player) role (Step 2).

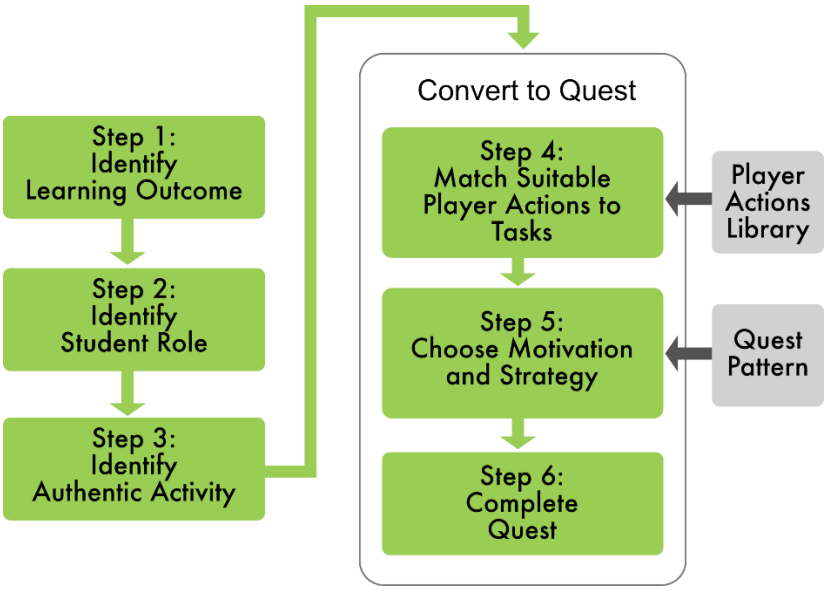


Figure 3.1. High-Level Conceptual Model of the SRPG Design Method

Learning activities to be represented as LQs must be authentic activities set in an authentic context (i.e., scenario) relevant to the knowledge or skills learners are expected to learn (Step 3), which forms as the basis for an LQ presented earlier (Section 3.2). The example activity (Table 3.6) relates to a specific knowledge on fire prevention[1], set in a scenario where players must inspect a house. Important tasks in the activity must then be matched to an appropriate PA (Step 4). The tasks in the example activity involves learners to check cooking appliances and make sure they are turned off. The associated player actions are to "fix" the cooking appliance (where "fix" in this context represents "turning off" the appliance), and "talk" to the house-owner, (where "talk" represents "reporting back" to the house-owner NPC).

A suitable quest motivation and strategy must then be selected from the QP (Step 5), by identifying motivations that contain the player actions identified in Step 4. Once the motivation and strategy have been selected, the quest can be completed by filling

[1] https://www.london-fire.gov.uk/schools/learning-at-home/fire-safety-education-at-home/

in the objects required by the selected motivation and strategy (Step 6). These objects are the *gameobjects* that players are expected to interact with in the quest.

Table 3.6. Design output of the Design Method.

		Quest Conversion		
Step 1 and 2 **Learning Outcome(s) and Player role**	**Step 3** **Authentic Activity**	**Step 4** **Match Activity Tasks to Player Actions**	**Step 5** **Choose Quest Motivation [and Strategy]**	**Step 6** **Complete Quest**
Students should know how to prevent fires from starting in homes. Student plays as a Fire Dept. Officer.	**Check**[*] all cooking appliances are **turned off** [*] after cooking.	1. **Fix**[**] (Turn off) cooking stove. 2. **Talk**** to Homeowner.	Protection: [Treating or repairing]	Initiator: Homeowner Player needs to: 1. Fix ("Turn Off") *Cooker*[+] 2. Talk ("Report") to *Homeowner*[+]

[*] Tasks in learning activity
[**] Player actions representing task
[+] Interactive game-objects

3.4 EVALUATING THE DESIGN METHOD: A FOCUS GROUP STUDY

Evaluating the design method with educators is crucial to ensure the suitability of the RPG game pattern and overall design workflow, which was achieved by conducting a focus group study. This method was deemed appropriate for the exploratory nature of the work where participants with different experience and expertise regarding SRPG could explore the prototype together, stimulating each other and sharing perceptions (Lazar et al., 2017). The study was aimed to address the following research questions:

- *What is educators' experience when using a design method that focuses on instructional design?* (RQ 2A)
- *Is using game patterns to represent instructional activities usable for educators?* (RQ 2B)

3.4.1 Study Protocol

Three groups of six educators were involved in the study (Table 3.7). Each focus group was allocated to one session lasting around 2 hours. Prior to the study, participants were given all the relevant documents, including a document containing the design method, quest pattern (Appendix A2), consent form, and participation information sheet. In each session, participants were asked to design a quest for a chosen topic of their domain using the design method. Participants were then asked to discuss their game design, opinions, and experience at the end of each step of the method. Video and audio recordings were made during every session. Participants were informed of this and were asked to sign the consent form at the start of a session.

3.4.2 Analysis Method

Thematic Analysis was performed on the data collected during the study, which included transcribed audio and video recordings, and the produced game designs. The data were coded in several cycles. Firstly, the first author coded the data to identify the initial codes and themes. A second coder then went through twenty percent of the data and coded it using the codebook drafted by the first author. The first author and second coder then discussed further on refining the codebook. Subsequently, a second round of coding was carried out by both the first author and second coder using the refined codebook. A high level of agreement between the two coders was reached with the interrater reliability (IRR) being Cohen's kappa = 0.9.

3.5 ANALYSIS OF THE FOCUS GROUP STUDY

Three main themes identified (Figure 3.2) are described in this section, where relevant quotes from participants (P) are cited to elaborate the themes. Table 3.8 shows the example quests produced by some of the participants to illustrate certain points during the analysis. Designs produced would include all necessary components of an SRPG (e.g., gameobjects, locations where scenarios would take place), which educators can use as input when completing the QDD.

Table 3.7. Focus Group Participants.

#	Focus Group	Participant ID	Academic Level Taught	Domain
1	1	P1	Undergraduate	Communication & Computer Networking
2		P2		Chemistry
3		P3		Professional Communication
4		P4		Computer Logics
5		P5		Internetwork Communications and Mobile Wireless Network
6		P6		Game Development
7	2	P7	Lower Secondary	English Language
8		P8		Chemistry
9		P9		History
10		P10		Computer Studies
11		P11		Mathematics
12		P12		Accounting
13	3	P13	Higher Secondary	Business Studies
14		P14		Mathematics
15		P15		General Paper
16		P16		History
17		P17		Biology

Table 3.8. Example of quests produced by participants.

Participant	Learning Outcome	Learning Activity	Player Role	Quest
P1	Cable a network according to a topology network.	Identify the correct network cables required according to the topology diagram.	Assistant Lab Technician at a company.	Players need to **explore*** a lab to look for the correct cables needed. They will **take*** the correct cable and **give*** it to the Lab Technician (NPC) for checking.
P3	To be able to see and explain the differences between the different reference system.	Analyse and demonstrate different reference system e.g., IEEE, APA	Tribe Leader	Players need to **gather*** APA referencing, and **exchange*** with other tribes (NPC) in order to complete the APA references.
P8	Identify correct starting materials; identify correct apparatus; and able to conduct the experiment.	Prepare insoluble salts.	Chemist at a lab.	Players need to **explore*** a lab and **take*** the required salt and reagents to create some insoluble salt. They then need to **explore*** the lab and **take*** the correct apparatus. Players will then **repair*** (carry out experiments) by doing the proper sequence of tasks.
P13	Identify suitable decisions to solve indicated problems in a case study; and to understand on the roles of their appointed tasks and the impacts from their decisions.	Come up with business decisions and objectives based on problem scenarios.	Manager of a franchise business.	Players need to investigate the current problem faced by the business, by talking (**listen***) to NPCs. Then they must explore possible solutions to address the problem. Player must then **repair*** (i.e., use a chosen solution) the problem.

3.5.1 Usefulness of the Method

Participants found the procedures in the design method were similar to their current approaches when designing non-game learning activities (*Familiar Process)*, and that it is useful in the aspects of designing *Authentic Activity* and *Beneficial End Product*.

Familiar Process. Several participants (N=5) felt that the design process was similar to how they normally design their instructions. Such familiarity could tap into educators' extant knowledge, enabling the transfer.

> *"I think most teacher, they have already done this in their teaching. It's just that they never like actually label it, like call it a 'strategy'" (P10)*

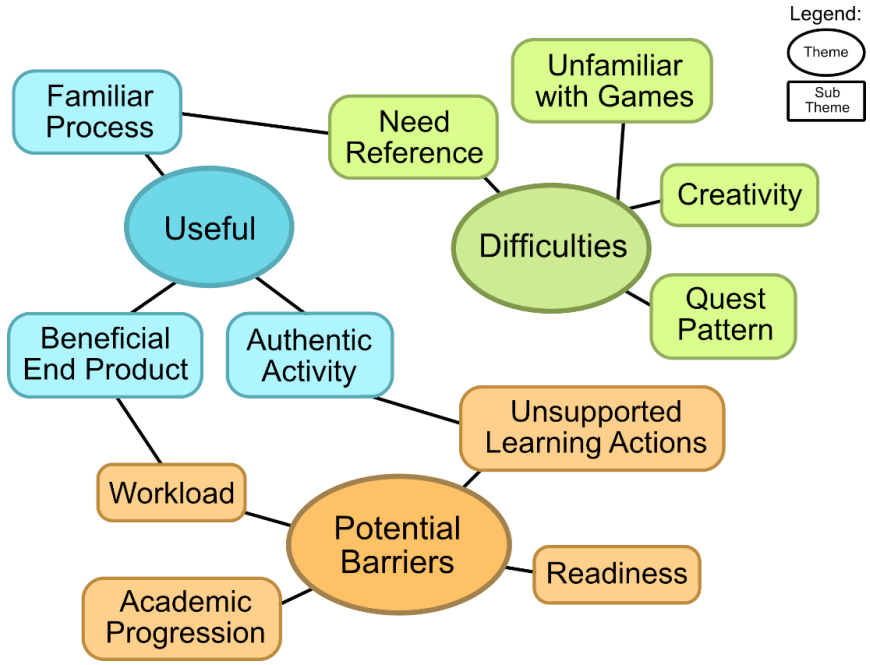


Figure 3.2. Thematic Map of Focus Group Study Analysis

Authentic Activity. Participants who used practical-based (e.g., chemistry) or case-study activities (e.g., business studies) found it easier to come up with authentic activity for their domain, suggesting the suitability of these type of domains with the design method (P1, P8 and P13 designs in Table 3.8).

> *"We use CISCO materials. Our activities are lab-based. We have everything ready (for the activity), the learning objectives and tasks. This is like a quest already. We can just come up and add a story to it." (P1)*

Beneficial End Product. Most participants (N=7) believed that SRPGs produced could be beneficial in the sense that it could improve students' motivation.

> *"It could be done for some topics. Not all. But good motivation, to increase students' interest in history" (P9)*

The advantage of simulating real-world environment was also mentioned by several participants.

> *"It's a really good substitute to carrying out real experiments that you can't do in the lab. You know, at least they get to see or feel how to do it" (P17)*

3.5.2 Difficulties Experienced by Educators

There were several general difficulties experienced by the participants, in particular their *Unfamiliarity with Games* and lack of *Creativity*. In terms of using the design method, participants noted on the importance of *Helpful References.* Participants also identified the unsuitability of the *Quest Pattern* component.

Unfamiliarity with Games. Several participants (N=5) were unfamiliar with RPGs and found some of the terms used in the method confusing. There were several instances where the participants did not understand the purpose of the quest motivation, the strategies and the player actions. One participant, P1, thought the quest motivation was intended for the players, rather than for the NPC offering the quest. Three participants also misunderstood the Player Actions. For example, P13 used the "*explore*" player action to mean "*explore various solutions to solve the problem*" rather than the actual meaning "*explore the game world*" (Table 3.8). Furthermore, two participants could not envision how the player action sequence would be portrayed in the game.

Creativity. Another significant difficulty experienced by participants was related to creativity. Three participants had a very hard time coming up with an authentic context for their topic. P3, for instance, believed that creativity would help educators come up with a learning quest, where she mentioned this fact numerous times during her session.

> *"To translate (my activity) into a scenario, I am having trouble with that. I'm not very creative here. It's quite a challenge, for domains*

without practical (activities). It's possible, but you really have to be really creative." (P3; See Table 3.8 for her quest design)

Helpful References. When designing the quest, several participants (N=4) emphasised the importance of helpful references (e.g., examples or manuals). As P2 noted "*It would be better to have a sample. It would help us more in designing the quest*". Several participants also had a better understanding of using the design method after listening to other participants' presentations of their quests. P7 said that "*Based on what the other teachers have shared, it kind of give me an idea on how to use it*".

Quest Pattern. Several participants (N=7) felt that the quest pattern (Appendix A2) contained too much information. P15 commented: "*it takes too much time to read*". Two participants also found it difficult to choose a suitable quest motivation and strategy, and ended up using their own player action sequence. P10 stated "*I am using my own quest strategy, because I didn't find anything that suits my needs, not in one specific strategy.*".

3.5.3 Potential Barriers

Several barriers towards the use of the design method were identified during the study, including: *Unsupported Learning Actions*, *Workload*, *Readiness*, and *Academic Progression*.

Unsupported Learning Actions. Two participants believed that quests would not be suited for certain hands-on experience or skills, or tasks involving complex tools.

"That brings me to my point of view as an engineer, you want it to be hands on using the real equipment. These pieces of equipment can give many errors (device intricacies). In this game, you just click, click." (P5)

Workload. All participants agreed that the effort that went into creating SRPGs was the most significant barrier, where they believed that their existing workload would make it hard to design a game.

"The only barrier I see, when teachers are actually asked to use the tool, to create the game, that might actually be the issue. Not just this, even making a presentation slide from scratch, takes a long-time. We have too much workload." (P10)

While P13 agreed that it would be a burden to create a game at the start, he could see how it is beneficial in the long run.

> *"It will be a big burden in the short term. Maybe for the long term, you can keep on recycling the games. Especially for other teachers or tutors to just use your games. So, it will be beneficial in the long term." (P13)*

Readiness. The aspect relating to readiness at the personal and institutional levels was also identified. The issue with the workload seems related to institutional support in terms of giving educators opportunities to improve teaching. Participants frequently associated the workload challenge to administrative priorities. As P1 commented: "*If we were given less administrative work, I would spend more time on this.*". Three participants emphasised that administrative tasks usually take precedence over other matters.

> *"Even if you give us a very easy authoring tool, we will still focus more on making the lesson plan look as good as possible. Because we are being graded based on that." (P10)*

Educators' perspective on using games to teach would also be an important barrier to overcome. Four participants stated that the use of SRPGs would only be applicable to lower academic levels.

Academic Progression. Two participants also emphasised that the quests should have clear consequences towards students' academic progression.

> *"It's fun (playing games), but you have to give me a specific reason and tie it to the school as why am I (the student) doing this, with my time. Give rewards somewhere. That they do this and it's helpful." (P15)*

3.6 DISCUSSION

For participants who used practical or case studies, they were able to convert their existing instructions into LQs by simply mapping tasks in their instructions to corresponding player actions. Their ability to relate their domains to real-world scenarios could be due to the specificity of their domain, with limited or obvious situations requiring specific procedures. Participants teaching mathematics on the other hand found it hard when designing their quest, which could be related to the

abstract tasks normally used in the domain. Adding real-world context to mathematical tasks is a complicated process (Gainsburg, 2008; Sullivan et al., 2003). Not all educators are proficient in designing instructions (Atkin & Black, 2003), as such it is not surprising that some of the participants struggled with designing authentic context (and activities) for the quests. Educators' creativity could be an important criterion when designing quests. While the mathematics teachers couldn't come up with authentic context, other participants were able to provide examples on their behalf. The ability to relate knowledge content with an authentic context is one indicator of creative educators (Horng et al., 2005). Several participants also showed ingenuity during the studies. P4, for example, realised that players could not "*program*" in the game, she thus designed her quest so that players would explore the game world looking for notes containing programming code and arranging them in the correct order to form the complete program. This activity would still align with her intended learning objective which is "to teach the concept of programming structure".

In the studies, several participants stated that they understood more on how to approach the design after listening to the descriptions of the quests created by fellow participants during the discussion. Some of the participants had limited prior knowledge or experience on RPG gameplay, and getting examples from more experienced participants helped them familiarise better with the gameplay and understand more about the method. Collaboration was noted to be a catalyst to improve creativity in educators (Horng et al., 2005). Designing quests through group collaborations could enable educators to use the design method more creatively and effectively, and could improve educators' knowledge and skills in using the design method (Kafyulilo et al., 2016).

Most participants did not find the quest pattern used in the method useful. Unfamiliarity with RPG gameplay and the extensive list of patterns could be the major reasons, but it could also indicate the unsuitability of entertainment-based quest structures. Several participants did come up with their own strategies based on the tasks they thought was important. It is clear that the participants could create their own sequence of player actions that resembles their learning task without referring to the quest pattern.

Several participants felt that the use of SRPGs would only be applicable for lower-level education, due to the use of LOTS normally found at this level i.e., remembering, understanding and applying. P6 also touched on the inability for quests to address certain skills such as fine-motor skill. It was anticipated from the conception of the design method that not all learning outcomes could be addressed. P5 understood this fact and stated that:

> *"It depends on the learning outcome. If it (the game design) can achieve that learning outcome, that should be enough. There are certain learning outcomes that cannot be achieved".*

Several studies have actually shown the applicability of RPG in higher level education (McConville et al., 2017). The important aspect of serious games are the game activities and how they align with the intended learning outcome (Wouters et al., 2013).

A key area that should be considered is to connect players' game progress to their academic progress. Rewarding players through game points has been shown to increase students' motivations in gameplay and could potentially improve the efficacy of serious games (Nagle et al., 2014). Aligning rewards with students' academic assessment could in principle further improve this aspect. To this end, an explicit step in the design method to grant rewards to players upon successful completion of quests is thus necessary.

The most important barrier identified by participants seems connected to the organisational support provided by the institution's educational system and management. While the idea of creating SRPGs is useful to most participants, opportunities for real-world implementation are difficult due to their existing workload, which reduces the time they could spend creating the games. Institutional-level priorities (e.g., a strict schedule for completing a syllabus) could impede exploration of new educational platforms (Rogers, 2000). The adoption of SGs in general can be improved if institutional changes are made that give educators opportunities to develop and use this technology as teaching and learning tools.

Possible initiatives to address the issues relating to creativity could involve training educators in the use of the design method, as well as encouraging team development efforts. This could perhaps improve their familiarity and efficiency in designing SRPGs.

3.7 SUMMARY

The intention of the focus group study was to explore educators' experience with the design method proposed in order to answer RQ2A (i.e., *What is educators' experience when using a design method that focuses on instructional design?*). From the findings, educators find the concept of the design method similar to their existing instructional design approaches and mostly suitable for simulating procedural knowledge activities. Challenges experienced by educators mostly relate to factors not within the control of the design method such as existing educator workload, readiness and creativity.

With regard to answering RQ 2B (i.e., *Is using game patterns to represent instructional activities usable for educators?*), the general use of common game player actions to represent learning task was found acceptable for certain learning tasks. Other complex tasks (e.g., fine motor skills), however, could not be replicated. The use of entertainment-based Quest Pattern, on the other hand, seems unsuitable for educators. Most participants struggled to identify suitable motivations and strategies for their quests, with a few of them preferred creating their own quest strategies.

Another design task that needs to be considered is defining students' rewards in completing a quest, such as granting players skills or experience points to recognise their performance during gameplay. Scaffolding is another important component for learning in general, specifically AL (Section 2.5). While this can already be incorporated using SRPG components (e.g., dialog with NPC), there are no explicit steps in the design method to include this aspect, which needs to be included in the next iteration of the design method. The design method was revised by taking into considerations these points (Figure 3.3). The revised design method was used in a case study (Chapter 4), where two lecturers spent more time with the design method.

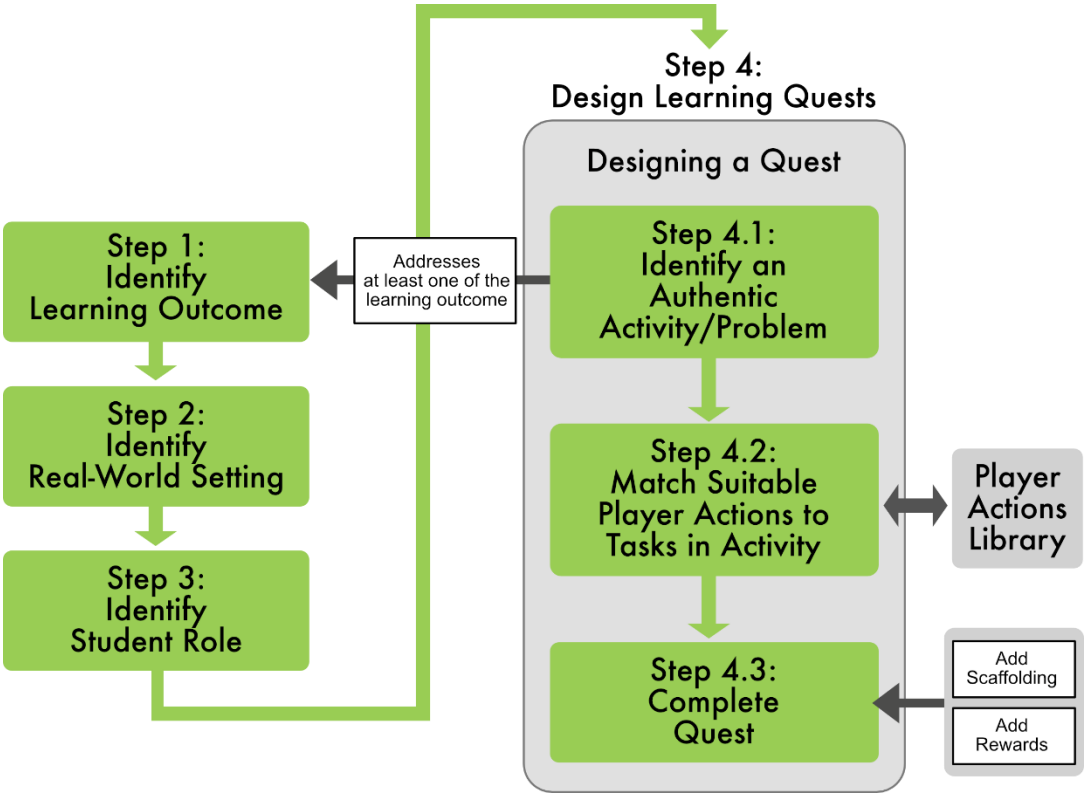


Figure 3.3. Overview of the Revised SRPG Design Method

CHAPTER 4

USING THE DESIGN METHOD: A CASE STUDY

The focus group study presented in Chapter 3 showed the general suitability of the proposed design method in which most of the initial process was applicable to educators' existing instructional design techniques, which were then integrated into the revised design method.

This chapter presents a case study where two lecturers designed two SRPGs each for their specialised domain. A case study is typically carried out to investigate a particular unit of interest (e.g., a person or a group) from a defined target population, in order to explore certain phenomenon (Gerring, 2004; Heale & Twycross, 2018). The case study presented here aims to identify whether educators can design SRPGs using the proposed design method. The study methodology is described first, followed by presenting the data regarding the games designed by the participants and their experience with the design process, before concluding the chapter.

4.1 STUDY METHODOLOGY

A case study methodology was adopted to explore how educators would use the proposed design method in designing SRPGs as teaching and learning tools. The case study aims to address RQ 2C (i.e., *Can a design method that focuses on instructional design guide educators in designing SRPG?*).

In this section, the study protocol is discussed first, including participants' tasks and the data collected during the study. This is followed by elaborating participant

selection criteria and subject domains. Finally, circumventing the complications encountered during the study is also discussed.

4.1.1 Study Protocol

In the study, each participant was given three weeks to design two SRPGs based on their specialised subject domain. Figure 4.1 shows the overview of the tasks performed by the author and participants during the case study.

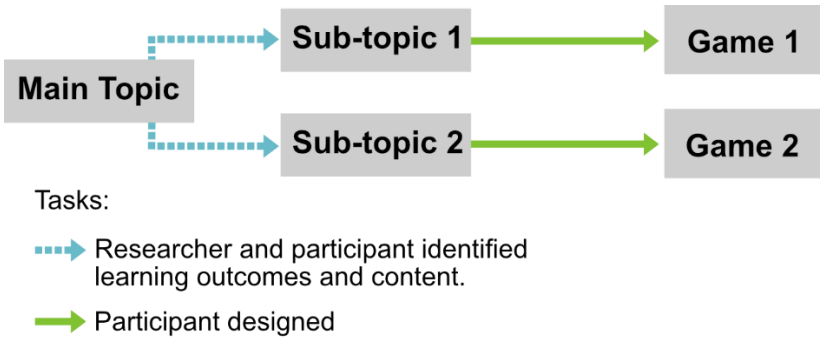


Figure 4.1. Participants' tasks in the case study.

4.1.2 Participants Task

Each participant was required to produce two SRPGs at the end of the study. Each of these games covered one sub-topic based on one main topic from the participants' specialised domain, with each game containing five quests (i.e., learning problems) to address the specific learning outcomes and content related to each of the sub-topics. The topics were predetermined by the author upon discussion with the participants. Once the two sub-topics for each subject domain were decided, the learning outcomes and content were identified and converted into lecture notes and learning activities. The participants were then expected to design the SRPGs based on this material. Throughout the study, each participant was expected to spend six hours in total (i.e., two hours a week) on designing the SRPGs.

4.1.3 Materials

At the start of the study, each participant was given a design method document, a game sheet form, and a quest design form. The *design method document* contains the list of detailed steps to be taken to design an SRPG. The steps correspond to the

revised design method presented in previous chapter (Figure 3.3). The *game sheet form* is a document used by participants to fill in information (i.e., lesson description, learning outcomes, real-world setting and player character) about the SRPGs they are expected to design. This corresponds to steps 1-3 in the design method (Figure 3.3). The *quest design* form is a document used by participants to fill in information about a quest that is to be included in a game. The form contains sections that correspond to step 4 in the design method (Figure 3.3).

4.1.4 Data Analysis Procedure

At the end of the study, each participant was then interviewed to investigate their overall experience in the design of the games using the proposed platform. Thematic analysis was applied in the data analysis phase, where the transcribed interview audio recordings, along with the game designs were used.

4.2 PARTICIPANTS

The initial plan for this study during the earlier stage of the research was to recruit two university lecturers and two secondary school teachers. However, considering the difficulties experienced in a previous study (i.e., a complicated process with the relevant authorities and difficulty in recruiting voluntary teacher participants) and the limited time available for the research, it was decided to involve only two lecturers for this case study, one from a technical subject domain and another from a non-technical subject domain. The selection of these subject domains was to investigate any contrasting experience between two different sets of domain areas and educators' technical expertise and experience.

Several lecturers from the Computing and Informatics, Business, and Engineering faculties at UTB were approached several months before the study. Only two female lecturers (from here on identified as L1 and L2), both from the "Computing and Informatics" faculty, agreed to volunteer.

L1 was teaching the subject "Digital Art and Design" (identified as *DigiArt*) and L2 was teaching "Information Security Fundamentals" (identified as *InfoSec*). L1 has been teaching as a lecturer for nine years, specialising in graphic design. L2 has been teaching as a lecturer for around twenty years, specialising in network security. Both

participants had no prior experience in creating games. Both participants were not involved in the previous focus group studies (Section 3.4).

4.3 REVISED PROTOCOL

There were several complications encountered during the study. Both participants were involved in some unavoidable administrative duties during the time of the study and was noted by both of them as a distraction towards the full engagement with the study. Furthermore, participant L1 was in the third trimester of her pregnancy. Due to the limited time that could be allocated for this case study, and difficulties in recruiting other lecturer participants who would be willing to voluntarily participate, the study protocol was revised to reduce the tasks required of the two participants.

In the revised protocol, participants were given one week to devise ten case-study-based or real-world learning scenarios (i.e., five scenarios for each sub-topic) addressing the learning outcomes identified for their specific topics. During this time, L2 was able to produce ten learning problem scenarios for the sub-topics "Malware" and "Basic Network Security" (Section 4.4.2), while L1 was only able to produce 5 scenarios for the sub-topic "Copyright and Design" (Section 4.4.1). The author came up with the missing 5 scenarios for L1's second sub-topic (Table 4.1). These new five scenarios were designed based on L1's scenarios to keep the scenarios comparable (i.e., sharing the same structure but different content). L1 was presented with the new scenarios and agreed to its suitability in terms of the content and learning outcome of the sub-topic (Table 4.1).

Each participant then had a face-to-face working session with the author and spent around one and a half hours converting the scenarios into learning quests using the design method. During the sessions, the author introduced the design method and guided the participants to convert one scenario into a learning quest as an introductory activity, which was followed by the participants converting the remaining scenarios with minimal guidance. At the end of the session, both participants did not complete converting all of their scenarios and continued with the conversion in their own time. LQs produced by the participants also received minimal modifications by the author, upon discussion and approval from the participants. The modifications generally

included small changes such as NPCs' names and roles, and locations where events in the scenario took place.

4.4 SUBJECT DOMAINS

As described above, the domains taught by the two participants were "Digital Art and Design" and "Information Security Fundamentals". Further descriptions of these subjects are presented below, along with a description on their respective learning outcomes and content used in this case-study.

4.4.1 Digital Art and Design

This subject is undertaken by students from the "Creative Computing" undergraduate programme during their third semester. It covers various aspects in the creation of digital art, such as the principles of graphic design and the use of digital tools for the creation of digital graphics. The learning activities in the subject mostly involve the creation of visual-based products (e.g., posters) through the use of specialised tools, and would not be suitable to be replicated in an RPG. One aspect in the subject however relates to Intellectual Property (IP), which focuses on the knowledge pertaining to the fair use and protection of various creative products. Both the author and L1 decided that this was a suitable topic to be used in the study. This topic was broken down into two sub-topics, "Copyrights and Design" and "Trademark and Patent".

Both sub-topics share the same learning outcomes, where students should be able to: 1) identify an innovation's potential IP, and 2) advise on the appropriate actions to protect the IP. The "Copyrights and Design" sub-topic covers the concepts of copyrights and design IPs, while the "Trademark and Patent" covers the concepts of Trademark and Patent IPs. A list of learning objectives from the topic was also identified. These objectives were identified by both the author and participant L1 in order to narrow down the content that was to be learned from the game and guide the participants in terms of planning the real-world scenarios for the games. Table 4.1 shows the learning objectives for this domain.

4.4.2 Information Security Fundamentals

This subject is undertaken by students from various undergraduate programmes (i.e., in Computer and Information System, Computer Network Security, and Creative Computing) during their first semester. It covers the introductory basics on computer network and security, where students are taught on the various security threats within a computer network such as viruses and phishing, and security measures for improving the integrity of network infrastructures such as user awareness and the use of hardware/software security tools (e.g., firewalls). The author and L2 decided the sub-topics "Malware" and "Basic Network Security", under the main topic "Introduction to Cyber Security", were suitable to be used in the study.

Table 4.1. Learning objectives for the domains in the case-study.

Domain	**Learning Objectives**	
	Game 1	**Game 2**
Digital Art and Design (DigiArt)	Explain copyright.	Explain trademark.
	Identify what can be copyrighted and how to apply copyrights.	Identify the benefits of trademark.
	Explain the benefits of copyrighting.	Explain patent
	Explain actions to be taken for copyright infringement.	Explain non-disclosure agreement (NDA).
	Explain how to protect a product design.	Identify the benefits of patent.
Information Security Fundamentals (InfoSec)	Identify how malware can infect computers.	Explain Firewall.
	Explain phishing emails and its impact.	Explain the use of a network firewall.
	Identify how vulnerabilities can be addressed.	Explain Virtual Private Network (VPN).
	Identify the effects of malware regarding stolen information.	Explain the purpose of regularly updating software.
	Explain ransomware and associated actions when dealing with it.	Explain Intrusion detection system (IDS).

Both sub-topics share the same learning outcomes, where students should be able to: 1) analyse potential cyber-attack vulnerabilities in an organisation, and 2) advise on the appropriate measures to improve an organisation cyber security. The "Malware" sub-topic covers these learning outcomes in the aspects of malware, how it can affect an organisation, and how to prevent an organisation from being affected by malware in terms of user awareness. The "Cyber Security" sub-topic, on the other hand, addresses these learning outcomes by focusing on the technical hardware and software aspects for improving a network infrastructure. Specific learning objectives for this domain was also identified by the author and participant L2 (Table 4.1).

4.5 RESULTS

Results of the data analysis are presented in this section with two separate analyses: game designs and educators' experience. The game designs produced by participants are discussed by looking into the overarching theme of the games and their gameplay. Educators' experience was gathered by analysing the interview data and are discussed in terms of their experience designing the real-world scenarios and converting these scenarios into learning quests.

4.5.1 Game Designs

The general goal of analysing the game designs is to identify the type of games educators can produce in relation to their specialised domain. The theme settings for the participants' games are presented, followed by their gameplay.

Games' Theme Settings

The games designed by participant L1 assign players as a Junior IP Lawyer working in an IP Advisory office. The central premise of the game requires players to address various IP-related issues in terms of giving legal advice to clients coming into the advisory office. The issues presented to the players reflect the concepts found in the IP lecture notes identified earlier. This includes scenarios relating to copyrights, protecting designs, trademarks, and patent.

The games designed by participant L2 assign players as an Information Technology (IT) officer working in a clinic. The main task of players in the game revolves around

managing the clinic's IT operations. In the context of L2's domain and the learning outcomes of the topics used within the case study, the game requires students to ensure that the devices and network infrastructure within the clinic is safe and secure. The scenarios in the games reflect the concepts found in the Cyber Security lecture notes identified earlier, which include scenarios relating to malware and its prevention, and improving the security of the network and devices in the clinic through the use of network security hardware and software.

Gameplay

Table 4.2 shows the summary of player tasks and quest objectives identified in the participants' quest designs. The objectives of L1's quests generally involve providing advice to NPCs on various IP-related queries and protecting NPC's IPs, which can be accomplished mostly through making conversations with NPCs (Table 4.2). In one of her quests for example, a musician NPC comes to the IP advisory office asking for advice on copyrights. In this quest, the NPC asks player a series of questions about what a copyright is and what can be copyrighted, and how to protect his music with regards to copyrighting it. Players must then select the most appropriate responses. Selecting the correct response results in players receiving rewards (skill or attribute points), while selecting the wrong response results in a feedback message given to the platers. This feedback message aims to provide supportive feedback to the players, which they can then use as a hint to successfully complete the quest.

Quests by L2, on the other hand, were varied in terms of the objectives and the tasks players need to perform (Table 4.2). Her quests also involve the use of conversations similar to L1's quests, where players must select the appropriate response to questions or dialogues posed by NPCs. Furthermore, L2's quests also employ other form of tasks such as interacting with objects (e.g., fixing, installing) and carrying out an investigation (e.g., examining an object to find clues). Selecting the correct response in conversations and performing the correct non-conversational actions (e.g., installing the correct hardware) result in players receiving point rewards, while incorrect answers or actions result in feedback messages provided to players as supportive feedback.

Table 4.2. Player tasks and quest objectives in participants' games.

Domain	Player Tasks	Quest Objectives
DigiArt	Talk to NPC; Answering MCQs; Find an item; Get an Item; Give an Item	Giving advice; Protecting a client
InfoSec	Talk to NPC; Answering MCQs; Find an item; Get an Item; Give an Item; Find an NPC; Examine an object; Install a device; Fix/Configure a device; Use a device;	Giving advice; Solving a problem; Fixing a problem; Investigate a problem; Protecting the organisation

One of L2's quests for example involves an activity to teach the concept of "VPN" (Virtual Private Network). In this quest, a doctor at the clinic is attending a conference and wants to connect to the system at the clinic to do some work while he is away. Players then engage in a conversation with the IT department supervisor, who asks for players' opinion on the best approach to do this while ensuring the security of their system. This requires players to select "VPN" as a response. Players then need to implement a VPN by installing a VPN server on the clinic's server machine and a VPN client on the doctor's personal laptop in order to ensure safe connection to the system. To perform this activity correctly, players must first find a VPN hardware server from the IT office room and install it on the server machine in the server room, and then going to the doctor's house and interact with his laptop to download and install the VPN client and connect it to the VPN server.

4.5.2 Educators' Experience

During the interview, several key themes were identified that can describe educators' experience during the creation of the scenarios used as the basis of the quests, and the conversion of these scenarios into learning quests using the design method.

Experience in Using Real-World Scenarios as Instructions

The first step in designing a learning quest is identifying a real-world scenario that can reflect the issues pertaining to a particular concept that is to be learned by students in the game. L1 had difficulty in coming up with case-study scenarios relating to the main topic of IP. She identified that the main reason was due to her difficulty in visualising the whole narrative of a scenario that would be acted out in the game.

> *"I have problem with creating the scenarios because it's something I've never developed and experienced, creating games. So, to come*

> *up with the narratives for the games and to expand your creative side to that extent is a bit difficult for me.*
>
> *I can come up with the general scenarios, but then to expand that further requires a longer period of time to come up with suitable narratives that could actually fit the storyline. Because I am a visual person. I need to visualise first the whole scenario so that I can understand how the scenario can fit with the learning content."* (L1).

One of the possible reasons for her difficulty could relate to the nature of the instructional activities she typically employs in her subject, which is mostly focusing on the techniques and tools for the creation of visual assets. She had never used real-world scenarios as activities.

> *"Most of the time, the work in my class relates to real-life issues. Like current issues, for example, child abuse. I ask the students to create a poster based on this topic. To see if they can design something related to the topic. Sort of like a problem-solving technique, where they need to come up with something suitable with the theme."* (L1)

Another reason might be due to her lack of mastery with the topic IP. The major component of her subject was in the technical aspects of creating digital art. The IP topic used in this study was a short one lesson topic from her lessons, introducing students regarding intellectual property.

L2 on the other hand has used real-world scenarios in her current learning instructions, as she stated, "*I've created something like this for exam questions and tutorials. Not similar to the ones I've created for this game, but it has the same feel.*". She was able to describe her scenarios in terms of what is happening (i.e., problems, events and actors involved) and what students need to do (i.e., actions). This is perhaps due to the procedural knowledge implicit within the concept in her topic "Cyber security", such as the procedures of diagnosing issues, identifying vulnerabilities, identifying security approaches, and implementing the approaches.

Both participants felt that designing the real-world scenarios were actually the most complicated aspect in the whole SRPG creation process. L1 stated that extensive time would be needed when coming up with the scenarios, especially in terms of designing the narratives within the scenarios.

> *"Creating the storyline takes time. So, one would need to think about how to unfold the story. The problem here is just coming up with the*

storyline. Whether or not you are asking the right questions because you have to ensure it's the right things to ask, so it would actually lead to the learning outcomes." (L1)

Easy to Convert Scenarios into Learning Quests

Both participants found the use of the design method to convert scenarios into learning quests easy to perform, where they felt the structured guideline presented in the design method was easily understood and managed. They also felt that matching the learning tasks in a scenario to suitable game player actions was easy and could be matched to a suitable player action.

"Converting the storyline was easy. Because I just have to select the game elements. That's like straightforward. Because the game elements are predefined, I can tailor it accordingly to what I need. To make it suitable to the learning task". (L1)

L2 also commented that the design method actually helped her in better visualising the scenarios within the context of a game. According to her, she was able to visualise how the scenarios would unfold in the game in terms of the narratives, and NPC's and player's actions.

"Coming up with the scenario was a bit hard because, I cannot see it as a game. After this designing quest activity, in my head I am seeing a movie now. But when I started with the scenario, I couldn't picture it as a game. When creating the tasks in the quests, I could see now where everything is in place. Yeah. So, when we run this process, it started me to think like 'ok, this is how I want to stage it'." (L2)

L2 also felt that she could easily come up with real-world scenarios by taking cue from the design method and adopting its steps. According to her, the structured guideline, specifically through structuring tasks in a quest and identifying actors and game objects involved, helped her visualise the scenario.

"I think it'll be easier now to come up with the scenarios. Because, the thing here is you have a set of things to guide us in doing the quest itself. So then, at the end of the day, when we understand this, then we know how to, for me, I feel that it is easier to do the scenario. Because then you can see already where to place everything." (L2)

Both participants quickly improved their understanding with the design method after converting their first scenario. L2 in particular noted that understanding the capabilities of the design method in terms of the tasks and what player actions could

be used helped improve the ease of creating scenarios. She also commented that practice would be required in order to get used to the design method.

> *"Yay. I get better after the first one. I am in tuned to it already. And then in my head I was feeling like, 'ok I need to think if I need MCQs, or just use a dialog'. That sort of thing. We actually need some training so we can get used to it.".* (L2)

One aspect both participants found time consuming was creating the dialogues script used in conversations with NPCs. As L1 stated, "*It's a bit tedious. Trying to come up with the dialogues, it takes time. I guess, because it's not my area.*".

4.6 DISCUSSION

In this section, I first discuss the games designed by the participants in order to address the research question RQ 2C (i.e., *Can a design method that focuses on instructional design guide educators in designing SRPG*). This is then followed by discussing their experience during the design phase to address the research question RQ 2A (i.e., *What is educators' experience when using a design method that focuses on instructional design?*).

4.6.1 Gameplay Designed by Educators

Several different types of gameplay activities were identified in the games designed by the participants (Table 4.2), which can be related to common RPG quest motivations (Table 3.2; Doran & Parberry, 2010).

Complexity of the Quests

Table 4.3 shows the use of common RPG tasks (Doran & Parberry, 2011) found in the educator games. Quests by L1 are limited in terms of the player actions used, and most of the implemented actions relate to getting and giving information. L2 on the other hand utilised more player actions for her quests compared to L1 and were varied in their nature (e.g., getting and giving information, fixing, exploring, finding objects). Some of the tasks, such as capture, defend, damage, are commonly found in combat-based games, which might not be relevant for most educational domains.

Quests by L1 are also limited to some common RPG quest motivations that relate to gaining knowledge and protection in which the objectives of her quests are mostly on providing advice. Her quests mostly only employed conversational tasks which involve answering questions posed by various NPCs relating to IP issues, essentially reflecting typical MCQs in non-game based instructional activities. Quests by L2 are richer in terms of the RPG quest motivations and player tasks. Her quests can be related to various motivations such as gaining knowledge, comfort, protection, ability, and equipment. Achieving these objectives also requires players to perform various player actions, thus creating rich gameplay activity. In her example quest presented in the previous section, players need to converse with NPCs to identify problems and propose a solution and implement the solution by exploring the game world, looking for particular objects (e.g., laptop) and configuring objects (e.g., installing software in a laptop).

Table 4.3. Common RPG player actions used in the educator-designed games.

Common Player Actions	**Action Description**	**Implementation in game design**	
		DigiArt Game	**InfoSec Game**
Capture	Catch someone as a prisoner.	-	-
Damage	Damage someone or prop.	-	-
Defend	Defend somebody or something from being damaged.	-	-
Escort	Bring someone to someplace.	-	-
Exchange	Exchange items with someone.	-	-
Experiment	Use something to find out what it does.	-	✓ Example: player can try using different types of firewall on a server to find out their uses.
Explore	Explore somewhere.	-	✓ Example: player has to find a shop to buy some required items.

Common Player Actions	**Action Description**	**Implementation in game design**	
		DigiArt Game	**InfoSec Game**
Examine	Get some information by examining something.	-	✓ Example: player has to examine a computer to diagnose a problem.
Gather	Take and collect some items.	-	-
Give	Give some item to someone.	✓ Example: player has to give an application form to a client.	✓ Example: player has to
Go to	Go to someone or somewhere.	✓ Example: player has to go to a character.	✓ Example: player has to find a character.
Kill	Destroy someone.	-	-
Listen	Interact with someone to get information.	✓ Example: player has to interact with a character to find out his query relating to IP.	✓ Example: player has to interact with a character to identify the cause of a problem.
Read	Read something (readable item e.g., books) to get information.	-	-
Repair	Turn something into a desirable state.	-	✓ Example: player has to configure a firewall.
Report	Give NPC some information	✓ Example: player has to tell client what can be done to protect their designs.	✓ Example: player has to tell their supervisor what needs to be done to solve some problem.
Spy	Get information by spying on someone.	-	-
Stealth	Sneak up on someone.	-	-
Take	Take something from someone or somewhere.	✓ Example. Player has to take an application form from the office.	✓ Example: player has to take a new hard disk from the store room.

Common Player Actions	Action Description	Implementation in game design	
		DigiArt Game	InfoSec Game
Use	Use something that affects someone or the environment.	-	✓ Example: player has to use a new hard disk on a computer.

Game Patterns used in the Quests

Gameplay identified in the participants' games can be associated to established game patterns proposed in the literature (Marne et al., 2012). Some of these patterns were found in the participants' games and are presented in Table 4.4.

Instructive Interaction. The conversational tasks used in L1's and L2's quests relate to the "questions-answers" game pattern, which is the most basic form of interactions and typically used in quiz-based SGs. The context to which this pattern is used can also relate to the "teachable agent" pattern, which relates to imparting learning content to NPCs. Both L1's and L2's quests involve players advising or providing correct solutions to a problem faced by NPCs.

Table 4.4. Established game patterns found in the participants' games.

Category	Aspect	Game Pattern*	Implementation in Participants' Quests
Instructive Interaction	Learning	Question-Answers	Conversations with NPCs
		Teachable Agent	Conversations with NPCs
		New Perspectives	Acting a pre-defined authentic role
		In Situ Interaction	Solving real-world authentic tasks
		Quick Feedback	Pop-up messages
Reflection		Debriefing	Conversations with NPCs; Pop-up message
Progression/ Motivation		Reified Knowledge	Skills/Attribute point rewards
	Fun	Fantasy Worlds	Simulated real-world environment

* Game patterns by Marne et al. (2012).

The gameplay in L1's and L2's games also put players in an authentic role relating to their specific domains, which relate to the "New Perspectives" pattern. This pattern

concerns with providing players with an outlet to play and appreciate a domain from different points of views. L2's quests also incorporate "In Situ Interaction" pattern, which relates to placing players in a realistic situation which can exemplify a concept. This is evident in L2's quests, where players are continuously engaged in simulated real-world situations relating to issues on cyber security. Due to the rich gameplay afforded in L2's quests, "quick feedback" pattern is also used, which relates to the use of short and useful information to guide players. For example, the VPN quest in L2's game uses pop-up messages to inform players on what to do, such as a message that says "Get a VPN hardware device from the storeroom" to inform players that they need to get a VPN device in order to set up a VPN in the clinic.

Reflection. Both participants' quests also incorporate the "Debriefing" pattern as a way for players to reflect on their actions, especially after incorrect ones. This is implemented in their games through the use of pop-up messages or dialog interventions from the NPCs. In L2's VPN quest, if player chooses a different response other than "VPN", the IT supervisor responds with a dialogue that provides a hint to player on the suitability of VPN within this quest.

Progression/Motivation. "Reified knowledge" pattern is consistently used in both L1's and L2's games. This pattern relates to giving rewards in order to help players become aware of the knowledge or skills they have acquired, which can be used for players to track their progress through the games. For example, players receive skills points associated to the problems in the domain of IP such as "Intellectual Property Mastery" skills, in relation to their ability to giving correct IP-related advice to NPCs. This reward can also contribute to the motivational aspect of the games. Another pattern implicit in the participants' games is the "fantasy world" pattern, which is related to the use of a fictional simulated world in order to provide a fun context within a game to motivate players.

4.6.2 Conditions to Ease Educators in Using the Design Method

Several factors were identified during the case study, and it resonates with certain findings from existing literature and the earlier focus group study (Section 3.6).

Knowledge and Skills in using Real-World Scenarios.

The first condition necessary for the use of the design method is knowledge and skills in creating real-world scenarios. Similar to the finding in the earlier focus group study, educators who typically use real-world scenarios in their teaching find it easier to come up with scenarios. L2 was able to come up with various scenarios due to her experience devising such scenarios for her exams and tutorial activities in her subject. The use of real-world or problem-based scenarios is quite common in the domain of computer networking (Prvan & OžEGOVIć, 2020). In contrast, L1 found this aspect difficult and was only able to come up with five scenarios during the case study. Although real-world scenarios can also be used in the domain of IP[1], L1 had never used it extensively in her instructional activities beyond using story problems in exam questions. While she stated that she was able to come up with the general scenarios, expanding it by adding detailed narratives was the difficult aspect. This difficulty can be attributed to two reasons. Firstly, it could relate to the suitability of learning activities as quests in RPG. L1's quest for instance mostly relates to activities that could perhaps be more suited to be incorporated in other genre such as puzzle games.

Secondly, not all educators are able to design real-world scenarios as their instructions (Lee, 2012; So & Kim, 2009), and, as postulated earlier, can be related to their creativity (Horng et al., 2005). The differing capabilities in creating scenarios possessed by both of the participants exemplify that different educators face different difficulties in design instructions (Masterman, 2019). Another possible reason relates to the experience of educators, where experienced educators are more capable of generating and using various ways to represent learning concepts (Freitas et al., 2004).

Exposure to the Design Process.

The inability to visualise the scenario as a whole is one of the recurrent challenges faced by L1, specifically in the context of re-enacting the scenario as a play involving actors and narratives. The use of the design method helped the participants in being able to visualise the scenarios within the context of an SRPG. By understanding the components of an LQ (e.g., structuring the tasks, identifying gameobjects involved,

[1] https://www.ipo.gov.uk/ip-support

player actions available.), L2 felt that it could help in coming up with future scenarios since she knew what to expect and what was required in terms of identifying the necessary components. The participants were only introduced and exposed to the design method within a short amount of time, which could have overwhelmed the participants during the case study. Introducing and exposing educators with the various components in the design method gradually could further improve its use, allowing educators to get attuned in designing the scenarios and consequently the learning quests.

Training educators is another obvious condition necessary in order to introduce and expose educators with the creation process of the proposed design method. Both participants' experience in converting the scenarios into LQs using the design method considerably improved after converting their first scenario upon guidance by the author. They were also able to appreciate the structured guideline provided by the design method, in which they found the conversion process manageable and easier compared to planning the real-world scenarios beforehand.

Creativity and Knowledge Expertise.

Both participants identified the need to be creative in addressing certain aspects of LQs which required extensive planning. Creativity is important not just in designing the gaming aspect, but also in designing learning instructions (Masterman, 2019). L1 specifically identified the significance of creativity in terms of designing the scenario and expanding it into a story with narratives and planning the conversation dialogues. Indeed, these aspects would require some time, creativity, and effort in its planning. L2 was able to devise a scenario better than L1 regarding the ability to visualise the scenario and expand it into narratives and events. She also resorted to using simple and short textual content and dialogues. This attribute can be associated to experienced educators, who are more adept than inexperienced educators at using various ways to represent concepts, and using simple explanations to help guide students towards grasping important concepts (Freitas et al., 2004).

Adequate level of "*Content Knowledge*" (CK) and "*Pedagogical Content Knowledge*" (PCK) in educators are essential for being able to design real-world scenarios to teach a learning concept (Chick & Pierce, 2008). CK relates to educators' deep understanding of a topic, while PCK relates to educators' knowledge in teaching

strategies related to the topic (Kleickmann et al., 2013). Significant expertise in CK and PCK enables educators to identify the suitability and affordances of real-world scenarios for students learning, and identify ways to incorporate the examples in their teaching and learning activities (Chick & Pierce, 2008). L1's difficulty in identifying scenarios could be due to her lack of CK and PCK in the topic of IP, since it only forms a small aspect of her subject.

Dependent on the Learning Content.

Creating the scenarios can also depend on the type of knowledge of a particular domain. The nature of a domain's content can affect the types of activities the respective educators employ in their teaching (Masterman, 2019). L1's topic mostly concerns declarative knowledge, which is the type of knowledge that relates to knowing facts, concepts and principles (De Jong & Ferguson-Hessler, 1996). In L1's topic, typical learning activities mostly involve identifying the IP related problem and recalling facts on the different types of IPs. L2's topic on the other hand involves activities that contain the type of knowledge that is beyond simply knowing facts. The activities in L2's topic require students to be able to identify and diagnose problems, recall facts on cybersecurity, choose an appropriate solution and implement the solution. This relates to procedural knowledge, which involves students making use of facts as well as performing actions or manipulations within the instructions (De Jong & Ferguson-Hessler, 1996).

4.7 SUMMARY

The aim of the case study is to identify whether educators can design SRPGs using the design method. Findings from the case study answered RQ 2C (i.e., *Can a design method that focuses on instructional design guide educators in designing SRPG?*). The participants found it easy regarding the process in converting relevant real-world scenarios into learning quests. They appreciated the structured guideline provided by the proposed design method. Understanding the process also helped improve their ability to visualise a scenario in the context of an RPG.

Educators were also able to design SRPGs with gameplay typically found in existing entertainment-based RPGs. This is exemplified by the games produced by one of the

participants. Her games incorporated various common quest challenges and rich sequences of player actions typically found in existing RPGs. Various SG-specific game patterns were also implemented in her games. This, however, relates to the complexity and detailed planning of the real-world scenarios devised by the participants at the start of the quest creation process.

The difficult part in the whole design process was in identifying and planning the relevant real-world scenarios that can help address the intended learned concept. Prior knowledge and skills in creating real-world scenarios is implicit in the use of the proposed creation platform and is found to be a crucial attribute that educators should possess in order to be able to effectively engage with the proposed platform. Apart from experience with using and creating real-world scenarios as a teaching and learning approach, educators' creativity, the type of learning content of a domain, and educators' CK and PCK also seems to play an important part. Learning activities that lack suitable real-world scenarios will not be able to fully take advantage of the RPG genre. This is exemplified by the games produced by L1, where quests in her game would be more suited in mini-games incorporating quiz-based gameplay.

CHAPTER 5

DEVELOPING AND EVALUATING THE AUTHORING TOOL: METHODOLOGY AND OUTPUT

As mentioned in Chapter 2 (Section 2.6.4), developing SGs involve various experts and tools (Figure 2.4). Few SG authoring tools have been proposed in the literature that aim to simplify the development process (Section 2.6.4), particularly focusing on reducing the complexity in programming gameplay. An educator-oriented authoring tool would require further simplification not just on the programming component, but the other game components as well, such as graphics creation. Together with the features of existing SG authoring tools, common features of other form of educational-technology authoring tools were also reviewed to identify suitable mechanisms that can be incorporated in an educator-oriented SRPG authoring tool (Section 2.6.5).

This resulted in the identification of using simple visual editors for the creation of game graphics (e.g., characters and game world), and BBP as the mechanism to program gameplay. These mechanisms were aligned with the process of the SRPG design method proposed (Chapter 3) to provide a seamless workflow, which resulted in a bespoke tool that will be presented in this chapter. The tool prototype was developed for the current research and is presented in Section 5.1. Several usability studies were conducted to evaluate the usability of the tool on educators (Sections 5.4 and 5.5), in order to address RQ 3b (i.e., *Are the interfaces and workflow usable for educators?*).

5.1 ARQS AUTHORING TOOL

As mentioned in Chapter 1, the ARQS platform consists of the design method and a web-based authoring tool (Figure 1.2). The authoring tool serves as the point where educators implement SRPG designs produced through the design method (Section 3.3) into a finished game, in which game data are formatted as JSON (JavaScript Object Notation) and stored in a database. Players (i.e., students) can access these games using a web-based game engine app which loads and parses the JSON game data into a runnable game. This workflow can allow quick and ad-hoc editing of games without code compilation, further simplifying the development process.

The authoring tool provides components that is in concert with the ARQS design method, such that the authoring workflow is somewhat parallel to the design procedure (Figure 5.1). In this section, the relationship between the design and the development phase is further explained, through the introduction of the general concept of the bespoke prototype tool and its components.

5.1.1 Authoring Process and Tool Components

The authoring process involves the configuration of the key RPG components (Figure 5.1): *theme setting*, *player configuration*, *game world*, *quests* and *gameobjects*. Table 5.1 shows the tool components within the authoring tool to configure each of these game components. Structuring the authoring workflow into these separate components can guide educators in configuring each component individually, making the process systematic but less flexible as compared to game development software such as Unity. Nonetheless, a variety in gameplay is still possible through the different themes, game worlds, characters and quest designs educators can produce.

The tool predominantly uses standard form controls (e.g., text fields) to configure the components and their corresponding settings. Certain components require the use of more complex interfaces, specifically various graphical editors to create the game world and virtual characters, and a BBP editor to program the gameplay logics.

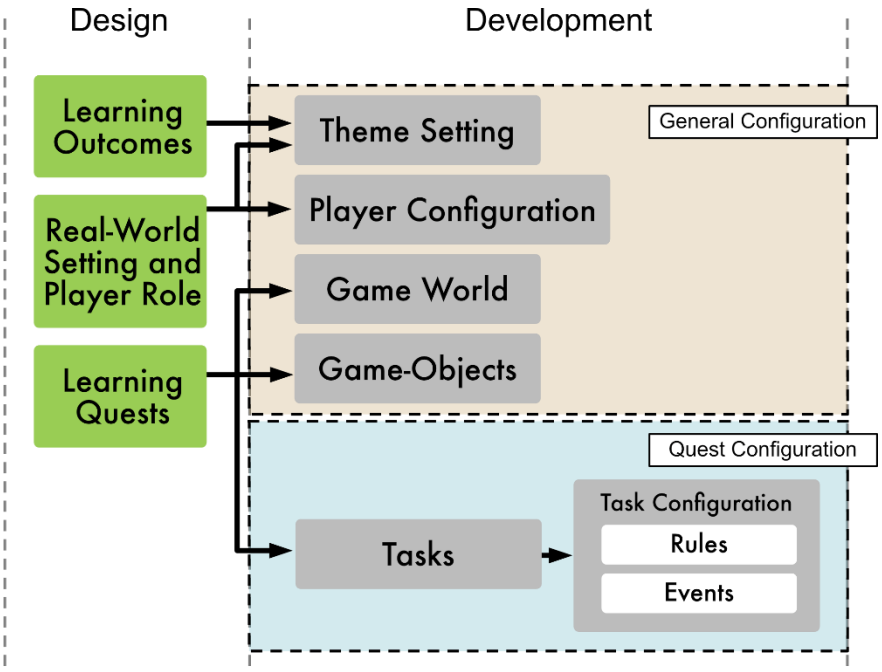


Figure 5.1. Overview of the authoring workflow.

Theme Setting

Educators can set the overall theme setting of an SRPG using the theme editor. The theme setting includes setting up the lesson description and learning outcomes identified during the design phase, which are presented to players at the start of the game. This serves as the way to inform players on the main educational objective of the game.

Player Configuration

The Player editor provides form controls for educators to configure players' role in the game. A drawing editor (Figure 5.2A) is also used to set the appearance of a player's avatar, which involves configuring the appearance of NPCs. The configuration allows educators to manipulate the different parts of the character such as the facial and clothing appearance. The process is aimed to facilitate a simple and quick method of creating NPCs, especially where educators are concerned to decide on their visual aesthetics, while the animation aspects (e.g., a character's walk cycle animation) are handled automatically by the game engine. Player characters can also be programmed using BBP (Figure 5.2B). This includes configuring the attributes or characteristics of characters (e.g., strength, agility).

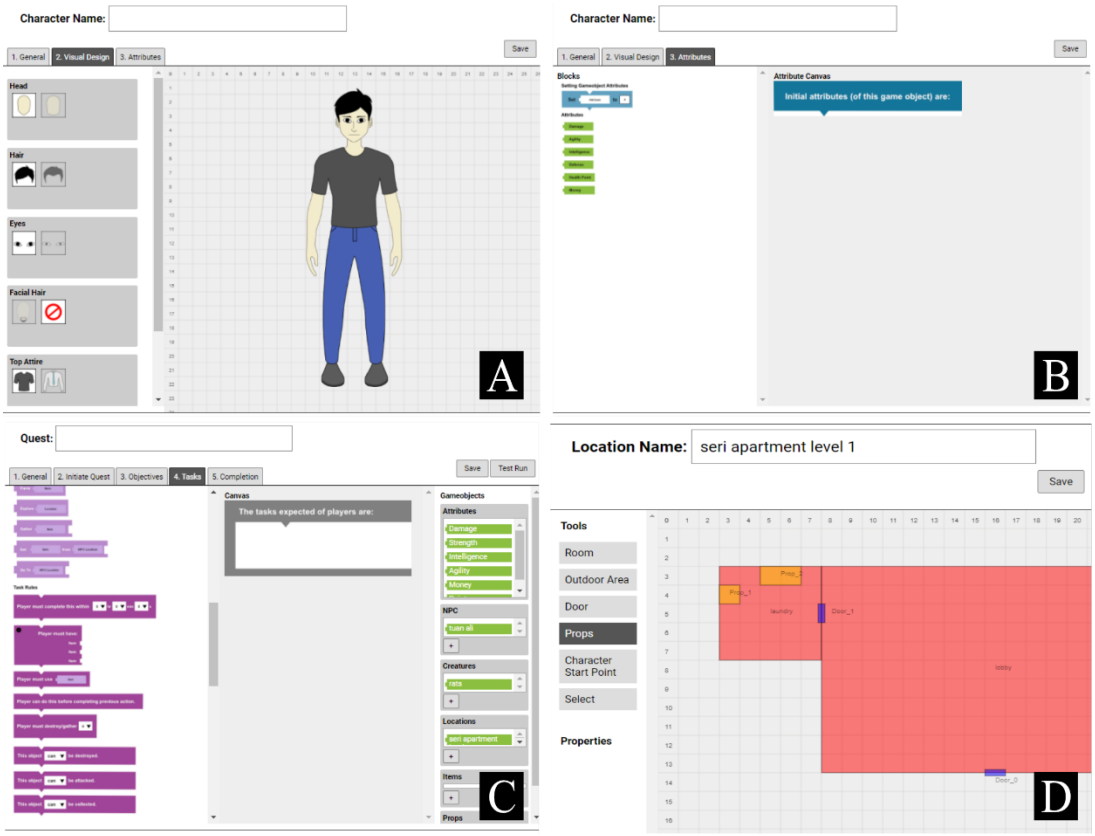


Figure 5.2. Low-fidelity prototype.
Player character drawing editor (A), Programming gameobjects (B),
Quest editor (C), Map editor (D)

Table 5.1. Components of the authoring tool.

Game Component		**Interface**
Theme Setting	Set lesson description (i.e., educational objective) and learning outcomes (LO) students are expected to achieve during the game. (Shown on an introduction scene)	HTML Form controls
Player Configuration	Set player avatar's role, attributes and skills (related to the lesson).	HTML Form Controls
Game World	Create the virtual game world.	HTML Form Controls, Drawing Editor
Quest	Create quests players must solve.	HTML Form Controls, BBP Editor
Gameobjects	Create gameobjects that are involved in the quests.	HTML Form Controls, Drawing Editor (for NPC, Enemy)

Game World

The World component is for creating the virtual world of a game. A world consists of *maps* that contain *locations* (i.e., buildings) players can enter. A location consists of connected *areas* (i.e., rooms or outdoor areas) which players can explore using their avatar. Drawing editors (Figure 5.2D) are used to create these elements, employing simple operations such as selecting pre-defined images (e.g., a house, furniture) and placing it on a drawing canvas. Creating locations also involve creating the floorplan of a building, by drawing rectangles to define the size and placement of the areas in the building. The drawing operations provide a quick and easy way to design the layout of the game environment, allowing educators to visualise the placements of props, e.g., furniture, and how spaces within a location are connected. The game engine app can automatically apply the appropriate textures (e.g., tile texture to floors) and visual assets (e.g., image of furniture) when players run the game.

When running the game in the game engine app, the game world was initially planned to be represented in an isometric view (Figure 5.3B). However, a consideration was made on simplifying the effort when implementing the authoring tool and game engine. This led to the decision to render the game world in a top-down view (Figure 5.3A). The visuals within an SG have an insignificant effect on students' learning performance or affective aspect (Clark et al., 2016), as such, the decision to display the game world as isometric or top-down would have less or no impact on the potential benefits of SRPGs produced by the ARQS platform.

Gameobject

Several editors are used to create core RPG gameobjects (Table 5.2). These editors provide form controls to configure the properties of gameobjects such as name, description and uploading image file as visual representation of the objects in the game. Character-based gameobjects (i.e., NPC and Enemy) also require drawing editors to configure their visual aesthetics and BBP editor to configure their attributes (similar to configuring player character described above).

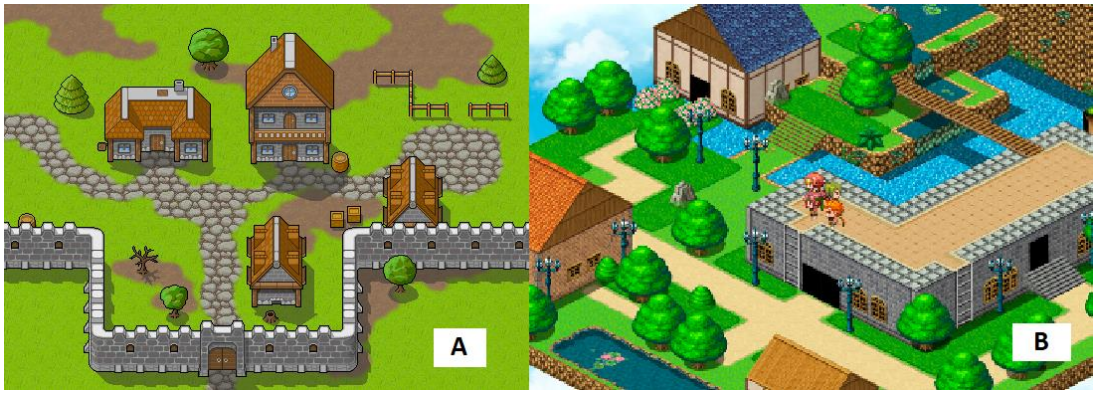


Figure 5.3. Common view perspective of 2D RPG.
Top-down (A[9]) and Isometric (B[10]) game view.

Table 5.2. Editors to create gameobjects for a game.

Editors		**Settings**
NPC	Create virtual non-player characters.	Name, Description, Visual Aesthetic
Enemy	Create combative virtual non-player characters.	Name, Description, Visual Aesthetic
Item	Create items that players can take and use.	Name, Description, Image File
Readable Item	Create readable items that contains readable content.	Name, Description, Content Hyperlink
Prop	Create props that will be placed in the game world.	Name, Description, Image File

Quest Editor

ARQS emphasises in using LQs as the focal outlet where learning activities can be embedded in an SRPG. Quest is the most important component of an SRPG, where game-logics and learning activities can be embedded. A quest editor (Figure 5.2C), which employs BBP, is used to configure LQs. The process of authoring LQs coincides with the structure of quests as described in Section 3.3. It consists of setting

[9] opengameart.org/content/top-down-rpg-mockup-scene

[10] forums.rpgmakerweb.com/index.php?threads/creative-eds-isometric-solution-alpha-0-2.98725/

up the components in a quest structure (Table 3.4), to define the tasks that players must complete, and game-logics that is executed during the quest.

5.2 DEFINING BLOCKS PROGRAMMING LANGUAGE FOR ARQS

VPLs were introduced earlier (Section 2.6.6), where the advantages of using VPL, in particular BBP, were discussed in terms of simplifying the programming aspect in application development. The ARQS authoring tool implemented BBP as the mechanism for educators to program the gameplay logics for an SRPG. This includes configuring LQs, and the characteristics and behaviours of the player avatar and gameobjects.

The ARQS engine app contains pre-built RPG game logics such as moving characters and collecting items. These game logics are run based on the properties of LQs and gameobjects configured by educators. Gameplay logics of SRPGs created in ARQS are driven by educators staging scenarios, which includes setting the actors (NPCs), props, items, actions that should take place, locations where the scenarios will take place, and dialog scripts when a player interacts with NPCs. Students would then play out the scenarios such as interacting with NPCs and solving problems. These components are used to control the learning process as intended by educators, primarily by requiring players to perform the required actions as prescribed by educators needed to solve some problems.

Two sub-sets of blocks were designed to address the configuration of LQs and gameobjects.

5.2.1 ARQS Blocks for Learning Quests

The quest structure presented earlier (Table 3.4) was used as the basis for the quest blocks in ARQS. In this section, the blocks and execution flow of an LQ will be presented, accompanied with an example showcasing the usage of the blocks in configuring the “Fire Prevention” example quest presented earlier (Table 3.6). The blocks are mainly used to program the gameplay logics of an SRPG, particularly through the configuration of LQs. When a game is run on the game engine app,

appropriate game mechanics will be applied and executed based on the blocks used to configure these quests. Table 5.3 shows the summary of the type of ARQS blocks used to address the different components in an LQ. Figure 5.4 shows an example of the blocks used to configure an LQ.

This *main* block is the initial block created for a quest. It consists of several component that needs to be configured. The *initiator* component refers to the NPC that players need to interact with before starting the quest, which is set using a drop-down menu containing the list of created NPCs. In the example quest (Table 3.6), the initiator is the NPC who plays as players' "homeowner".

Initial gameobjects component refers to the gameobjects that will be created in the game world when the quest is started, which can be set by adding *Gameobject Placement* blocks. In the example quest, two game-objects are needed for players to interact with in the quest, the "homeowner" NPC and the "cooker" prop.

Table 5.3. Blocks for Configuring Learning Quests.

Blocks	
Main	Configure the initiator, initial game-objects, and first task in a quest.
Sub-Task	Add a sub-task to a quest.
Gameobject Placement	Add gameobjects that will be created at the start of a quest or during an event in a task.
Rules	Set items (type or quota) or time limit required to complete a task.
Events	Set player or timer events that can be triggered during a task.
Actions	Set event actions that will be executed when an event is triggered.
Messages and Dialogs	Set conversational dialogs, notifications or MCQ that will be presented when an event is triggered.

The *main task* component refers to the first task that players need to complete in the quest. The component includes several sub-components to define a task, which includes *player action*, *rules*, *events* and *sub-tasks* components. The player action refers to the task players are expected to perform, which is set using a drop-down

menu containing the list of *player actions* (Table 3.3). The *rules* component refers to the items or time limit conditions that must be met by players for completing a task, which can be set using the *rules* block. The *events* component refers to the events that can be triggered during the task, which is set using the *events* block. Each event block added needs to be configured in terms of the player or game events that will be triggered. *Action* blocks are added to an event block to configure the actions that will be executed when an event is triggered. The sub-task component refers to any subsequent tasks in the quest, which is set using a *sub-task* block. The block is essentially similar to the main task component, which includes the player actions, rules and events components.

Figure 5.4 shows the block configuration for the example quest (Table 3.6). The main task in this LQ involves the player action "talk", where player must interact with the "Homeowner" NPC (i.e., the LQ's initiator). This task requires the "Interact with Initiator" event block, which will trigger a dialog and message actions when player interacts with the Homeowner NPC. The dialog and message are used to present information about the problem of the LQ. The second task in the LQ involves the player action "fix" to denote "turning off" the cooker in the kitchen. This task requires the event "Interact with gamobject" block, which will trigger an MCQ when player interacts with the cooker gameobject. The MCQ is where players must choose the correct course of action that needs to be performed. The second task also consist of a rule where players must complete the task within a certain amount of time, which is configured using the timer rule block.

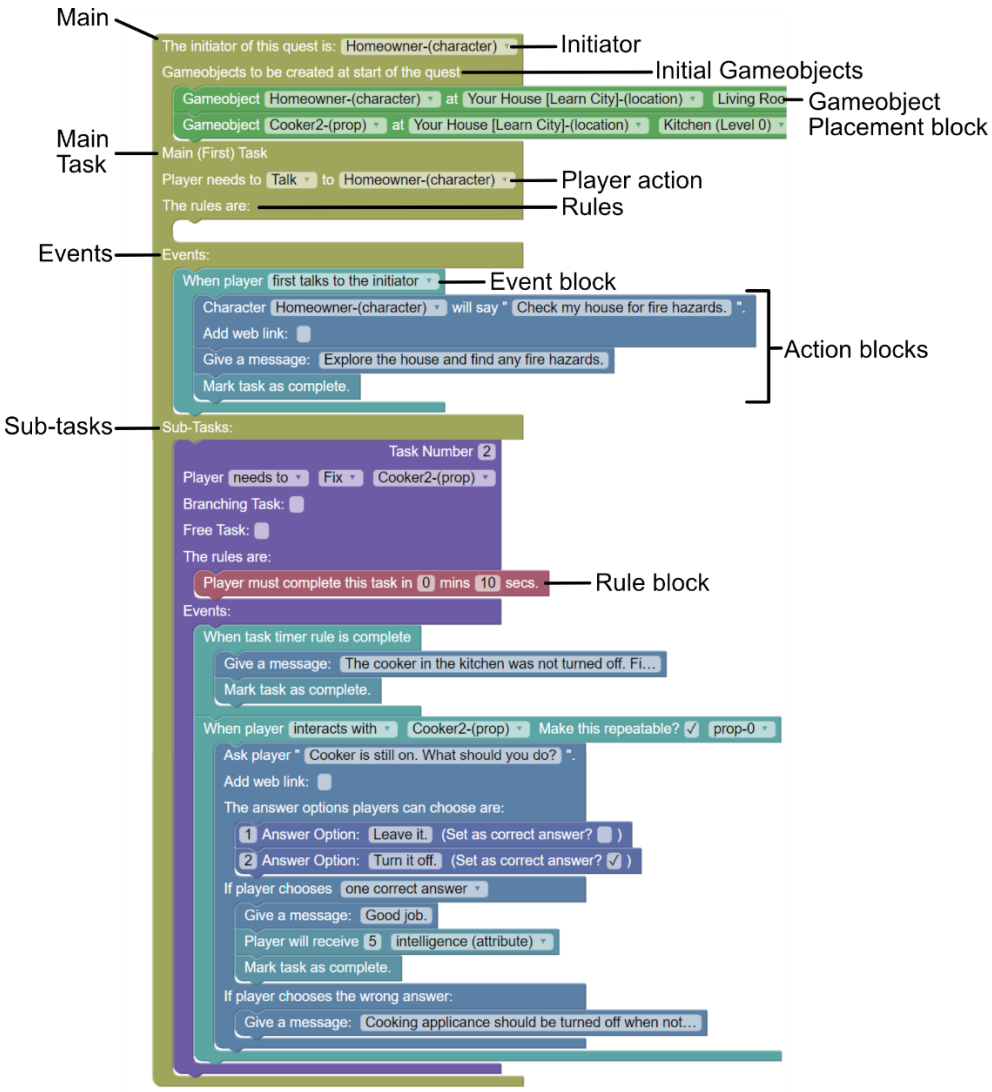


Figure 5.4. Blocks to configure a learning quest.

5.2.2 Quest Life-Cycle

The blocks configuration of an LQ is parsed by the game engine app during gameplay following a specific order of code execution (Figure 5.5). During gameplay, the engine will run through a "*Quest Queue*", which contains the list of quests created, and activates the first available quest (i.e., quest that is not yet completed; Sequence 1). When a quest is first activated, the game will create the NPC associated to the *initiator* of the quest (Sequence 2) and starts listening for the *events* set in the first task of the quest (Sequence 3). Events are consistently listened to as long as a quest is still active. Only event type "interacts with initiator" will be processed at this stage, which when triggered will start the quest (Sequence 4), the first task activated (Sequence 5), and gameobjects set in the *Initial Game-objects* created (Sequence 6).

Other event types will only be processed when a quest is started. When a set event is triggered, *actions* for these events will be executed (Sequence 7). If the event type requires explicit *rules*, checks will be made to see if players have met the set rules before executing the events' actions (Sequence 8). When the specific "*End Task*" action is executed, the game will deactivate the current task and checks the *sub-tasks* component (Sequence 9). If there are sub-tasks added to a quest, the game will activate these tasks in the sequence order they were added in the quest configuration (Sequence 10). A quest will be deactivated when no more tasks are found (Sequence 11), which will cause the engine to check the quest queue for the next available quest.

5.2.3 Programming Gameobjects

BBP is also used to program the characteristics (i.e., attributes and skills) and behaviour (i.e., certain global events such as gameobjects being destroyed) of a player's avatar and gameobjects. A sub-set of ARQS blocks were designed to address this aspect (Table 5.5). A sub-page within the player configuration and each gameobject's editor provides a BBP interface for educators to program these gameobjects.

5.2.4 Learning Activities in SRPGs

Tasks that can be set in an LQ were based on common RPG player actions (Table 3.3). Each of the tasks is associated to specific gameobjects, which can define the scope of the learning activity during an LQ. Table 5.4 shows the details of the player actions and learning activities that can potentially be incorporated in SRPGs. As described in Chapter 3, learning activities found in SRPGs will depend on the actions that educators want learners to carry out in solving real-world problems related to a particular learning domain. For domains such as Information Security for example, an educator might want learners to understand and realise the importance of periodically updating anti-virus software. Educators might then use the player actions that relate to this aspect such as "Fix", which can be used within the context of "updating an anti-virus".

Table 5.4. Player actions and Potential Learning Activities in an SRPG.

Player Actions	**Required Gameobjects**	**Potential Learning Activities**
Attack	NPC, Location	Learners have to attack an NPC or Location.
Capture	NPC	Learners have to capture an NPC.
Examine	Item, Prop	Learners have to examine an item or prop to get some information.
Experiment	Item	Learner has to use an item to find out what it does.
Explore	Location, NPC, Item, Prop	Learner has to explore a location to find some character, item or prop.
Escort	NPC, Location	Learner has to bring some character to some location.
Follow	NPC, Location	Learner has to follow some character to some location.
Fix	Prop, NPC, Item	Learner has to fix some prop or character, by using some items.
Go To	NPC, Location	Learner has to go to some location or character.
Gather	Item	Learner has to collect some items.
Give	Item, NPC	Learner has to give some item to some character.
Make	Item	Leaner has to make a new item using certain items.
Protect	NPC, Location, Prop	Learner has to protect some character, location or prop.
Read	Item	Learner has to read a readable item to get some information.
Sneak Up	NPC	Learner has to sneak up on some character.
Talk	NPC	Learner has to talk to some character to get or give some information.
Wait At	Location	Learner has to wait at some location for something to happen.

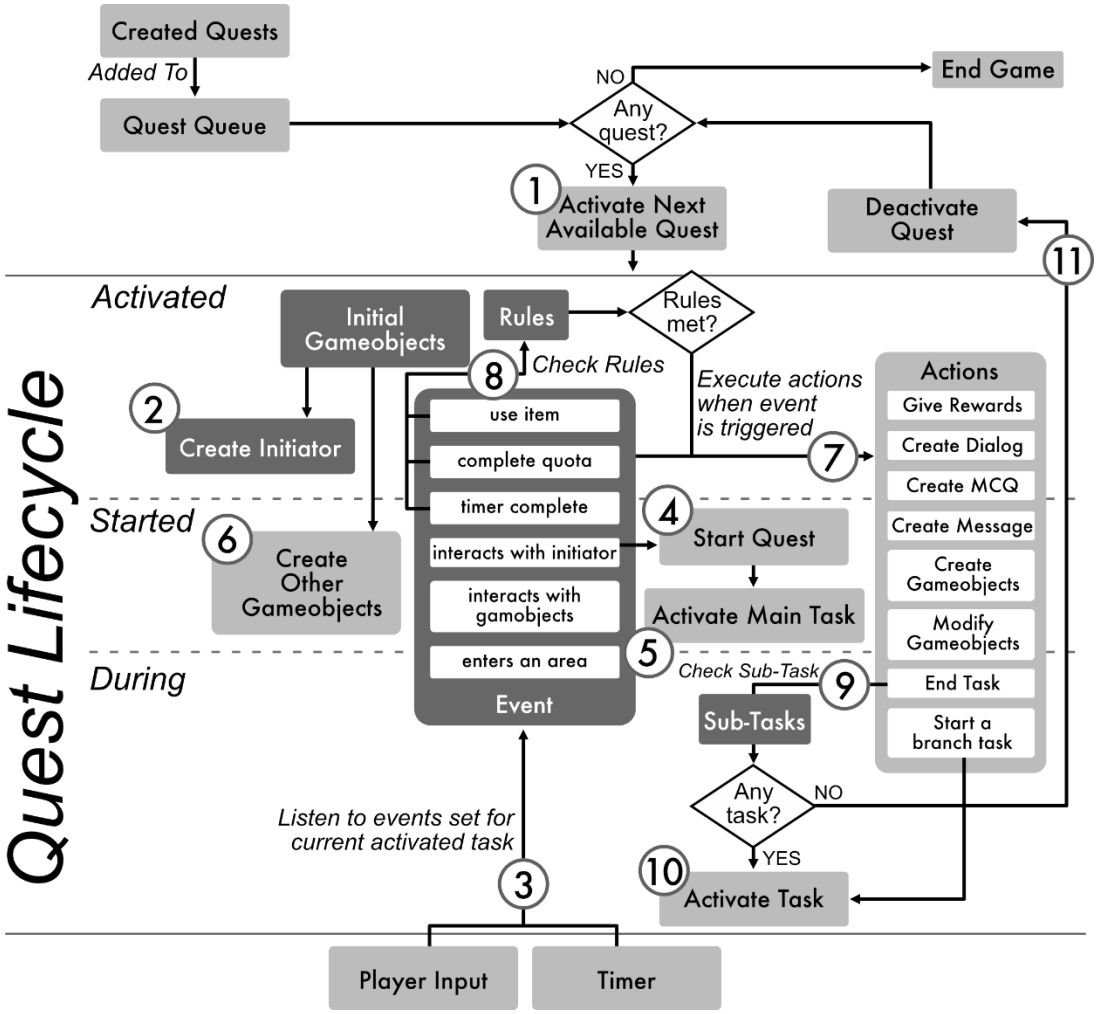


Figure 5.5. Code Execution Sequence of a Learning Quest

Table 5.5. Blocks for Programming Player Avatar and Gameobjects.

Blocks	
Gameobject Interaction	Set what will happen when a player interacts with gameobjects.
Gameobject Destroyed	Set what will happen when a player destroys gameobjects.
Item Handler	Set what will happen when a player uses an item.
Character Attributes	Set the attributes of a player's avatar and gameobjects.

5.3 USABILITY EVALUATION OF THE AUTHORING TOOL: CONCEPTS AND METHODS

A usability study (Redish et al., 2002) is typically carried out when investigating how users interact with, and how they experience a tool in order to evaluate the tool's perceived effectiveness and efficiency, and user satisfaction. This aligns with the basic human-centred design principle, involving target end-users from the early conception and throughout the development process of a system, thereby ensuring user acceptance and adoption of the system (ISO 9241-210, 2019).

There are two major types of usability study, formative and summative (Lewis, 2014). Formative usability study is carried out in the early development phase of an application, with the main goal of diagnosing usability problems in the application. Summative usability study, on the other hand, is carried out towards the end of the development lifecycle of an application, with the main goal of finding out whether the target users can use the application effectively, efficiently and with an acceptable level of satisfaction. These usability studies were conducted for this thesis and are presented below.

5.4 FORMATIVE USABILITY STUDY: PROCESS AND RESULTS

A formative evaluation study was conducted with educators using a low-fidelity prototype of the authoring tool to evaluate the: 1) perceived ease of use, and 2) perceived usefulness of the authoring tool. The evaluation is also expected to identify any problems and inputs from the target users that can inform the next phase in developing a high-fidelity prototype.

Six teachers from several secondary schools in Brunei Darussalam and three lecturers from UTB were recruited to take part in this study (Table 5.6). One student counsellor from a secondary school volunteered to participate in the study and was included, considering that their tasks involve interacting with students by conducting extra-curricular classes. The inclusion would further extend the reach of ARQS to encompass educators from all forms of education or training. The secondary school

teachers taught different subjects whereas all three lecturers taught subjects concerning computer and network security. Figure 5.6 shows the overview of the study protocol. Sessions were conducted individually for each educator, where each session lasted between 60 and 90 minutes. Each session was facilitated by the author. The sessions were conducted in various locations; a laboratory provided by UTB and at facilities provided by the schools where the secondary school teachers worked at. Audio, video, and screen capture recordings were made during each session.

5.4.1 Study Protocol

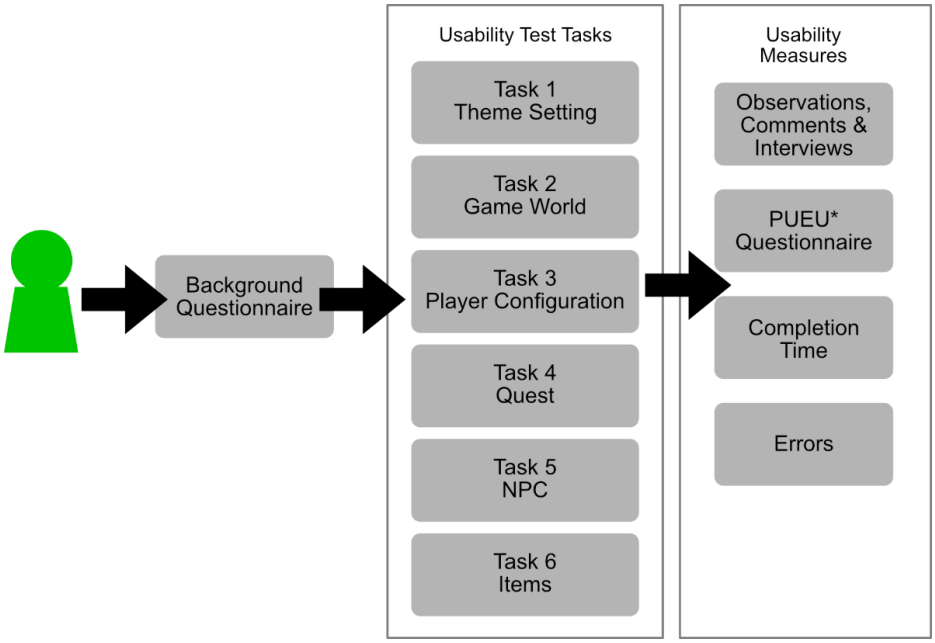


Figure 5.6. Study protocol for the formative usability study.
*PUEU: Perceived Usefulness and Ease of Use

The study involved using a pen-and-paper and a low-fidelity web-based prototype. These media are normally used in evaluating the usability of software applications at its early stage of development, since it requires minimum effort in constructing such low-fi prototypes and affords quick changes to be made. The web-based prototype tool consists of the pages for the major components as described above but with limited interactivity. For components requiring BBP and the use of ARQS blocks (e.g., configuring the LQ), paper-based prototype was used where participants could interact and code with the blocks (Figure 5.7).

Table 5.6. Participants in the Formative Evaluation.

Participant ID	**Subjects Taught**	**Academic Level**	**Experience in using educational games or game-based learning platform.**
F1	People and Security	Undergraduate	-
F2	Network Security	Undergraduate	√ (Kahoot)
F3	People and Security	Undergraduate	√ (Kahoot)
F4	Thinking skills	Secondary	√ (Non-digital)
F5	English	Secondary	-
F6	Student Counselling ECA*	Secondary	-
F7	Mathematics	Secondary	√ (Kahoot)
F8	English	Secondary	√ (Kahoot)
F9	Chemistry	Secondary	-
F10	Physics	Secondary	-

*ECA: Extra-Curricular Activity

Establishing Participants' Background

Participants were briefed at the start of their session, followed by an interview to establish their general background in relation to their current teaching activities, experience with using educational games or game-based learning platforms, experience with using general IT as teaching tool, past experiences in the development of educational games, and experience in programming and BBP. Understanding participants' teaching activities could provide insights into how SRPGs could potentially be incorporated into various teaching strategies. Data regarding participants' experience in the use of educational games is expected to provide insights into educators' familiarity with game-based learning, or inclination towards adopting such approach. Similarly, data regarding their experience in the use of general IT is expected to identify their familiarity with technology-mediated teaching.

Identifying participants' experiences in the development of educational games, programming and BBP can help establish the usefulness of the ARQS authoring tool.

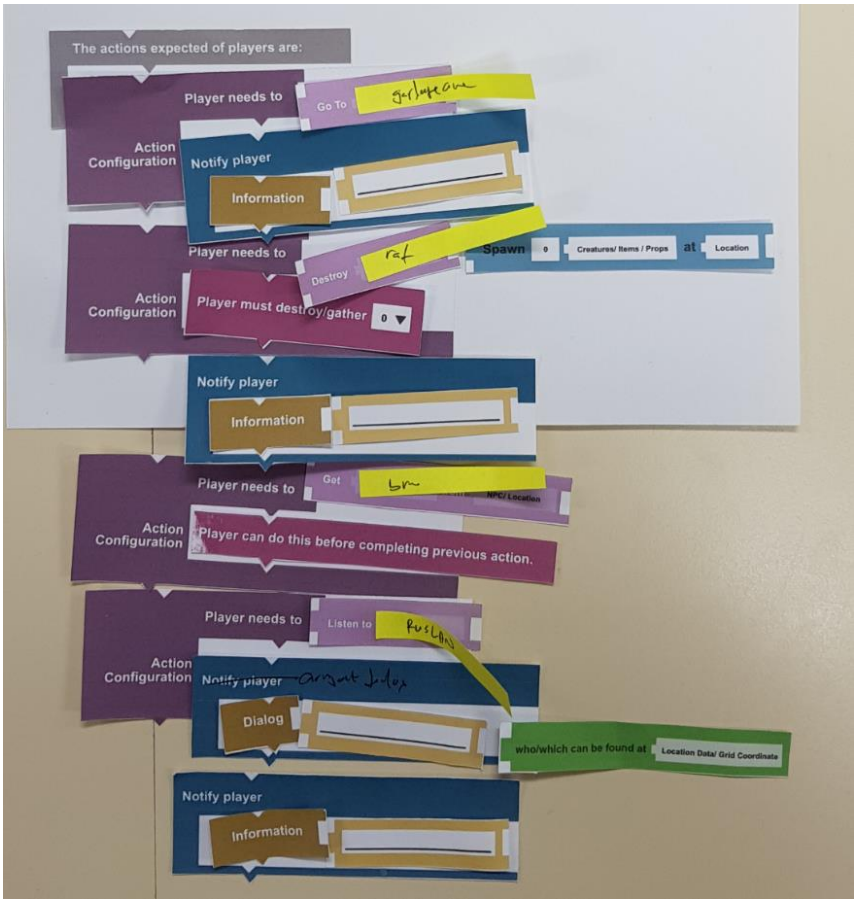


Figure 5.7. Quest configuration using paper-based BBP.

5.4.2 Usability Test

Participants then proceeded with using the prototype in the usability test, where they were provided with a series of hand-outs. This included the list of tasks they were required to carry out using the prototype, a map sketch for the location in the game world, and a pre-designed quest. The map sketch, used as reference for the "Create game world" task (Task 2), consists of the floor-plan of the interior of a building that is to be recreated in the game. The pre-designed quest contains the quest structure for "Attacks and attackers" (Quest 1) topic of an undergraduate security module, which was provided to the lecturers, and a geography "Underpopulation and Overpopulation" (Quest 2) topic which was provided to the high-school teachers. These topics were selected due to the author's familiarity with the topics and access to educators who were consulted in identifying topics with suitable case studies that

serve as the basis of the quest structure. In Quest 1, the scenario revolved around a "network technician" (i.e., players' role) of a company, which is tasked to help investigate possible hacking attempt on its server by carrying out tasks to check for any intrusion made to the server and where it originates. The quest could be part of several quests that can potentially be used to teach students on the knowledge relating to "data or information leak". Quest 2, on the other hand, placed players as a "town council officer", and requires players to aid an NPC in identifying the cause of a rat infestation in an apartment. This quest could also be part of several quests to potentially teach students on the negative impact of overpopulation.

Participants could refer to the pre-designed quest to complete the quest (Task 4), NPC (Task 5) and items (Task 6) creation tasks. In every session, the author made observations while participants were performing the tasks. Participants were asked to think aloud during the tasks. During the task, the Wizard of Oz (Maulsby et al., 1993) approach was applied; the author acted as the computer such as providing feedback that the tool would provide in a high-fidelity prototype. This included providing error feedback (e.g., when participants performed impermissible actions), and a help or manual feature users could access anytime during the tasks. At the start of Task 3 and 4, participants were briefed on the general process of BBP, and in particular in the use of ARQS blocks. Configuring LQs in Task 4 mainly requires the structuring of the quest using BBP. Task 3 involves the configuration of the player avatar, which includes setting up the visual appearance of the character and using BBP to configure the characteristics of the avatar. These tasks required the author to explain the concept of BBP at the start, and on the overall structure of the blocks in ARQS. This was deemed necessary because eight of the ten participants were inexperienced in BBP.

5.4.3 Interview and Usability Questionnaire

After the completion of each task, the author interviewed the participants to gather insights into their experience with the tool as well as to encourage constructive feedback and suggestions. At the end of each session, participants were asked to complete the two dimensions of the Technology Acceptance Model (TAM) - Perceived Usefulness and Ease of Use (PUEU; Davis, 1989) questionnaire to establish the general usefulness and usability of the tool.

5.4.4 Analysis Procedure

Participants' background data, experience during the usability test, time taken to complete the tasks during the test, and data from the PUEU questionnaire were used in the analysis of the study. The experience component includes observation notes made by the author as well as the participants' comments and feedback.

5.4.5 Results

In this section, the profiles of the participants were first analysed. Results of the evaluation sessions based on the analysis of the responses of the participants regarding the use of the ARQS authoring tool were presented.

5.4.5.1. Participant Profiles

Experience with Educational Games in Teaching. Nine participants were familiar with educational games, but only four participants had actually used games in their teaching, specifically using MCQ styled game-based learning platform Kahoot (Table 5.6). Three of the participants who had never used games in their teaching, did consider using educational games, but due to various reasons did not have the opportunity to implement it. Two participants (F1 and F9) stated that games that are freely available from the web were not suitable for their required syllabus or intended teaching. Regarding developing custom educational games as a personal initiative, S1 who had experience in game development commented that the time it would take to design and develop games as a self-initiative approach would not be feasible.

Developing Educational Games. Three participants had some experience and prior involvement in developing educational games (Table 5.7). F1 taught game development undergraduate courses and considered himself knowledgeable in game development. F10 had develop a physics-course educational game as part of his postgraduate "Masters in Teaching" programme, although he did require help from more knowledgeable programmers. F3 was involved in several past projects developing interactive educational packages using Authorware[11]. F1 and F3 were both

[11] https://en.m.wikipedia.org/wiki/Adobe_Authorware

IT lecturers with background in programming, and thus had the necessary knowledge and skills in this area and were involved in game development projects either within their teaching activities, supervising students' projects or as consultants for projects in collaboration with external organisations.

Table 5.7. Experience in developing games and block-based programming.

Participant ID	**Experience in developing games (Software/Technologies used)**	**Programming background**	**Experience with using BBP (BBP platform)**
F1	√ (Unity, Flash)	Proficient	√ (MIT App inventor)
F2	-	Intermediate	√ (Alice)
F3	√ (Authorware)	Intermediate	-
F4	-	Past formal training	-
F10	√ (Unity, Vuforia)	Beginner	-

Programming Knowledge and Experience with Block-Based Programming. Five participants had some form of background knowledge or experience in programming (Table 5.7). F1 was proficient in programming, having taught several programming-based subjects. F2 and F3 had intermediate knowledge in programming but would struggle to code without referring to more expert programmers. F4 had some basic training in programming in high school. F10 was a beginner self-taught programmer. Only F1 felt confident in developing video games from scratch with his current knowledge and expertise. Only two participants (F1 and F2) had experience in using BBP; MIT "App inventor" and "Alice", respectively. Both of them agreed on the ease of use of BBP.

Using other Technologies in Teaching. Nine participants had experience in using IT in their teaching. The recent shift to online learning due to the COVID-19 pandemic had caused educators to make use of alternative teaching platforms such as Kahoot, Microsoft Teams and Zoom. Only F6 was not actively conducting activities during this time due to her nature of work as a student counsellor. F9 also commented on the technology-based nationwide initiatives where schools in Brunei Darussalam were encouraged to make use of technology in an effort to realise the industrial revolution

4.0., which could explain educators' current willingness to adopt and incorporate technology in their teaching.

Teaching Strategies. Teaching strategies in the context of this thesis are teaching methods educators use to present instructional materials to students. Participants implemented various teaching strategies in the classroom (Table 5.8). Seven of the ten participants have used real-world scenarios in their teaching. This involves basing activities on real-world situations or examples that students can relate to. Two participants have implemented role-playing in their teaching. All three lecturer participants actively use case studies in their teaching. Three participants teaching secondary school science and mathematics subjects applied some form of visualisation to help students visualise the concepts taught, including demonstration, simulation exercises or the use of examples. Two participants within the English-language domain predominantly implemented communicative approaches (e.g., discussions).

Table 5.8. Teaching strategies implemented by participants.

Teaching Strategy	**Number of Participants**	**Participants ID**
Real-world scenarios	7	F1, F2, F3, F4, F7, F9, F10
Role-Playing	2	F4, F9
Communicative	2	F5, F8
Visualisation (e.g., demonstration, simulation exercise, examples)	3	F7, F9, F10

5.4.5.2. Responses to the use of ARQS Tool

Time Taken to complete Tasks and User Errors. For each participant, the completion time for each task was recorded (Table 5.9). Task 1, with the mean completion time of 1 minute), involved a straightforward data entry operation, requiring participants to simply type in the theme settings in the appropriate form controls. Creating the game world in Task 2 also incorporated typical operations familiar to participants, where the mean completion time for the task was around 4 minutes. The player configuration (Task 3), creating NPC (Task 5) and items creation tasks (Task 6) shares some similar process. Task 3 was the first time the participants come across the

process of creating gameobjects, where they had to use the drawing editor to configure the visuals of the player character. Furthermore, the task included BBP activity where participants were required to program the characteristics of the player avatar. Task 5 and 6 on the other hand only required participants to configure the visuals of the NPC and items.

Table 5.9. Participants' Task Time (minutes).

	Task 1	**Task 2**	**Task 3**	**Task 4**	**Task 5**	**Task 6**
Mean Time	1	4.2	4	25.3	1	1
Std. Dev.	0	1.32	1.7	7.10	0	0

Task 4 has the longest duration throughout the whole test, with the mean completion time of 25 minutes. This task involves configuring an LQ using the blocks. The mean completion time recorded for the tasks during the study could serve as a benchmark to which the subsequent summative usability study with a high-fidelity prototype of the authoring tool could be compared to (Bergstrom et al., 2011; Sauro, 2008).

Table 5.10. Ease of Use of the Authoring Tool's Components.

	Ease of Use * (Number of participants)				
Components	**1**	**2**	**3**	**4**	**5**
Theme Setting	-	-	-	-	(10)
Map Editor	-	-	-	(7)	(3)
Game-Objects Editor	-	-	-	(7)	(3)

*5-likert scale: 1 (Very Difficult), 5 (Very Easy).

Ease of use of the Authoring Tool. All participants found the authoring tool's components easy to use in general (Table 5.10). Through the observations during the sessions, participants had no trouble navigating between the components in the authoring tool, i.e., they were able to navigate to the proper page when trying to configure the different components of the SRPG. All ten participants found Task 1 very easy. Regarding creating the game world task, all of the participants found the process of creating the game world (Task 2) using the drawing canvas generally easy

(n=3 for very easy; n=7 for easy). F1, however, made a user error where he tried to create several location entries for each room found in the game world, instead of creating one location and several rooms. The mistake was due to him not reading the menu labels clearly before actually doing the task. The errors made by participants are summarised in Table 5.11.

Table 5.11. Errors observed during the study.

Task	Errors Observed
1	None
2	Created multiple entries for every room of the location.
3	Dragged the wrong blocks into the canvas without first using another block
4	Dragged the wrong blocks into the canvas without first using another block; connecting incompatible blocks; connected the wrong block
5	None
6	None

A similar trend was observed for the creation of gameobjects i.e., avatar (Task 3), NPC (Task 5) and items (Task 6), where all of the participants found the process of using the gameobjects' editors generally easy (n=3 for very easy, n=7 for easy). Generally, participants completed the visual representation of gameobjects around the average time of 1 minute. Adding the character's attributes to the avatar in Task 5, however, required participants to carry out BBP, where participants spent around the average time of 3 minutes to complete. The BBP aspect was found by participants as the difficult aspect in creating the player avatar. There were multiple instances where most participants initially dragged blocks that could not be added to the canvas without first using another required block. This was expected since it was the first time most of the participants experienced BBP and used the ARQS block language. After receiving the error feedback of the impermissible action from the author acting as the computer, all of the participants subsequently did manage in identifying and connecting the correct sequence of blocks. One participant (F2) suggested that the configuration of character attributes could be done using simple form controls rather than using BBP.

Table 5.12. Ease of Use of the Quest Configuration Process and Blocks.

	Ease of Use * (Number of participants)				
	1	**2**	**3**	**4**	**5**
Easy to understand the process.	-	-	(2)	(6)	(2)
Easy to learn the process.	-	-	-	(5)	(5)
Easy to understand the blocks.	-	-	-	(7)	(2)

*5-likert scale: 1 (Very Difficult), 5 (Very Easy).

In terms of Task 4, all participants found the process in configuring the quest easy to understand and learn (Table 5.12), with an average completion time of 25 minutes. Figure 5.7 shows an example of the quest structure created by one of the participants. Two participants (F5 and F10) did have a neutral view (i.e., bordering between easy and difficult) in terms of understanding the quest creation process, particularly on the structure of the blocks when configuring the quest. According to F10: "*It was difficult for me when arranging the block sequence for the tasks (in the quest). It was harder at first, but I got used to it.*" Other participants also stated that it took them a while to understand how to use the blocks to create the quest, but their understanding soon improved after a while. As F8 reflected: "*Once I've done it a couple of times (creating the quest task), I get the hang of it. I remember what to do, where to look for the blocks.*". Few participants also found that information received from the "help" feature greatly helped improved their understanding. According to F6: "*I understood only after you (help information) explained on how to use the blocks.*"

Nine participants found the blocks were particularly easy to understand. Five participants stated that the shapes, colours and labels helped them in this respect. The shapes of the blocks and their connectors helped them identify which blocks could be connected together. All participants did try to connect incompatible blocks especially at the start, but after receiving the error feedback that the blocks couldn't be connected, participants built upon this knowledge and understood the role the shapes played. The colours of the blocks helped them in recognising the categories of the blocks. This was evident during the observations where after some time using the tool, several participants would correctly scroll to the appropriate coloured-category

section in the "blocks" library looking for the specific blocks needed in the task. They also understood the intent of the blocks based on the labels, which most of them found obvious. There were several instances, however, where participants got confused between several blocks, which they thought could be used to do a task. This related to the labels used on the blocks, which one participant mentioned as misleading.

Table 5.13. Usefulness of the Authoring Tool.

	Usefulness * (Number of participants)				
	1	2	3	4	5
Useful for creating learning activities	-	-	-	8	2
Intention to use in the classroom	-	-	2	6	2

*5-likert scale: 1 (Very Unlikely) – 5 (Very Likely)

Eight participants agreed that they found the tool useful for teaching (Table 5.13). F3 and F9 felt that they were very likely to use ARQS and SRPGs in general for their own teaching. P3 said: "*This is very good for problem-based learning. You can create the problem that you want to pinpoint to students and let them experience it.*" Two participants (F4 and F6) were not sure if they wanted to use it in their teaching. F4 in particular was not sure how the game activities would fit within his normal teaching. The two participants (F7 and F10) who would be likely to use the tool in their teaching were not in favour of the time they anticipated it would take to create the games. F10 commented that the current workload of teachers would make it difficult for them to find the time in creating SRPGs from scratch.

5.4.6 Discussion

Use of Educational Technology

While nearly all ten participants are aware of educational games, only half of the participants have actually applied game-based approaches in their teaching, mainly through the Kahoot platform. The existing platform used by these educators provides an easy method for them to create game-based learning activity, where students attempt to answer quizzes in the form of multiple-choice-questions. Although some of the participants are aware of the low efficacy of MCQs, they understand the

implications of using such an approach, where they believe that it can provide a fun and engaging experience for students. Some participants have also tried implementing freely available educational games, but the learning goals of these games do not entirely meet their teaching requirements, particularly regarding the syllabus or curriculum. This shows that some participants are willing to implement SGs as teaching tools. The misalignment between gaming and learning, however, is still one of the main barriers for adopting digital educational games in the classroom.

The integration of educational technology has been further emphasised due to the shift towards providing online learning caused by the recent COVID19 pandemic. During this time, participants have adopted various IT platforms to conduct their classes and learning activities online, showing that participants, and educators in general, are capable of engaging and making use of IT tools. During the formative usability study, most of the participants found the concept in the authoring tool prototype useful, and would likely use it within their teaching. Two participants stated that they would be very likely to use the tool, where one of the reasons would probably be due to their preferences in incorporating case-studies and real-world scenarios within their teaching. As stated earlier in previous chapter, RPGs would suit learning that involves real-world scenarios, case studies and problem-based learning (O'Brien et al., 2010).

Complexity of Existing Tools

Educators are not expected to have experience in developing educational games, apart from using web-based platforms to create quizzes such as Kahoot. Creating a more complex SG using existing commercial game engines or SG-specific authoring tools was found to be highly complicated for educators (Marchiori et al., 2011). This fact was acknowledged by several participants. Two participants with prior experience in creating games were computing lecturers, who already had the necessary knowledge and skills in the area of game creation. Another participant, who was a secondary school teacher with no formal training in these areas, self-taught himself how to use Unity. According to these participants, the learning curve required to use existing game development software would be too much for the average educator, especially concerning the time and effort required to learn and create SGs.

Usability of the Prototype

Creating the Game World and Game-Objects. Participants found the components of the authoring tool prototype regarding the creation of the game world and gameobjects generally easy. The high usability of the game world component might be due to their prior experience in carrying out similar drawing operations, for example when drawing graphics (e.g., shapes) with commonly used software such as Microsoft PowerPoint. The creation of gameobjects, on the other hand, only requires participants to perform simple button clicks to set the appearance of various gameobjects. From the observations made during the usability tests, participants also learned how to use these components quickly. One recommendation was given regarding the use of BBP to configure attributes of gameobjects, which could be made simpler by utilising form controls instead.

Configuring Learning Quest. More complex operations are required for the creation of LQs, which requires participants to use BBP. This was expectedly the most complicated aspect of the authoring tool. Understanding and learning the concept of BBP and the use of the ARQS blocks, however, were found easy by most participants. The finding shares the same conclusion from a recent study regarding the use of Scratch BBP tool (Fesakis & Serafeim, 2009). Few participants did have a neutral view on the ease of use regarding the quest creation. This is understandable when using the tool and BBP for the first time.

While configuring the block structure for LQs in the authoring tool is easy, designing LQs would take most of the time when creating SRPGs, and requires creativity and self-initiative from the educators as mentioned in the previous chapter (Section 3.5.2). Several of the participants commented on the tedious work that might be involved when designing the quests. F3 commented that designing the LQs would probably take more time than actually developing the finished game. He likened the complexity of designing LQs to designing typical learning activities, then he said: "*But once you've designed the LQ, it should be easy for me to develop it into the RPG with this tool*". P3 later added: "*You can also reuse and build upon the game over time, which is fine with me.*" Although the amount of work in designing the quests would take time, developing SRPG designs into a finished game and consequently reusing and updating LQs with the ARQS authoring tool would be simple enough for educators

with no programming skills, showcasing that the tool is suitable for educators in the development phase of SRPGs creation.

Manual References and Feedback. Participants commented that learning how to program with the blocks was easy after building a few blocks and receiving the tip from the "help" feature. Readily available and supportive user manual in the form of documentation or videos should be provided in a high-fidelity version of the tool, providing a way for educators to refer to for help during quest creation. The high-fidelity tool should also provide immediate feedback when connecting blocks (e.g., blocks pinging back to the blocks library when trying to connect incompatible blocks). During the usability tests, there were several instances where participants were confused during the quest creation task, typically when performing impermissible actions, where the feedback they received was cues from the author saying they should not do the action. Visual cues used as feedback in a high-fidelity prototype would undoubtably give a more user-friendly experience.

5.4.7 Conclusion of the Formative Usability Study

The primary aim of the ARQS authoring tool is to provide a tool that allows educators to develop SRPGs themselves. The tool provides a systematic workflow that can guide educators to address the important SRPG components. The tool also provides interfaces that are suitable for educators, without requiring prior knowledge for various tasks that are typically required in the development of games, such as graphic design and programming. The formative usability study presented above (Section 5.4) serves as an initial data gathering by including target users in the design and development of the authoring tool, where outcomes from the study informed the future design of a high-fidelity version of the tool.

Participants in the study generally found the tool easy to use for the creation of the various aspects of the game such as the game world and game-objects, since it involves common operations participants were already familiar with. Using the drawing canvas to draw the game world map and locations was straightforward for the participants. So was the process of selecting visual assets for the creation of game-objects.

BBP are used to program certain aspect of the game such as the gameobjects attributes and behaviours, as well as the configuration of LQs, in which all the participants were

able to successfully complete the tasks related to these aspects. They found the overall process and blocks easy to understand and learn. Participants new to BBP, however, required help in introducing them with the concept. As identified during the study, introductory tutorials and accessible references would be provided in the high-fidelity version of the tool. Another point of consideration was related to the labels used on the ARQS blocks, where labels used would be amended to make the blocks clear, concise and obvious to educators.

While most participants found the tool useful and could be used within their teaching, considerations need to be made with regards to the workload involved in developing SRPGs from scratch. Although participants found the process of configuring LQs based on ready-made pre-defined quests easy, designing the LQ itself could still be challenging. This fact was indeed shared by findings from the studies on the design method (Sections 3.6 and 4.6).

Overall, there is still more work that needs to be done to make the AQRS authoring tool deployable in real-life settings. Nonetheless, the above presented work has clearly demonstrated the workflow and interfaces' strong potential as a usable, viable and desirable tool for teachers to support their students to learn with enjoyment. Several comments by participants were used to improve the tool for the high-fidelity prototype implementation. In particular, the use of BBP to configure gameobjects (e.g., virtual characters), and labelling of blocks. Configuring gameobjects (such as defining their properties) using BBP were found unnecessary. Form controls were identified to be more suitable in this respect. Certain block labels were also changed to a more suitable and understandable labels.

5.5 SUMMATIVE USABILITY STUDY: PROCESS AND RESULTS

The outcome from the formative usability study described above was used to refine the concept of the authoring tool, based on the participants' feedback and observations made during the study. The refined concept was then developed into a high-fidelity prototype, and subsequently used in a summative usability study, which is presented in the section.

5.5.1 Implementation of the High-Fidelity Prototype

The high-fidelity prototype was implemented prior to the summative usability study. The prototype included the completed user-interface and functionalities, allowing educators to be able to create working SRPGs (Appendix A10). HTML5 (i.e., HTML, CSS and JavaScript) was used to develop the front-end. PHP was used to implement the back end. MySQL database was used to store game data. Blockly[12] was used to implement the ARQS blocks. The data model and code architecture of the authoring tool and game engine are shown in Appendices A7, A8, and A9.

5.5.2 Study Protocol

Ten university lecturers specialising in various domains were recruited for this study (Table 5.14). Participants were given several documents prior to the study: a participation information sheet, a consent form, a privacy notice, and a questionnaire to establish their general background.

Table 5.14. Participants in the Usability Study.

ID	Age Group	Gender	Teaching Years
S1	25-39	F	9
S2	25-39	M	10
S3	25-39	M	12
S4	40-60	F	17
S5	40-60	F	23
S6	40-60	F	17
S7	40-60	M	25
S8	40-60	F	27
S9	25-39	M	11
S10	40-60	M	15

[12] https://developers.google.com/blockly

Establishing Participants' Background

The general background questionnaire was used to establish participants' general background (i.e., age range and gender), teaching experience, and any existing experience in using game-based learning or creating any forms of serious games or interactive digital-based learning activities (e.g., online quizzes). Furthermore, the questionnaire also aimed to establish participants' prior knowledge or experience in programming, especially in the use of BBP. Table 5.15 shows the participants' background.

Table 5.15. Participants in the Usability Study.

ID	Using SGs	Create Games	Create Interactive Activities	Experience in Programming*	Experience with BBP
S1	No	No	Yes	1	No
S2	No	Yes	Yes	5	Yes
S3	No	No	Yes	3	No
S4	No	No	Yes	4	No
S5	No	No	Yes	3	No
S6	No	No	Yes	2	No
S7	No	No	Yes	3	No
S8	No	Yes	Yes	3	No
S9	No	Yes	Yes	4	Yes
S10	No	No	Yes	Never	No

* Programming experience rated using a 5-likert scale.

5.5.3 Usability Test

During the usability test, each participant was required to sit for a one-on-one session with the author. Each session was allocated one-hour to complete. Each session was facilitated by the author and took place at a designated room provided by UTB. A designated computer with access to the prototype stored in a local server was provided in the room for participants to carry out the tests. The screen of the computer was mirrored to another monitor located opposite the participants' computer, thus allowing

the facilitator to constantly and unobtrusively observe participants' actions during the tests.

During the tests, each participant was required to use the prototype authoring tool in carrying out 13 tasks (Table 5.16) to create a pre-designed game. The game was designed by the author specifically for the study and was based on the "Fire Prevention" topic presented earlier (Table 3.6). Several documents were provided to each participant at the start of the test. The documents included the list of tasks, the game design document containing description on the game theme settings and player configurations, as well as the pre-designed quest detailing the structure of the LQ that participants needed to configure in the tests. Participants were asked to think aloud when carrying out the tasks during the tests. Audio and screen capture were recorded during each session. A safety restriction requiring the use of face masks was in place during the tests, and as such, recording facial expressions of participants was impossible and thus not included as one of the means for evaluating users' experience.

Table 5.16. Participants' Tasks.

Tasks			
1	Create a new Game	8	Create an NPC
2	Set lesson description	9	Create a Prop
3	Set learning outcomes	10	Create a quest
4	Configure player settings	11	Set the quest scenario
5	Create a map	12	Set the learning outcomes for the quest
6	Create a location	13	Configure the task structure for the quest
7	Create two rooms for the location		

No unsolicited help was given to participants throughout the test. The only exception was during Task 13, where they were briefly explained at the start of the task on the concept of BBP, and the author showed an example on carrying out one action (i.e., dragging one block from the library and adding it to the quest structure). This was deemed necessary as 80% of the participants were not familiar with the concept.

5.5.4 User Feedback and Usability Questionnaires

At the end of each task, each participant was asked to rate the difficulty using a 7-point Likert scale (i.e., 1: very difficult to 7: very easy) based on the SEQ (Single Ease Question; Sauro, 2012). At the end of the whole test, each participant was asked to complete the USE (Usefulness, Satisfaction and Ease of Use) questionnaire (Lund, 2001), a 7-point Likert scale (i.e., 1: strongly disagree to 7: strongly agree) metrics. The USE questionnaire also includes an open-ended question that asks participants to identify and describe five positive and negative aspects of the authoring tool prototype. Both the SEQ and USE metrics are often used in usability studies (Assila & Ezzedine, 2016).

5.5.5 Analysis Procedure

The time participants took to complete each task during the tests was recorded. Data from the background and usability questionnaires, observation notes, transcribed audio recordings of participants' comments and feedback during the tests, and screen capture recordings were used in the analysis of the study.

5.5.6 Results

In this section, the results of the task completion rate and time are first presented, followed by the results of the usability questionnaires. Positive and negative aspects of the tool identified by participants at the end of the study are also presented.

5.5.6.1. Task Completion

Table 5.17 shows the task completion rates for each of the participants, where all ten participants were able to complete Tasks 1 to 12. Only seven participants were able to complete Task 13. Participants found Tasks 1 to 4 and 8 to 12 generally "very easy" (Table 5.18), where they did not experience any difficulties in completing these tasks since it only involved simple typing and mouse click operations using form controls.

Tasks Using Drawing Editors. Tasks 5 to 7 (Table 5.16) involved creating the game world. Difficulties experienced by participants mostly related to editing drawn objects (e.g., selecting, editing.). The procedure required participants to first deselect the currently selected drawing tool from the tools panel before selecting drawn objects to be edited, where all participants took time to figure it out. Although instructions were

displayed, it took some time for them to notice the message. S6 mentioned that the instructions were positioned far from the tools panel. She suggested: "*Maybe it can be placed near the tools panel, so we easily see what is expected.*".

Task 5 was the first instance where participants experienced using the drawing editors, where the ease of task was rated as "4". All participants' proficiency did however improve in Task 7, where the average ease of use was rated as "very easy" (Table 5.18), showing they were able to remember and replicate the process as the task progressed. This fact was mentioned by three participants, that they just needed time to familiarise with the application. S8 said that: "*In the beginning you have to learn a new environment, but after a while it gets easier.*". Four participants did pick up the procedures quickly and was very proficient in these tasks, which they attributed to their prior experience with similar drawing tools such as Photoshop.

Table 5.17. Participants' Tasks' Completion.

		Completion Time		
Task	Completion Rate	Avg.	Mean	Std. Dev.
1	100%	18 secs	12 secs	0.2
2	100%	42 secs	24 secs	0.6
3	100%	1 min 36 secs	1 min 30 secs	0.8
4	100%	1 min 12 secs	1 min 12 secs	0.4
5	100%	5 min 42 secs	5 mins	2.9
6	100%	10 mins	9 mins 42 secs	5.2
7	100%	4 mins 36 secs	4 mins 18 secs	2.0
8	100%	3 mins 24 secs	3 mins 12 secs	1.4
9	100%	1 min 24 secs	1 min 18 secs	0.5
10	100%	12 secs	12 secs	0.2
11	100%	30 secs	30 secs	0.2
12	100%	18 secs	12 secs	0.1
13	70%	17 min 42 secs	17 mins	6.3

Task using BBP. Task 13 involved the BBP editor to configure the task structure of a quest, and the average ease of task was rated as "4". Individual ease of task ratings for the task were mixed, where four participants found it hard, four found it not difficult nor easy, and two found it easy. Only 70% of the participants (n=7) completed this task. Three participants who did not complete the task did not set the same field of the same block. During the observation, participants generally were able to locate the correct blocks to configure the quest structure.

Table 5.18. Ease of tasks rated by participants.

	Ease of Task (SEQ ratings)		
Task	Avg.	Mean	Std. Dev.
1	7	7	0.3
2	7	7	0.3
3	6	7	0.9
4	7	7	1.0
5	4	4	1.6
6	5	5	1.5
7	6	7	1.2
8	6	6	0.9
9	7	7	0.5
10	7	7	0.3
11	7	7	0.3
12	7	7	0.4
13	4	4	1.7

Table 5.19. Usability of the tool.

USE Component	**Avg. Rating**
Usefulness	
It helps me be more effective in creating educational games	6
It helps me be more productive in creating educational games	6
It is useful	6
It makes creating educational games easier to get done	6
Ease of Use	
It is easy to use	5
It is user friendly	5
It requires the fewest steps possible to accomplish what i want to do with it	5
I can use it without instructions	3
I can use it successfully every time	5
Ease of Learning	
I learned how to use it quickly	6
I easily remembered how to use it	6
It is easy to learn how to use it	5
I quickly became skilful with it	6
Satisfaction	
I am satisfied with it	6
I would recommend it to a colleague	6
It is fun to use	6
I feel I need to use it for some of my learning activities	6

5.5.6.2. Usability of the Authoring Tool

Table 5.19 shows participants' ratings on the tool for the Usefulness, Ease of Use, Ease of Learning and Satisfaction components of the USE questionnaire. The tool was rated highly on the usefulness, ease of learning and satisfaction components, while the ease of use scored slightly lower. This was due to the complexity of the game world environment drawing tools mentioned above, and the participants' unfamiliarity with BBP.

5.5.6.3. Positive and Negative Aspects

Table 5.20 shows key positive and negative themes identified by participants during the study. Two participants found the general interface of the tool familiar and intuitive. S5 said that "*Some of the ways to do the tasks are repetitive and similar to other applications. Like drag and drop, and clicking.*". In terms of experience, three participants noted that the tool was interesting and fun to use. S1 was excited and felt a sense of accomplishment when she played the game she created. She commented while laughing: "*Yay, I made a game. In less than an hour.*" Four participants felt the authoring workflow was easy to understand. S6 for example commented that it was easy to master due to the repetitive process and helpful component breakdown presented in the tool. Two participants commented on the lack of auto-save in some of the components of the tool, where they ended up re-doing some tasks as they forgot to save their progress before navigating to another page. Five participants noted that they needed more time to familiarise with the process, especially the BBP editor. One negative point two participants mentioned relating to BBP was the inconsistent block labels. One of the events needed to be created in Task 13 (Table 5.16) was to "show a message", but the block required to do this was labelled "Notify Player". All ten participants kept on looking for a "Show Message" block, before asking for clarification, and confirmed by the facilitator that the blocks were the same.

In terms of creating the game world environment and game-objects, four participants appreciated the responsiveness, quick and easy process of drawing the world environment and virtual characters. Three participants commented on the inability to zoom the drawing canvas in and out, making it difficult to draw the floorplan of a

location. S4 also commented on the lack of labels on the menu buttons. Menus were only presented using icons (e.g., "bin" for delete), but certain icons were not clear to participants. During Task 6 (Table 5.16), participants were asked to create a location. Once a building image on the drawing canvas was selected, they must click on the "wrench" icon on the "Edit" panel to edit and create the floorplan. All ten participants spent quite some time before actually clicking this button. When asked, they said that they were looking for a "Create a Location" button and didn't realise at first, that they could do that using the "wrench" button. Lack of action feedback when doing non-permissible actions was also commented by S5, as she said: "*Some hints may be useful when we do actions that can't be done, for example why we can't drop some objects on the canvas.*". Lack of instructions was also mentioned by three participants. Although there was a "Help" button at the top right of the screen, only three participants actually used it.

Table 5.20. Positive and Negative Aspects of the tool.

Categories	**Positives**	**Negatives**
Experience	Interesting, Easy to learn, Easy to understand, Fun, Sense of Accomplishment	-
Workflow	Helpful Component Breakdown, Familiar Process, Repetitive process, BBP is understandable,	Time spent, No Auto save, Need time to familiarise, Inconsistent Block labels, Lack of Instructions
Object Customisation	Responsive, Quick process, Game world and object customization	Lack of Action Feedback, Unable to Zoom location, Difficult Locating Drawing Tiles, Lack of Labels on Menu/Buttons
Interface	Familiar, Intuitive	Not user friendly, Unclear breadcrumbs

5.5.7 Discussion

The proposed tool was aimed to provide educators simple and quick way to create an SRPG. All participants agreed that the tool was generally very useful and easy to learn in this regard. All participants were also satisfied with it whereas some found it fun to use and provided a sense of accomplishment. However, participants found the game world drawing editors and BBP complicated as compared to the other aspects of the tool. The complexity experienced in the world drawing editors was primarily related

to the user interface design and certain drawing procedures. During the world environment tasks, all the participants were looking for specific menus to perform drawing operations (e.g., select object, create location, delete). Adding clearly labelled and persistent menus on the tools panel to carry out all the necessary drawing operations could further improve the usability of the tool.

While 80% of the participants had no experience in BBP, a 70% completion rate in the BBP tasks (Task 13, Table 5.16) can be considered a desirable outcome. Furthermore, the participants who did not complete this task only missed to complete one field in one of the blocks. This was understandable since most were inexperienced in BBP and had limited time to study and familiarise with the blocks. It was a big achievement for the participants to be able to develop a game from scratch within 1 hour (as exemplified by S1's excitement when trying out the game she produced), considering the fact that most of them had no prior knowledge or experience in BBP and game development. Creating a similar game using typical processes would involve creating the image assets using image software such as photoshop, before importing to a game software e.g., Unity. Further tasks such as creating the game's UIs, scenes, animating characters, programming player mechanics and gameplay, would make the process longer and require more effort. Although the image assets used in the prototype tool were uniform and would result in games being similar visually, the key educational component of SRPGs was the quests. The pre-defined image library can always be expanded to include more images. A feature within the tool to allow importing custom-made assets can also be incorporated in future improvements.

Another significant feature that needs to be addressed is providing clear and obvious feedback and instructions. During Task 7 (Table 5.16), participants tried to add a "sofa" to a room. Some participants initially clicked on the back wall of the room, which was not permissible unless the object to be added was a "wall" ornament. They kept on clicking on the wall and wondered why it was not drawn on the canvas. An instruction was actually shown when selecting the image in the library panel, but due to its location and long wordings, was missed by these participants at first. Displaying obvious, clear and concise feedback in response to unsuccessful user actions, as well as providing visual instructions displayed at the start of carrying out each task will be helpful.

5.5.8 Conclusion of the Summative Usability Study

All ten participants who took part in the summative usability study agreed that the tool was useful, easy to learn, and was very satisfying to use. The ease-of-use of the tool, however, received a slightly lower rating, which was primarily due to certain aspects of the drawing operations in the game world drawing editor. Providing menus to perform all the necessary drawing operations as identified by participants can improve the usability of the tool.

One key component of the tool is in the creation of quests, which is the primary outlet for embedding learning activities, and thus gameplay. BBP are used to configure these quests. Although 80% of the participants had no experience in BBP, 70% of them were able to configure a quest. The findings agree with the previous formative usability study (Section 5.4), showcasing that BBP is suitable for educators to program SGs gameplay.

Since most of the participants (n=7) in the study had never developed games, they might not be able to appreciate the simplicity of the tool as they had no baseline to make comparisons. S2 and S9 are the only participants who had extensive knowledge and were still active in game development, as both of them were currently teaching within this field. During the study, S2 said that "*The process of creating the game world is quicker (than when using Unity)*". In order to evaluate the extent to which this tool simplifies existing game development processes, future comparative analysis between the authoring process and features of the prototype and existing game development software would be needed.

One limitation of the study relates to the narrow focus on the ARQS tool. A broad study comparing the usability of various authoring tools would perhaps provide more insight into the suitability of different workflow and features. With regards to educators' experience with the ARQS tool, the usability study has demonstrated the suitability of the tool and its concept in allowing educators with no background in game development to be able to create SRPGs easily, which can bridge the gap of the low adoption in SGs. The tool can open up opportunities for educators to gamify their learning activities and present students with a more interactive and enjoyable learning experience.

5.6 SUMMARY

Findings from both the formative and summative usability studies have answered RQ 3b (i.e., *Are the interfaces and workflow usable for educators?*). The structured workflow in configuring the components of SRPGs was found to be usable by educators. In terms of the drawing features in the authoring tool, educators were able to use the workflow and tools due to similarities with existing tools they have used. In terms of programming the gameplay, BBP was found to be suitable for educators without background in programming. Although we can't make direct comparison between the proposed tool and existing game development software, average educators being able to create the SRPGs using the proposed tool shows the suitability of the interfaces and workflow with regards to educators. Participants were very satisfied with the tool, with one participant in particular was visibly excited and proud of creating a game using the authoring tool.

CHAPTER 6

EFFECTIVENESS OF EDUCATOR-AUTHORED GAMES

Research-based evidence on the positive attributes of SGs in terms of improving learning performance and affective experience have been discussed earlier (Section 2.4). This chapter approaches the final research question pursued in this thesis, regarding the effectiveness of educator-authored SRPGs as learning instructions. The games designed by educators (Chapter 4) were used in two separate experimental studies with the aim to evaluate the effectiveness of these games as learning tools. These studies are presented in this chapter, and the findings give an indication on the effectiveness of the educator-authored real-world scenarios incorporated as RPGs as learning instructions, consequently validating the usefulness of the platform.

Existing studies in the evaluation of SGs are presented first in order to portray the current research trends on how experimental studies are being implemented for establishing the effectiveness of SGs. This is followed by introducing the experimental studies conducted in this thesis, by presenting the overall study protocol and conceptual model. Recruited participants and results for each study are then discussed, before concluding this chapter.

6.1 EXISTING STUDIES IN THE EVALUATION OF SERIOUS GAMES

Evaluating the effectiveness of SGs (i.e., intervention treatment) can be achieved by carrying out an experimental study that compares the effects of this intervention against those of a non-game learning activity (i.e., control). Two types of experimental studies commonly used to this end are random control trial (RCT) and quasi-experimental design (Boyle et al., 2016; Udeozor, Toyoda, et al., 2022). In an RCT, participants are divided and randomly assigned into two groups, with each group receiving either the intervention or control (Torgerson & Torgerson, 2012).

Comparing these groups commonly involves administering tests to participants before and after their interactions with the treatment (i.e., pre-post-test), in which any differences in the learning gain (i.e., difference between pre-tests and post-tests) between the two groups are used to ascertain the learning improvement and thus the effectiveness of the treatment (Udeozor, Toyoda, et al., 2022).

A quasi-experimental design, on the other hand, differs to RCT in that participants are not randomly assigned to an intervention or a control group, rather assigned to a group based on some pre-requisite attributes (Maciejewski, 2020). Quasi-experimental designs are used more frequently than RCTs in the evaluation of SGs (Boyle et al., 2016; Udeozor, Toyoda, et al., 2022). This is due to difficulties or inconvenience in randomly splitting participants into two groups (Udeozor, Toyoda, et al., 2022). While it can provide evidence on the effectiveness of SGs, quasi-experimental design is inferior than RCT (Torgerson & Torgerson, 2012). Due to the splitting of participants based on some characteristics, some confounding factors may not be evenly distributed amongst the groups and may cause bias in the study's outcome (Barnett, 2004).

One limitation in the existing SG studies relates to the use of incomparable treatments such that the instructional activities and tasks are not equal between the different treatment groups. The study by Lopez-Fernandez et al. (2021) for instance had the control group exposed to a teacher-led class with lecture slides to accompany the teacher's explanation. Participants in the game group on the other hand were only exposed to a quiz-based SG. In this study (Lopez-Fernandez et al., 2021), participants

in both groups differ in the medium (i.e., SG vs non-game) and instructional activity (e.g., listening to lectures vs attempting quiz). The instructional activity in this current study exposed students with different set of tasks, such that the learning task in the game is not available in the control group.

According to Mayer (2019), the effectiveness of a learning activity lies in the instructional design and not merely in the medium. Students, for example, can perform better when learning with a non-game computer-based instructions than those who learn with SGs (Mayer, 2019). Experimental studies comparing SG and non-game learning materials should ensure that the only different factors between the different treatments are the inherent characteristics of the medium such as interactivity and visualisation.

6.2 LEARNING ATTRIBUTES STUDIED

Common learning attributes measured in the field of SGs were described earlier (Section 2.4). The attributes relevant to this thesis are knowledge acquisition, motivation, emotion and learning experience, which are described in the following.

6.2.1 Knowledge Acquisition

As mentioned in the previous section, pre-post-tests are administered during an experimental study to compare the effects of different treatments in various factors. The most studied factor being knowledge acquisition as the cognitive learning outcome (Boyle et al., 2016), which is one of the main foci of the experimental studies conducted in this thesis. However, most studies mainly focused on LOTS, which is an unproductive effort in the area of SGs during this past decade, considering the potential affordances of SGs in supporting HOTS (Clark et al., 2016). These studies (e.g., Lopez-Fernandez et al., 2021; Peng, 2009; Rondon et al., 2013) generally involved assessing participants using study-specific custom-designed tests that required the recall of information. The tests administered in the current experimental studies focused on HOTS, which are further described in Section 6.5.3.

6.2.2 Motivation

As addressed earlier (Section 2.4), motivation can be linked to successful learning, and is commonly studied in the area of SGs (Kara, 2021; Min et al., 2022; Udeozor, Toyoda, et al., 2022). It is typically measured using self-assessment questionnaires (Udeozor, Toyoda, et al., 2022). The *Intrinsic Motivation Inventory* (IMI; *Intrinsic Motivation Inventory*, n.d.) is a multidimensional scale used to measure users subjective intrinsic motivation when engaging with any form of target activity (e.g., Augustyniak et al., 2016; Cocca et al., 2022). This scale was adopted in the current studies. The scale consists of seven subscales: enjoyment, perceived competence, effort, usefulness, pressure, perceived choice, and relatedness. Each subscale contains several seven-point Likert scale items. The *enjoyment* and *effort* subscales directly measure intrinsic motivation. The subscales perceived *competence* and perceived *choice* are related to self-efficacy, while the *pressure* subscale is related to anxiety. The subscales *usefulness* and *relatedness* are used in the context of identifying participants' perceived value of an activity regarding self-regulation and their interpersonal interactions, respectively. Inclusion and exclusion of the subscales and their items should depend on the nature of the research questions being addressed (Markland & Hardy, 1997), where previous studies have used only three of the subscales to create a short nine-item questionnaire. For the current studies, only the dimensions *enjoyment*, *effort*, *competence*, *pressure*, and *usefulness* were relevant and used.

6.2.3 Emotion

The design of activities affects learners' emotions, which in turn affects learning performance (Section 2.4). The principle within the Self-Assessment Manikin (SAM) method (Bartosova et al., 2019; Bradley & Lang, 1994) was adopted in the current studies to evaluate the emotional impact of the game and non-game treatments. SAM is an instrument intended to assess the *valence* (i.e., feelings of pleasure), *activation* (i.e., feelings of excitement) and *dominance* (i.e., sense of in control of the situation) associated in response to an object or event. Each of these dimensions are divided into two extreme polarities and can be rated using a nine-point Likert scale. For the valence dimension, 1 represents "extremely unpleasant" and 7 represents "extremely pleasant". For the activation dimension, 1 represents "extremely calm" and 7

represents "extremely excited". For the dominance dimension, 1 represents "extremely not in control" and 7 represents "extremely in full control".

6.2.4 Learning Experience

Both motivation and emotion essentially describe learners' experience in terms of how enjoyable learning activities are but do not provide a complete evaluation on the perceived effectiveness of the activity in terms of learning. Further dimensions can be measured to this end, such as evaluating the presentation of content, feedback provided, and level of engagement and involvement with the learning content (Zerihun et al., 2012).

The *EGameFLow* (EGF) is an eight-dimension scale that measures the learning experience of participants when engaging with SGs (Fu et al., 2009), and consequently used as a tool to evaluate the effectiveness of SGs in terms of perceived effectiveness of various pedagogical aspects. EGF is one of the mostly used SG evaluation method (Petri & Gresse von Wangenheim, 2017), and was derived from the original GameFlow model which is more focused on measuring players' experience with entertainment games (Sweetser et al., 2017). Being a more learning-centric experience instrument, the EGF removed the entertainment-focused *Player Skills* component from the GameFlow model and incorporated the component *Knowledge Improvement* in order to address the specific learning characteristic of an SG.

The eight dimensions of the EGF are concentration, goal clarity, feedback, challenge, autonomy, immersion, social interaction, and knowledge improvement (Fu et al., 2009). *Concentration* relates to the design of the activities in terms of sustaining students' concentration. *Goal clarity* relates to the clear presentation of the goals of game tasks to students. *Feedback* relates to the use of feedback in terms of helping students determine their current gap in knowledge. *Challenge* relates to tasks that are suitable for students' progressive level of skills. *Autonomy* relates to students' enjoyment in taking control and initiative during gameplay. *Immersion* concerns the nature of gameplay in terms of inducing students in a state of immersion. *Social interaction* relates to games tasks in terms of allowing social interaction between students. *Knowledge improvement* concerns the ability for an SG in terms of improving students' level of knowledge or skills. Each of these dimensions consists

of several seven- point Likert scale items, with 1 being “not at all true” and 7 being “very true”, for participants to rate their agreement with the item statement.

The original EGF scale was adopted in the current studies with some minimal modification in order to make the questionnaire relevant for both the SG and non-game treatments. This involved rewording the instances of the keyword “game” in any of the items for each of the dimensions to “tutorial activity”, to mean either the game or non-game control activities. Furthermore, the challenge and social interaction dimension was discarded. Although the challenge dimension is useful to identify the effectiveness and suitability of game challenges, it is not applicable to the game used in the current study (i.e., due to short and few challenges) and for the non-game exercises (i.e., in-game hints, progressively increasing difficulties of challenges based on player skills and player type). The social interaction dimension on the other hand relates to interacting with other learners, which is not focused and not relevant to the current studies.

6.3 CONFOUNDING VARIABLES IN LEARNERS

There are several confounding variables that have been considered in SG-evaluation experimental studies: learning styles, game genre preference, and game playing habit.

6.3.1 Learning Styles

Learning styles (LS) can affect learning in the context of SGs (Wong et al., 2022) and also learning in general (Kazu, 2009). LS relates to the concept that learners differ in the types of instruction or modes of study that are suitable and effective for them (Pashler et al., 2008). Learners’ preference for a learning activity (e.g., reading, practical) is determined by their learning styles (Loo, 2004). The type of activity can also have an effect on certain learning outcomes and learners with different learning styles. A recent study by Wong et al. (2022) showed that learners with certain learning styles improved their teamwork attitude after engaging with an SG. The study however found no differences in learning gains between learners with different learning styles.

There are nearly a hundred LS models in the literature (Coffield, 2004). *Kolb’s experiential learning theory* assumes that learning occurs in a consecutive cycle

consisting of the concrete experience (CE), Reflective Observation (RO), Abstract Conceptualisation (AC) and Active Experimentation (AE) dimensions, which relate to the general process of experiencing, reflecting, thinking and acting, respectively (Kolb, 2007). Learners' preferences on these dimensions during learning lead to four learning styles: converging, diverging, assimilating and accommodating. Converging learners favour thinking and acting, are good at problem solving and more interested in practical application. Diverging learners favour experiencing and reflecting, are often imaginative, focus on observation, and tend to work well with others. Assimilating learners are more inclined towards reflection and thinking, are more comfortable with making abstract concepts or theories, and less interested in practical applications. Lastly, accommodating styles learners favour experiencing and acting, preferring practical aspect and being involved in experiencing new situations.

While not exclusively for learning, the *Myers-Briggs Type Indicator* (MBTI) is an instrument aimed to identify individuals' general personality types in the dimensions of extraversion or introversion, sensing or intuition, thinking or feeling, and judging or perceiving (Coffield, 2004). Much like Kolb's learning style, individuals' preferences in each of the MBTI dimensions are used to establish their personality.

The *Felder-Silverman learning style model* is another LS model specifically designed to identify engineering students' LS (Felder & Spurlin, 2005). In this model, LS is classified in four dimensions: sensing or intuitive, visual or verbal, active or reflective, sequential or global. The *sensing/intuitive* dimension is directly taken from MBTI's sensing/intuition dimension, which is similar to Kolb's CE and AC dimensions. In this dimension, learners are differentiated between those who prefer facts and practical, or theory and abstract concepts. The *active/reflective* dimension is analogous to Kolb's AE and RO and related to the MBTI's introvert/extrovert dimension. This dimension differentiates learners who prefer practical activities and working in groups, or those who prefer thinking things through by themselves. The third dimension, *visual/verbal*, is concerned with learners' preferences on the presentation of learning materials. Visual learners prefer materials presented visually such as through the use of pictures or diagrams, while verbal learners prefer the materials to be written or spoken. This dimension relates to the visual and verbal modalities within the visual-auditory-kinesthetic learning modalities (Barbe et al., 1988; cited by Felder & Spurlin, 2005). According to the proponents of learning

modalities, individuals have different preferences and strengths for certain type of perception. The last dimension in the Felder-Silverman model is *sequential/global*. This dimension differentiates learners who prefer learning in sequence, or those who prefer learning in large chunks and connecting these chunks holistically. This dimension is also related and based on various learning concepts found in the literature (Felder & Spurlin, 2005).

6.3.2 Genre Preferences and Playing Habit

There is still a lack of studies looking into the effects of game preferences and prior playing habit towards the effectiveness of SGs (Udeozor, Russo Abegão, et al., 2022). Learners' game genre preferences, however, might affect the effectiveness of SGs, an assumption shared with Procci et al. (2011). Learners who dislike RPG for example might be less motivated to play an SRPG. Similarly, prior game playing habit could also play a significant role in how students engage with SGs, an assumption shown by a recent study by Kaimara et al. (2019), in which students with more game experience had better experience when playing SGs. Another study, however, contradicted this point of view (Udeozor, Russo Abegão, et al., 2022), leading to the need to carry out more research to establish the influence of genre preference and playing habit on the effectiveness of SGs.

6.4 EXPERIMENTAL STUDY METHODOLOGY

To address the research questions relating to the effectiveness of the games designed by the educators using the proposed platform (Chapter 4), two experimental studies were carried out using the games designed by educators. Each of the studies aimed to evaluate these games in the context of the aforementioned domains, "Digital Art and Design" (DigiArt) and "Information Security Fundamentals" (InfoSec), which will be further elaborated in the next two sections. These studies aim to answer the following research questions:

- How effective are educator-authored SRPGs as learning instructions in terms of learning improvement? (RQ 4A)
- What are students' perceptions of learning with educator-authored SRPGs? (RQ 4B)

The first research question involves measuring and comparing learners' learning gains (i.e., knowledge acquisition) between the SG and non-game learning activities. The second question relates to measuring and comparing learners' general experience (i.e., motivation, emotion, and learning experience) between the activities. Both experimental studies share the same hypothesis. In this section, details of the hypothesis, methodology and conceptual model is presented.

6.4.1 Hypothesis

Learning Gains between SG and Non-Game Learning

In relation to the RQ 4A, the effects of educator-authored SRPGs and non-game activities in improving learning gains is the first main hypothesis to be addressed. Due to the various evidence showcasing that SRPG can lead to better learning gains, the studies in this thesis were carried out with the main assumption that the educator-authored games would result in better learning gains as opposed to non-game learning activity.

- **Hypothesis 1:** The learning gain of the students taking part in the SRPG activities is significantly higher than that of those taking part in the non-game activities to learn the same content.

Learners' Experience between SG and Non-Game Learning

In relation to RQ 4B, the effects of educator-authored SRPGs and non-game activities in improving the various aspects of learners' general experience in terms of motivation, emotion and learning experience are addressed.

Motivation. The first aspect involves motivation during the learning activities. Firstly, each IMI dimensions (Section 6.2.2) between the SRPG and non-game group is compared to establish whether there is a significant difference between the two different treatments. Secondly, further analysis is performed to establish whether students' learning gains are associated with their motivation.

- **Hypothesis 2a**: Motivation (IMI dimensions) of the students taking part in the SRPG activities is significantly higher than that of those taking part in the non-game activities to learn the same content.
- **Hypothesis 2b**: There is no significant relationship between students' motivation (IMI dimensions) and learning gains.

Emotion. The second aspect addresses learners' emotions when engaging with the treatments (Section 6.2.3). Similarly, with the motivation aspect, emotions (SAM dimensions, Section 6.2.3) felt by students during the different treatments are compared to establish if there is any significant difference. Further analysis to establish the relationship between the students' emotions and their learning gains is also carried out.

- **Hypothesis 3a**: Emotion (SAM dimensions) of the students taking part in the SRPG activities is significantly higher than that of those taking part in the non-game activities to learn the same content.
- **Hypothesis 3b**: There is no significant relationship between students' emotion (SAM dimensions) and learning gains.

Learning Experience. The final aspect concerns students' general learning experience during the learning activities (Section 6.2.4). Comparing the learning experience (EGF dimensions, Section 6.2.4) between the two different groups is carried out in order to establish students' perception of the learning effectiveness of the activities in the different treatments. The learning experience is also analysed to find out whether there is any relationship with the students' learning gains.

- **Hypothesis 4a**: Learning experience (EGF dimensions) of the students taking part in the SRPG activities is significantly higher than that of those taking part in the non-game activities to learn the same content.
- **Hypothesis 4b**: There is no significant relationship between students' learning experience (EGF dimensions) and learning gains.

Effects of Learning Styles

Students' learning style was also considered in the studies as a confounding variable, based on the assumption that learners do not learn the same way and that they have different approaches when learning (Section 6.3.1). This assumption leads to the hypothesis that there is no difference in learning gain between the treatments even after controlling for the different learning styles in students.

- **Hypothesis 5**: There is no significant difference in learning gain between students taking part in the SRPG activities and those in non-game activities when controlling for learning styles.

Effects of Genre Preferences and Playing Experience

Students' game genre preferences and previous playing experience are expected to influence their experience with the educator-authored SRPGs. Genre preferences refer to game genres the students enjoy playing, while previous playing experience refers to their playing habit in terms of the frequency of playing games and their general experience during gameplay. These lead to the hypotheses that there are no significant relationships between these attributes and the general experience factors.

Hypotheses in relation to Game Preferences

- **Hypothesis 6**: There is no significant relationship between students' game genre preferences and (a) motivation (IMI dimensions), (b) emotion (SAM dimensions), (c) learning experience (EGF dimensions), during the SRPG activity.

Hypotheses in relation to Game Playing Experience

- **Hypothesis 6**: There is no significant relationship between students' game playing experience and (d) motivation (IMI dimensions), (e) emotion (SAM dimensions), (f) learning experience (EGF dimensions), during the SRPG activity.

6.4.2 Study Protocol

Learning Activity Treatments. The studies involved the use of the SRPGs designed by the two lecturers (Section 4.5.1) as the intervention treatment. A non-game activity was also created as the control. In order to ensure the comparability of both the intervention and control group, the activities from SRPGs were used as the basis for the activities in the control group. This involved converting the game activities into a question-and-answer format typically used in traditional non-game learning activity, which resulted in the creation of digital quiz-based activity for the control group. All important aspects of the SRPGs were able to be replicated in this format, but certain player tasks in the games cannot be presented in the control activity. For example, player tasks in InfoSec's games such as finding an NPC and installing a device require exploring a virtual world and interacting with game objects.

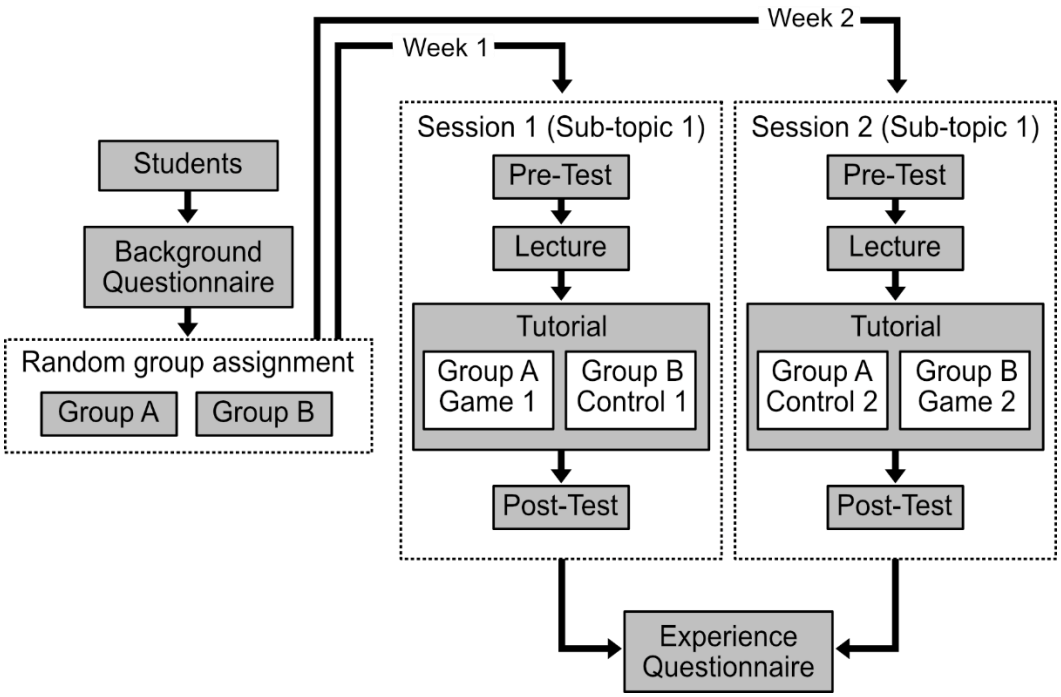


Figure 6.1. Procedure for the experimental studies.

Study Design and Procedure. As mentioned earlier, the two studies are concerned with the domains DigiArt (for Study 1) and InfoSec (for Study 2). Figure 6.1 shows the procedure of the studies. There were two sessions for each study, with each session only involved one type of activities: educator-authored games and their corresponding non-game control activities. Participants for each domain were randomly divided into two groups, with each group receiving different activities during each session. Table 6.1 shows the detail of the groups and their associated learning activities for each session.

Design of the procedure is to remove the order effect, particularly when conducting a within-subject analysis. A *within-subject* analysis was conducted by comparing the same groups' performance and experience with the game in one session and the non-game in the other session (e.g., DigiArtG1 in DigiArtGame1 vs DigiArtControl2). The same content cannot be used for both sessions in order to avoid memory effect, which is the reason why two related sub-topics were used instead within the two sessions (Table 6.2). Both sub-topics for each domain share the same learning objectives and related content.

Table 6.1. Activities exposed to participants during the studies.

		Activities	
Domain	**Group**	**Session 1**	**Session 2**
DigiArt	Group DigiArt 1 (DigiArtG1)	DigiArtGame1	DigiArtControl2
	Group DigiArt1 (DigiArtG2)	DigiArtControl1	DigiArtGame2
InfoSec	InfoSec Group 1 (InfoSecG1)	InfoSecGame1	InfoSecControl1
	InfoSec Group 2 (InfoSecG2)	InfoSecControl2	InfoSecGame2

Table 6.2. Sub-topics for DigiArt and InfoSec.

Domain	**Session 1**	**Session 2**
DigiArt	Protecting Copyright and Design	Protecting Trademark and Patent
InfoSec	Ways an organisation can be compromised (e.g., malware)	Protect an organisation from being compromised by malware (e.g., firewall)

A *between-subject* analysis was also conducted by comparing the groups in Session 1 (i.e., DigiArtG1 as game group and DigiArtG2 as non-game group). The decision to only use data from S1 for the between-subject analysis is due to the fact that S1 was the first time where participants were exposed to the treatment of the study.

One week before the first session commenced, participants were asked to complete a "Background" pre-questionnaire to establish their genre preferences, game playing experience and learning styles. Each of the sessions in the experiments was completed within 2 hours and conducted within the space of one week. At the start of each session, participants were first given a pre-test, where they were required to complete the test in ten minutes. Participants were then presented with a twenty-minute lecture. After the lecture, the game group for the session then moved to a different room. Both groups were then given their respective treatment. Each group were given twenty-minutes to engage in a tutorial activity with their allocated treatments. Once the tutorial was completed, participants were then given a post-test, which was the same as the pre-test. Before the conclusion of each session, participants were required to

complete the "Experience" post-questionnaire to report on their experience with the activities they received during the sessions.

6.4.3 Participants Recruitment

Participants in these studies were students from the respective DigiArt and InfoSec domains. Each participant was given the necessary participant information sheet, consent form and privacy notice prior to the experimental studies. All students (i.e., N=49 for DigiArt and N=79 for InfoSec) undertaking these subjects in that academic term agreed to participate in the studies. However, not all students attended the studies due to various reasons. A detailed breakdown of the participants who took part in the studies is presented in the respective sections (Sections 6.6 and 6.7).

6.4.4 Conceptual Model

Figure 6.2 shows the conceptual model of the experimental studies. The effectiveness of the educator-authored games was evaluated by comparing it against the non-game learning activities. Students' learning gains and experience with these treatments were used as dependent variables (DVs) for the comparison. Furthermore, the effect of students' individual differences was considered as co-variates. Learning style were assumed to affect the experience with the different treatments, while learners' game experience during the activities were assumed to affect their experience with the game treatment.

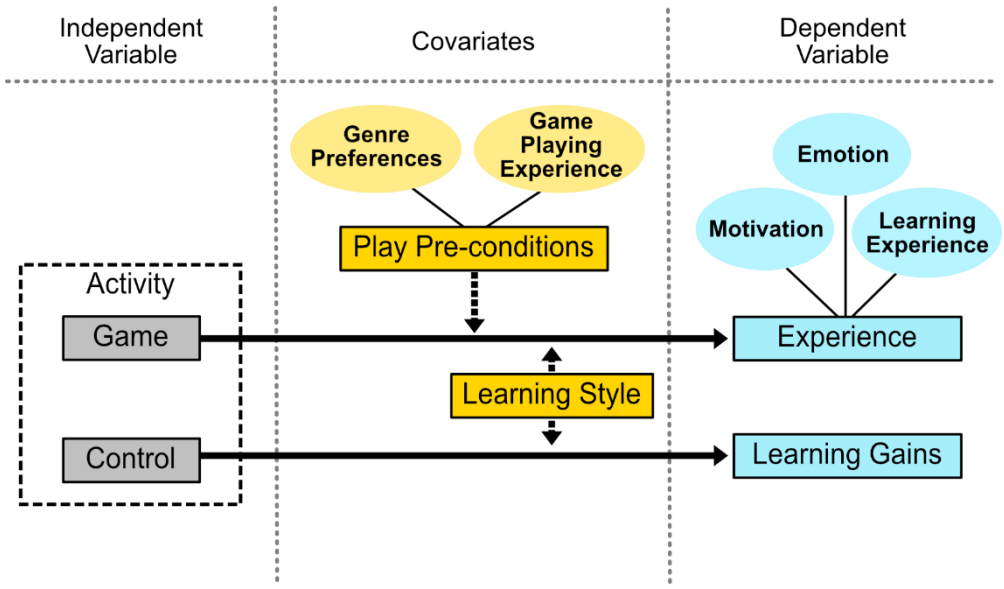


Figure 6.2. Conceptual model of the activities' impact on learning gains and experience.

6.5 STUDY MATERIALS

In this section, further description of the instruments used in the studies is presented.

6.5.1 Game Applications

The games used for the studies were designed by the two lecturers during the case study (Chapter 4). The gameplay for these games has also been introduced and discussed (Section 4.5). The games were implemented into working games using the ARQS authoring tool (Screenshots of the implemented games are shown in Appendices A5 and A6). The games were accessible online during the time of the studies through the ARQS web page[13]. Each participant was given a username and password to access the system a day before each session was conducted. Although participants could log into the web page before the study, the games were only made accessible during the tutorial activity in the sessions.

6.5.2 Background Questionnaire

The background questionnaire consists of three sections aimed to identify the participants' genre preferences, game playing experience and learning style (Appendix A3).

Genre Preference Section

The common relevant genres of Mini-Games, Action, Adventure, Strategy, Role-play, and Simulation were used in the background questionnaire. Participants were required to rate on whether they agreed and enjoyed each of these genres using a 5-point Likert scale, with 1 being "not at all true" and 5 being "very true".

Game Playing Habit Section

Participants were required to rate their frequency of playing entertainment and serious games. The term "Serious Games" was rephrased as "Educational Games" to allow participants to understand it. A 6-point Likert scale was used to rate this aspect (0

[13] http://arqs.azhanahmad.org/arqs

:"never played", 1: "yearly", 2: "six-monthly", 3: "monthly", 4: "weekly", 5: "daily"). Another set of questions relates to rating how much they enjoyed their experience when playing entertainment and educational games, using a 6-point Likert scale with 0 being "N/A" (i.e., when they never played a game), 1 being "very negative" and 5 being "very positive".

Learning Styles Section

The final section in the questionnaire was for participants to identify their learning styles using the "Index of Learning Styles" (ILS) questionnaire[14] which is available online. The questionnaire is based on the Felder-Silverman Model described earlier (Section 6.3.1). Participants were required to identify their learning style using the external questionnaire and input their learning style output into the background questionnaire. The decision to adopt the Felder-Silverman model and the ILS questionnaire in the current studies was based on the fact that it was specifically purposed for engineering students, which is highly related to the domains and students participating in the current studies, and readily available and free to use. Secondly, the dimensions in the model are based on other learning style models.

6.5.3 Knowledge Assessment Tests

The pre-post-tests administered during the studies are relevant to the first hypothesis (Section 6.4.1). As mentioned earlier, learning gains measured in the current studies relate to HOTS. The author designed one test for each session in each experimental study. The same test was used for the pre and post testing for each session. The learning content identified during the case study (Section 4.4) were used as the basis for the tests. The tests were moderated and reviewed by the two lecturers who designed the SRPGs for the current studies.

Test Format and Questions

Each test consists of a scenario describing the main overarching problem related to the sessions' respective sub-topic. This is then followed by a series of *constructed-response* questions relating to the scenario descriptions. A constructed-response

[14] https://www.webtools.ncsu.edu/learningstyles/

questions are open-ended, and require students to provide a response (e.g., written or demonstration) to show their understanding, ability to organise and apply learned knowledge or skills to a particular new context (Arter & McTighe, 2001). Each test in DigiArt consists of four questions with the total marks of 17 points, while each test in InfoSec consists of five questions with the total marks of 16 points. The questions mostly addressed the *analyse* and *evaluate* cognitive learning outcome dimensions (Table 6.3) based on Bloom's revised cognitive domain taxonomy (Krathwohl, 2002).

Analytical Questions. The "analyse" dimension involves breaking information into its constituent parts and identifying relationships between these parts and as a whole (Krathwohl, 2002). This typically involves the processes of differentiating, organising and attributing. One way of assessing this dimension involves the use of questions that require learners to analyse a piece of information and make inference of the central idea that is implicitly hidden within the information (Brookhart, 2010). Analytical questions in the current studies' tests require students to analyse the scenario. For example, the scenario in DigiArt's Session 2 test relates to a company and its product. The analytical questions require participants to analyse the scenario description and identify the uniqueness, significance and nature of the product, and thus provide a suitable intellectual property the company should apply for in terms of protecting an invention and establishing their company brand. For DB's Session 2 test, the scenario relates to a web-based management system used at a university to manage student progression, and learning and exam materials. The analytical question in this test requires participants to analyse the scenario description to identify the importance of the system in the context of storing sensitive and important data as a justification on the importance of securing the university's network.

Evaluate Questions. The "evaluate" dimension involves judging information based on criteria or standards, and typically involves the processes of checking and critiquing (Krathwohl, 2002). One way to assess this dimension is to use questions that require students to judge a piece of information or method for its intended purposes, and compare it against some criteria or standards (Brookhart, 2010). For example, the scenario in DigiArt's Session 1 test relates to a furniture company whose furniture design was stolen. One of the evaluative questions in the test requires participants to judge a course of action on whether it is a suitable approach in terms of protecting their furniture designs. This requires participants to understand what is being

protected and the suitable IP that should be applied based on this criterion. For InfoSec's Session 1 test, the scenario relates to a web-based management system used by the student registration office at a university to manage student enrolment and progression. One of the evaluative questions in the test requires participants to evaluate the suitability of the location where a dedicated computer to access the management system is located. Participants would need to realise the potential risks associated to this location and argue, with justification, against placing the computer at this location.

Table 6.3. Type of questions present in the knowledge pre-post-test for both domains.

Question No	DigiArt		InfoSec	
	Session 1 (Max Marks)	**Session 2 (Max Marks)**	**Session 1 (Max Marks)**	**Session 2 (Max Marks)**
1	Evaluate (4)	Analysis (4)	Evaluate (3)	Analysis (2)
2	Evaluate (5)	Evaluate (3)	Evaluate (3)	Evaluate (4)
3	Analysis (2)	Evaluate (4)	Evaluate (4)	Evaluate (4)
4	Evaluate (6)	Evaluate (6)	Evaluate (4)	Evaluate (4)
5	-	-	Evaluate (2)	Evaluate (2)
Total Max Marks	17 points	17 points	16 points	16 points

Scoring Rubric for Test Assessment

As identified earlier, the use of constructed-response questions is to identify if students are able to apply learned knowledge or skills to a particular context. Evaluating students' responses on these types of questions require a *performance criterion* as a guideline to objectively evaluate the responses (Arter & McTighe, 2001). The performance criteria can be used in a scoring rubrics to assess whether students have achieved the required performance in their responses (Moskal, 2002). Two types of rubrics are commonly discussed in the literature: analytic and holistic. An analytic rubric consists of several facets of a performance, with each facet evaluated using a separate scoring scale, while a holistic rubric involves evaluating the performance as a whole (Moskal, 2002).

Participants' answers to the knowledge tests in the current studies were evaluated using a combination of analytic and holistic scoring rubrics specifically designed for the tests. For each question, performance criteria related to the learning outcome were identified and used within the rubric. Each performance criterion is allocated a max of two points, which denotes that all facets of the performance are satisfied. One point is allocated for a criterion that is not fully satisfied, while zero point is allocated for a criterion that is not met at all.

6.5.4 Experience Questionnaire

The experience post questionnaire used in the studies (Appendix A4) was designed to measure participants' motivation, emotion, and learning experience in relation to the use of the SGs and non-game activities. Established instruments for each of these factors presented earlier (Sections 6.2.2, 6.2.3 and 6.2.4) were adopted and incorporated. The last section in the questionnaire includes two open-ended questions for participants to identify the positive and negative aspects of the tutorial activities they experienced during each session in the studies. The section aims to get some qualitative data regarding the different treatments from all participants without resorting to using interviews.

6.6 STUDY 1: DIGITAL ART AND DESIGN GAME

6.6.1 Sample Size and Analysis

Prior to the start of the study, the required sample size for the current study was calculated to be 16 participants per group (i.e., Total of N=32) based on the effect size of 1. The value is based on the average effect size for SG evaluation studies I the area of non-science domain (Mayer, 2019).

As mentioned earlier (Section 6.4.3), all students (N=49) who sat for DigiArt agreed to take part in Study 1. However, not all participants attended the study, and a few of them attended only one of the sessions in the study due to various reasons. Table 6.4 shows the final breakdown of participants used in the analysis for Study 1. 17 participants attended both sessions, and were divided into two groups: DigiArtG1 (n=10) and DigiArtG2 (n=7). In Session 1, DigiArtG1 was assigned as the game group

and DigiArtG2 was assigned as the control group. The treatment order was reversed in Session 2. A total of 28 participants attended Session 1, where they were divided into the game group (n=15) and control group (n=13). The procedure of the study was introduced earlier (Section 6.4.2), where a between-subject and within-subject analyses were performed. The between-subject analysis involved the two groups (15 Game and 13 Control) from session 1, while the within-subject analysis on the other hand involved participants who attended both sessions (n=17). Some participants are included in both of the data sets for these analyses. The total number of unique participants who attended the studies were 25 (game group) and 20 (non-game group). This data is used for hypothesis 2b, 3b, 4b, 5a, and 6 (Section 6.4.1).

Table 6.4. Participant breakdown (Study 1).

		Treatment Groups Sample Size		
	Session	**Game**	**Non-Game**	**Data Analysis**
Attended both sessions	1	10	7	Within-Subjects
	2	7	10	
Session 1 only	1	15	13	Between-subjects
Total (No overlapping participants)		25	20	*

*Data used in Hypothesis 2b, 3b, 4b, 5a and 6 (Section 6.4.1)

6.6.2 Results

Following the conceptual model described in Section 6.4.4, the data from the experiments were analysed to compare the effects of the SRPG and non-game treatments in terms of learning gains, students' experience, and the impact of students' individual differences (i.e., co-variates) on both the learning gains and students' experience.

6.6.2.1. Learning Gains

The analysis here addressed Hypothesis 1 (i.e., *The learning gain of the students taking part in the SRPG activities is significantly higher than that of those taking part in the non-game activities to learn the same content*). Table 6.5 shows the descriptive statistics for the analysis.

Learning gains refers to the difference between the pre and post-tests total marks (i.e., by subtracting pre-test marks from post-test marks for each participant). In the between-subject analysis, preliminary checks found the data met the assumptions of normality using Shapiro Wilk test (Game group: n=15, W=0.96; p=0.62, Control group: n=13, W=0.93, p=0.37). Independent t-test conducted found no significant effect of the game compared to the control (N=28, t(26)=0.18, p=0.43).

Table 6.5. Assessment marks statistics (Study 1)

		Game		Control	
		Mean	**SD**	**Mean**	**SD**
Within-analysis DigiArtG1 (N=7)	**Pre Marks**	2.00	1.15	2.86	1.95
	Post Marks	2.71	1.98	5.43	2.99
Within-analysis DigiArtG2 (N=10)	**Pre Marks**	1.9	1.66	2.5	1.65
	Post Marks	6.8	2.53	3.9	3.21
Between-Analysis (N=28)	**Post-Pre-tests Mark Difference**	1.53	1.96	1.38	2.33

In the within-subject analysis, several paired t-tests were conducted (Figure 6.3). The tests were performed for each group (i.e., DigiArtG1 and DigiArtG2) in each session, to identify any significant difference between the pre and post-tests. Results for the tests performed on the same group are then compared to identify whether the game results in a positive or better outcome than the control (i.e., Test 1 against Test 4 for DigiArtG1, Test 3 against Test 2 for DigiArtG2). This approach was implemented due to the different sub-topics used in Session 1 and 2. Applying paired t-tests to compare the learning gains between game and control activities from the different sessions is inappropriate due to the difference in the content of the activities. Preliminary checks with Shapiro Wilk tests found all the data were normal. One-tailed parametric paired t-tests were used to test whether the post-tests were greater than the pre-tests.

The results of the tests are shown in Table 6.6. DigiArtG1 performed significantly better in DigiArtControl2, while no difference was found when using DigiArtGame1. For DigiArtG2, both treatments resulted in a significant difference. However, their

results from DigiArtGame2 were better than DigiArtControl 1 in terms of effect size and mean difference.

The between and within analysis results showed weak evidence on the positive effects of the games used in Study 1, thus partially accepting Hypothesis 1a.

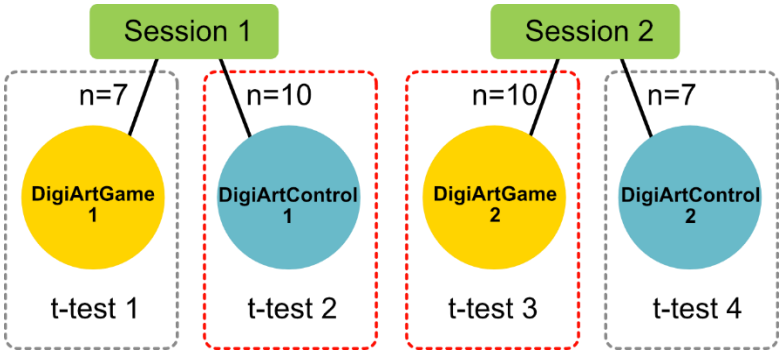


Figure 6.3. Tests to compare learning gains (Within-subject, Study 1).

Table 6.6. Test results (Within-subjects, Study 1).

	Game	**Control**
DigiArtG1 (n=7)	(Test 1) t(6)=1.18, p=0.14, d=0.2 mean difference=0.71	(Test 4) t(6)=2.32, p=0.03, d=0.5 mean difference=2.57
DigiArtG2 (n=10)	(Test 3) t(9)=5.44 p<0.001, d=0.8 mean difference=4.9	(Test 2) t(9)=1.99 p=0.04, d=0.3 mean difference=1.4

6.6.2.2. Motivation

Motivation between Game and Non-Game

The first analysis addressed Hypothesis 2a (i.e., *Motivation [IMI* dimensions*] of the students taking part in the SRPG activities is significantly higher than that of those taking part in the non-game activities to learn the same content*). Table 6.7 and Table 6.8 shows the descriptive statistics for motivation in the within-subjects and between-subjects analysis respectively.

In the between-subjects analysis, Mann-Whitney U test was used on each of the motivation dimensions. Only “enjoyment” was found significantly better in the game group (N=28, U=153.5, p<0.01, d=0.60).

In the within-subject analysis, Wilcoxon Signed-rank tests were carried out for both DigiArtG1 and DigiArtG2 (game vs control) on each of the motivation dimensions. No significant difference was found in DigiArtG1. In DigiArtG2, "enjoyment" was found to be significantly better during the game ($N=7$, $V=83.5$, $p<0.01$, $d=0.60$).

The results mean that the game in Study 1 is only more enjoyable than the control. Hypothesis 2a is accepted only for the enjoyment dimensions.

Table 6.7. Motivation's ratings (Within-subjects, Study 1)

	Within Analysis DigiArtG1 (N=7)				**Within Analysis DigiArtG2 (N=10)**			
Motivation Dimensions	**DigiArtGame1**		**DigiArtControl2**		**DigiArtGame2**		**DigiArtControl1**	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Enjoyment	5.14	0.90	4.83	1.17	5.2	1.03	3.7	1.06
Competence	4.43	0.79	4.40	1.14	4.7	0.95	4.7	0.95
Effort	4.00	1.15	3.83	1.17	4.4	0.97	4.4	0.70
Pressure	2.43	0.79	2.67	1.03	2.9	1.10	2.8	1.14
Usefulness	5.43	0.98	5.00	1.26	5.1	1.37	4.3	1.25

Table 6.8. Motivation's ratings (Between-subjects, Study 1)

	Between Analysis (N=28)			
Motivation Dimensions	**DigiArtGame1**		**DigiArtControl1**	
	Mean	**SD**	**Mean**	**SD**
Enjoyment	5.27	1.10	4.00	1.15
Competence	4.93	0.88	4.62	0.87
Effort	4.27	1.03	4.38	0.87
Pressure	2.13	0.99	2.62	1.04
Usefulness	5.20	0.86	4.54	1.20

Relationship between Motivation and Learning Gains

The second analysis addressed hypothesis 2b (i.e., *There is no significant relationship between students' motivation [IMI* dimensions*] and learning gains*).

Simple Linear Regression and Pearson's correlation coefficient tests were performed for each of the motivation dimensions against the learning gains for all the participants (N=45) in Study 1, in order to establish whether their learning gains were associated by any of the motivation dimensions. Only "enjoyment" was found to have a significant ($p \leq 0.05$) moderate positive relationship ($r<0.4$) with learning gains ($R^2=0.13$, $b=0.89$). The result leads to the conclusion that the learning gains are only associated to the level of enjoyment. Hypothesis 2b is thus rejected only for enjoyment.

6.6.2.3. Emotion

Emotion between Game and Non-Game

The first analysis addressed Hypothesis 3a (i.e., *Emotion [SAM dimensions] of the students taking part in the SRPG activities is significantly higher than that of those taking part in the non-game activities to learn the same content*). Table 6.9 and Table 6.10 shows the descriptive statistics for emotion in the within-subjects and between-subjects analysis respectively.

In the between-subjects analysis, Mann-Whitney U test was used on each of the emotion dimensions. Only "Activation" was found significantly different (N=28, U=147, $p<0.001$, d=0.60). In the within-subject analysis, Wilcoxon Signed-rank tests were carried out on each of the emotion dimensions for both DigiArtG1 and DigiArtG2 (Game vs Control). In DigiArtG1, "Activation" was showed to be significantly better during the game (N=10, V=41, p=0.01, d=0.6). In DigiArtG2, "Valence" (N=7, V=74.5, p=0.03, d=0.5) and "Activation" (N=7, V=80.5, p=0.01, d=0.6) were found significantly better during the game.

The results mean that that the game was perceived to be more pleasant and exciting than the control. Hypothesis 3a is accepted only for the dimensions Valence and Activation.

Relationship between Emotion and Learning Gains

The second analysis addressed hypothesis 3b (i.e., *There is no significant relationship between students' emotion [SAM dimension] and learning gains*).

Simple Linear Regression and Pearson's correlation coefficient tests were performed for each of the emotion dimensions against the learning gains for all the participants

(N=45) in Study 1, in order to establish whether their learning gains were associated by any of the emotion dimensions. No significant relationship was found. Hypothesis 3b is thus accepted.

Table 6.9. Emotion's ratings (Within-subjects, Study 1)

	Within Analysis DigiArtG1 (N=7)				**Within Analysis DigiArtG1 (N=10)**			
Emotion Dimensions	**DigiArtGame1**		**DigiArtControl2**		**DigiArtGame2**		**DigiArtControl1**	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Valence	6.43	1.4	5.71	1.6	7.0	1.41	5.6	1.58
Activation	5.86	1.46	4.00	1.53	6.0	2.31	3.7	1.95
Dominance	6.00	1.83	4.57	2.30	6.7	1.34	6.0	1.63

Table 6.10. Emotion's ratings (Between-subjects, Study 1)

	Between Analysis (N=28)			
Emotion Dimensions	**DigiArtGame1**		**DigiArtControl1**	
	Mean	**SD**	**Mean**	**SD**
Valence	6.53	1.36	5.85	1.57
Activation	5.67	1.80	3.92	2.02
Dominance	5.73	1.75	6.15	2.19

6.6.2.4. Learning Experience

Learning Experience between Game and Non-Game

The first analysis addressed Hypothesis 4a (i.e., *Learning experience [EGF dimensions] of the students taking part in the SRPG activities is significantly higher than that of those taking part in the non-game activities to learn the same content*). Table 6.11 and Table 6.12 shows the descriptive statistics for learning experience in the within-subjects and between-subjects analysis respectively.

In the between-subjects analysis, Mann-Whitney U test was used on each of the learning experience dimensions. "Concentration" (N=28, U=133.5, p=0.04, d=0.40)

and "Clarity" (N=28, U=141, p=0.02, d=0.50) were found to be significantly better in the game.

In the within-subject analysis, Wilcoxon Signed-rank test was used on each of the learning experience dimensions for both DigiArtG1 and DigiArtG2. Only "Clarity" was found to be significantly better in the game for DigiArtG1 (N=10, V=38.5, p=0.04, d=0.5). For DigiArtG2, "Clarity" (N=7, V=80.5, p<0.01, d=0.6) and "Feedback" (N=7, V=84, p<0.01, d=0.6) were found to be significantly better in the game.

The results mean that the learning activity in the game is better than the control in terms of making students more focused, useful feedbacks and clarity of task goals. Hypothesis 4a is accepted only for dimensions Concentration, Clarity and Feedback.

Table 6.11. Learning Experience's ratings (Within-subjects, Study 1)

	Within DigiArtG1 (N=7)				**Within DigiArtG2 (N=10)**			
Learning Experience Dimensions	**DigiArtGame1**		**DigiArtControl2**		**DigiArtGame2**		**DigiArtControl1**	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Concentration	5.71	1.11	5.17	0.98	4.9	0.88	4.7	1.25
Clarity	6.14	1.21	5.00	0.82	6.1	1.10	4.8	1.03
Feedback	5.00	1.41	4.71	1.25	6.1	1.45	4.3	1.16
Autonomy	5.00	1.63	3.86	1.07	5.2	0.92	4.4	1.35
Immersion	4.71	1.60	3.57	1.27	4.3	1.25	3.5	1.43
Knowledge	5.57	0.98	5.29	1.11	5.7	0.95	5.2	1.32

Table 6.12. Learning Experience's ratings (Between-subjects, Study 1)

	Between Analysis (N=28)			
Learning Experience Dimensions	**DigiArtGame1**		**DigiArtControl1**	
	Mean	**SD**	**Mean**	**SD**
Concentration	5.67	1.05	4.85	1.14
Clarity	5.93	1.03	5.08	1.04
Feedback	5.07	1.22	4.38	1.12

	Between Analysis (N=28)			
Learning Experience Dimensions	**DigiArtGame1**		**DigiArtControl1**	
	Mean	**SD**	**Mean**	**SD**
Autonomy	5.27	1.33	4.46	1.27
Immersion	4.47	1.41	3.69	1.44
Knowledge	5.73	0.88	5.38	1.26

Relationship between Learning Experience and Learning Gains

The second analysis addressed hypothesis 4b (i.e., *There is no significant relationship between students' learning experience [EGF dimensions] and learning gains*).

Simple Linear Regression and Pearson's correlation coefficient tests were performed for each of the emotion dimensions against the learning gains for all the participants (N=45) in Study 1, in order to establish whether their learning gains were associated by any of the learning experience dimensions. No significant relationship was found. Hypothesis 4b is thus accepted.

6.6.2.5. Impact of Learning Styles

Comparison of the learning gains between the game and control groups when controlling for the learning style co-variate (i.e., active/reflective, sensing/intuitive, visual/verbal, and sequential/global) addressed Hypothesis 5 (i.e., *There is no significant difference in learning gains between students taking part in the SRPG activities and those in non-game activities when controlling for learning styles*).

One-Way ANCOVA was used and conducted for all participants (N=45) in Study 1. The assumptions of normality ($W=0.97$, $p=0.39$), independence between variables using correlation tests, and homogeneity of variance ($F(1,83)=0.05$, $p=0.82$) were met. There was no significant difference in learning gains between the game and control after controlling for learning style ($F(1,38)=1.74$, $p=0.19$), and none of the learning styles showed significant impact on learning gains. Hypothesis 5 is thus accepted.

6.6.2.6. Impact of Genre Preferences

Participants' genre preference was another confounding variable that was considered to influence students' motivation, emotion and learning experience when they were engaged with the game treatment. Simple Linear Regression and Pearson's

Correlation Coefficient tests were performed for each of the genre preferences against each dimension in motivation, emotion and learning experience. Data used in the analysis involved all participants in the game group (N=25) during Study 1.

Relationship between Game Genre Preferences and Motivation.

The first analysis is to address hypothesis 6a (i.e., *There is no significant relationship between students' game genre preferences and motivation [IMI dimensions] during the game activity*).

Only the preference for "Adventure" games was found to have a significant ($p \leq 0.05$) moderate positive relationship ($r=0.4$) with the motivation factor "Competence" ($R^2=0.2$, $b=0.61$). The result implied that higher preference for adventure games was associated to a higher perceived competence with the game activity. Hypothesis 6a is thus rejected only for the significant relationship between adventure and competence.

Relationship between Game Genre Preferences and Emotion.

The second analysis is to address hypothesis 6b (i.e., *There is no significant relationship between students' game genre preferences and emotion [SAM dimensions] during the game activity*). No significant relationship was found between any of the genre preferences and emotion factors. Hypothesis 6b is not rejected.

Relationship between Game Genre Preferences and Learning Experience.

The third analysis is to address hypothesis 6c (i.e., *There is no significant relationship between students' game genre preferences and learning experience [EGF dimensions] during the game activity*). No significant relationship was found between any of the genre preferences and learning experience factors. Hypothesis 6c is not rejected.

6.6.2.7. Impact of Game Playing Experience

Participants' game playing experience is another confounding variable that was considered to influence students' motivation, emotion and learning experience when they were engaged with the game treatment. Simple Linear Regression and Pearson's Correlation Coefficient tests were performed for each of the game playing experience (i.e., entertainment games playing frequency, entertainment games experience rating,

educational games playing frequency, and educational games experience rating) against each dimension in motivation, emotion and learning experience. Data used in the analysis involved all participants (N=25) in the game group during Study 1.

Relationship between Game Playing Experience and Motivation.

The first analysis is to address hypothesis 6d (i.e., *There is no significant relationship between students' game playing experience and motivation [IMI dimensions] during the game activity*).

Only the "Educational game experience rating" was found to have a significant ($p \leq 0.05$) moderate positive relationship ($r=0.4$) with the motivation factor "Pressure" ($R^2=0.2$, $b=0.42$). The results implied that the game treatment had a negative effect on students' feelings of pressure, where better playing experience with existing educational games was associated to a higher perceived pressure with the game treatment. Hypothesis 6d is thus rejected only for the significant relationship between educational game experience rating and pressure.

Relationship between Game Playing Experience and Emotion.

The second analysis is to address hypothesis 6e (i.e., *There is no significant relationship between students' game playing experience and emotion [SAM dimensions] during the game activity*). No significant relationship was found between any of the game playing experience and emotion factors. Hypothesis 6e is not rejected.

Relationship between Game Playing Experience and Learning Experience.

The third analysis is to address hypothesis 6f (i.e., *There is no significant relationship between students' game playing experience and learning experience [EGF dimensions] during the game activity*).

Only the "Educational game playing frequency" was found to have a significant ($p \leq 0.05$) strong negative relationship ($r=-0.7$, $p<0.01$) with the learning experience factor "Feedback" ($R^2=0.44$, $b=-0.90$). The result implied that the game treatment had a negative effect on students' perception on the feedback, where playing educational games more frequently was associated to low ratings on the feedback used in the game

treatment. Hypothesis 6f is rejected only for the significant relationship between educational game playing frequency and feedback.

6.6.2.8. Positive and Negative Aspects

The qualitative feedback on the positive and negative aspects of the treatments were also collected during the study. The comments were categorised and shown in Table 6.13.

Table 6.13. Summary of comments in Study 1.

	Game (number of comments)	Non-Game (number of comments)
Positive	**Experience:** Fun (5), Engaging (3), Motivating (1), Interesting (3), **Application:** Interactive (2), Avatar customisation (3), RPG-style (1), Quest (2), Interact with virtual characters (2), Theme (1), Exploration (1) **Learning:** Feedback (4), Informative (7), Real-world scenarios (3), Simple challenge (1)	**Experience:** Motivating (1), Fun (1), Engaging (1) **Application:** Quiz (2) **Learning:** Informative (11), Feedback (4), Real-world scenarios (1)
Negative	**Experience:** Limited time (2), No collaboration (1) **Application:** Lagging (2), Low quality graphics (1), Small game world (3), Limited avatar customisation option (1), UI feature (2) **Learning:** Dialog (5), Limited challenge (1), Repetitive challenge (1)	**Experience:** Boring (6), Limited time (1) **Application:** No graphics (1), Typical activity (1), Simple quiz (1) **Learning:** Repetitive questions (3), Limited feedback (1)

Comments on User Experience

The first category of comment related to participants general experience with the game and control activities. Most of the positive comments pointed to the experience associated with the activities such *fun*, *engaging*, *motivating* and finding it *interesting*. There were more positive experiences mentioned in relation to the game. Several

comments were specifically associated to the unique and interesting nature of the game, and that game would be more fun than typical learning activities. For negative experiences, few of the comments were related to the *limited time* afforded during the study and the *lack of collaboration* (i.e., interaction with fellow students), which was unavoidable due to the purpose and nature of the study. With regard to the control, several comments were made on the *boring* aspect of the activity, which was associated to typical learning activities the participants were already accustomed to.

Comments on the Applications

The second category of comments are related to the overall nature of the platform (i.e., game and quiz). Positive comments on the game related to the inherent characteristics of games in general, such as *interactivity*, *exploration* and *character customisation*. There was only one positive comment for the control, which was related to the *quiz-based* nature of the application. For the negative aspects, there were more comments made for the game compared to the control. Some of these comments related to the unavoidable *internet connectivity* issues when first loading the game. Another aspect related to the limitations of the game implementation such as *low-quality graphics*, *few character customisation options*, and a *small virtual world*. The quality of the graphics and limited character options were due to the prototype phase when the platform was still under development, and these aspects were not the main focus of the studies in this thesis. The comments on small virtual world on the other hand were associated to the few places that players could explore. This was mainly due to the limitation of the quests designed by the educator, which only took place in one location.

One comment also identified one usability issue in relation to *missing UI feature* (User Interface), where the comment addressed the confusion that was caused when all quests had been completed with no "game over" notification was given. Incorporating this feature did not make it in time before the study took place, but it did not affect the overall gameplay during the game. Lastly, one comment was made in terms of irrelevant UI feature, in particular the health bar. The comment suggested that penalties should be given when incorrect actions were performed during the quests which results in decreasing the health bar. This could actually be implemented but was not included in the game when it was designed by the educator.

Comments on the Learning

The final category of comment related to participants' perceived learning. The positive comments mostly related to the *informative* (i.e., educational) nature and *useful feedback* used in the activities. The use of *real-world scenarios* was also mentioned, where participants appreciated this aspect more in the game. For negative comments, several participants identified the *dialogs* used in the game were too long and vague. *Limited challenges* (i.e., quests) was also mentioned, which related to the small number of quests available. This was again due to the nature of the study, where a small amount of learning content was used to target few learning outcomes. In terms of the control, one participant mentioned that the *feedback was limited*. One category of comment, *repetitive challenge/question* was referred in both the game and control, which could be attributed to the repetitive type of challenge (in the game) and question (in the control).

6.6.3 Discussion

The results of the hypothesis tests presented above are summarised in Table 6.14.

Table 6.14. Summary of the hypothesis results in Study 1.

	Hypothesis	**Result**
1	The learning gain of the students taking part in the SRPG activities is significantly higher than that of those taking part in the non-game activities to learn the same content.	Partially accepted.
2a	Motivation (IMI dimensions) of the students taking part in the SRPG activities is significantly higher than that of those taking part in the non-game activities to learn the same content.	Accepted only for the Enjoyment dimension.
2b	There is no significant relationship between students' motivation (IMI dimensions) and learning gains.	Rejected only for Enjoyment dimension.
3a	Emotion (SAM dimensions) of the students taking part in the SRPG activities is significantly higher than that of those taking part in the non-game activities to learn the same content.	Accepted only for dimensions Valence and Activation.
3b	There is no significant relationship between students' emotion (SAM dimensions) and learning gains.	Accepted.

Hypothesis		**Result**
4a	Learning experience (EGF dimensions) of the students taking part in the SRPG activities is significantly higher than that of those taking part in the non-game activities to learn the same content.	Accepted only for Concentration, Clarity, and Feedback.
4b	There is no significant relationship between students' learning experience (EGF dimensions) and learning gains.	Accepted.
5	There is no significant difference in learning gain between students taking part in the SRPG activities and those in non-game activities when controlling for learning styles.	Not rejected.
6a	There is no significant relationship between students' game genre preferences and motivation (IMI dimensions) during the game activity	Rejected only for relationship between: • adventure games and competence.
6b	There is no significant relationship between students' game genre preferences and emotion (SAM dimensions) during the game activity	Not rejected.
6c	There is no significant relationship between students' game genre preferences and learning experience (EGF dimensions) during the game activity	Not rejected.
6d	There is no significant relationship between students' game playing experience and motivation (IMI dimensions) during the game activity	Rejected only for relationship between: • educational game experience rating and pressure.
6e	There is no significant relationship between students' game playing experience and emotion (SAM dimensions) during the game activity	Not rejected.
6f	There is no significant relationship between students' game playing experience and learning experience (EGF dimensions) during the game activity	Rejected only for relationship between: • educational game playing frequency and pressure.

Inconsistent findings were found with the SRPGs in Study 1 in terms of learning improvement, where only one instance was found where the game performed better than the control. The between-subject analysis showed no difference between the game and control, which agrees with past findings (Lopez-Fernandez et al., 2021;

McKenzie, 2013). In the within-subjects analysis, DigiArtG1 performed better in the control, while DigiArtG2 performed better in the game. The case with DigiArtG1 agrees with previous findings where computer-based non-game activities can be more effective than SGs (Mayer, 2019). One possible interpretation could be due to learning effect caused in the participants. DigiArtG1 was exposed to the game first, where learned knowledge or skills could have been positively transferred to the control activities. The same could have applied for DigiArt2, where learned knowledge transferred from the control were further intensified in the game treatment.

The inconsistent effects on learning gains could also be related to the motivational and learning experience felt by participants during the games. In terms of motivation, the games were only found to be more enjoyable than the control, and enjoyment was found to have a positive relationship with learning gains. In terms of learning experience, the games were found better at encouraging players' concentration, goals were more clearly explained, and feedback was more useful. However, none of these dimensions were statistically significantly associated with learning gains.

The lack of differences for some of the motivation and learning experience dimensions found in Study 1 could be explained by the lack of SG characteristics for improving motivation (Section 2.4). One of the negative aspects of the games were related to the lack of exploration due to the small world represented in the games, where all of the quests and tasks took place at the same location (Section 6.6.2.8). This did not evoke curiosity in participants, which could perhaps reduce the "mystery" characteristic (Section 2.4) and could subsequently explain why participants did not put more effort in the game.

Another consideration relates to "Learner control" and "Optimal Challenge" (Section 2.4). The problem-solving tasks in the games in Study 1 were repetitive and only involved making conversations and answering questions (i.e., MCQs) from NPCs, which perhaps did not give players enough sense of control in completing the challenges. This could explain why the learning experience dimension "autonomy" was not better in the games. The challenges are also not completely in line with the "optimal challenge" characteristic, where challenges should be uncertain and require effort, rather than simply answering MCQs. This simple quiz-like tasks could explain why there are no difference in the motivation dimensions of "perceived competence" and "usefulness" between game and control.

Several qualitative comments were also made in relation to use of the conversational dialogs and the overuse of textual content to read. According to one comment: "*There are lots of text in the game, when chatting with NPC, which made me lost my interest.*". The overuse of the dialogs could have also made the narratives too rich and caused high cognitive effort in participants (Section 2.5), and lead to participants not valuing the challenges and felt negative emotions (Section 2.4). Although the analysis results found most participants felt more pleasant (i.e., valence) and excited (i.e., activation) with the game activity, none of the emotion dimensions were significantly correlated to learning gains. Emotions have been shown to affect learning performance (Section 2.4). The lack of association between any of the emotion dimensions and learning gains from the games in Study 1 could suggest that the levels of emotion felt by participants were caused by the novelty of the medium, as reflected by several of the qualitative comments (Section 6.6.2.8).

The gameplay issues mentioned above can be further supported by examining the relationships with genre preferences and game playing experience. Only one positive relationship was found between preference for adventure games and perceived competence, which could suggest that the gameplay in the game treatment was limited and did not offer gameplay found in other genres. The gameplay limitations could also be explained by the two negative relationships found regarding participants' prior experience with educational games. Those who played educational games more frequently found the feedback used in the game treatment not useful, while those who had better play experience with existing educational games felt more pressure when engaging with the game treatment.

6.7 STUDY 2: INFORMATION SECURITY FUNDAMENTALS GAME

6.7.1 Sample Size and Analysis

Similar to Study 1 (Section 6.6.1), the required sample size for the current study was calculated to be 32 participants per group (i.e., Total of N=64), based on the average effect size of 0.7 in the area of science domain (Mayer, 2019).

As mentioned earlier (Section 6.4.3), all students (N=79) who sat for InfoSec agreed to take part in Study 2. However, not all participants attended the study, and a few of them attended only one of the sessions in the study due to various reasons. Table 6.15 shows the final breakdown of participants used in the analysis for Study 2. 44 participants attended both sessions, and were divided into InfoSecG1 (n=22) and InfoSecG2 (n=22) groups. In Session 1, InfoSecG1 was assigned as the game group and InfoSecG2 was assigned as the control group. The treatment order was reversed in Session 2. A total of 57 participants attended Session 1, where they were divided into the game group (n=30) and control group (n=27). The procedure of the study was introduced earlier (Section 6.4.2), where a between-subject and within-subject analyses were performed. The between-subject analysis involved the two groups (30 Game and 27 Control) from Session 1, while the within-subject analysis on the other hand involved participants who attended both sessions (n=22). Some participants were included in both of the data sets for these analyses. The total number of unique participants who attended the studies were 52 (game group) and 49 (non-game group). These data were used for hypothesis 2b, 3b, 4b, 5a, and 6 (Section 6.4.1).

6.7.2 Results

Following the conceptual model described in Section 6.4.4, the data from the experiments were analysed to compare the effects of the SG and non-game treatments in terms of learning gains, students' experience, and the impact of students' individual differences (i.e., co-variates) on both the learning gains and students' experience.

Table 6.15. Participant breakdown (Study 2).

		Treatment Groups Sample Size		
	Session	**Game**	**Non-Game**	**Data Analysis**
Attended both sessions	1	22	22	Within-Subjects
	2	22	22	
Session 1 only	1	30	27	Between-subjects
Total (No overlapping participants)		52	49	*

*Data used in Hypothesis 2b, 3b, 4b, 5a and 6 (Section 6.4.1)

6.7.2.1. Learning Gains

The analysis here addressed hypothesis 1 (i.e., *The learning gain of the students taking part in the SRPG activities is significantly higher than that of those taking part in the non-game activities to learn the same content*). Table 6.16 shows the descriptive statistics for the analysis.

In the between-subject analysis, preliminary checks with Shapiro Wilk test found the learning gains (i.e., pre minus post-test marks for each participant) data did not meet the assumptions of normality (Game group: N=30, W=0.92, p=0.03, Control group: N=27, W=0.97, p=0.55). Mann-Whitney's U tests conducted showed no significant difference between game and control.

The within-subject analysis follows the same approach from Study 1 (Section 6.6.2.1), where several paired t-tests were conducted (Figure 6.4). Preliminary checks with Shapiro Wilk found that all of the data were normally distributed, justifying the use of parametric paired t-tests. One-tailed t-tests were used to find out whether the post tests were greater than the pre-tests. The results of the tests are shown in Table 6.17. All tests showed significant differences between the pre and post-tests marks for both the game and control groups. However, the effect sizes and pre-post-test mean difference in the game treatments were bigger than the control. The results showed that the game leads to better learning gains, thus Hypothesis 1a is accepted.

Table 6.16. Assessment marks (Study 2)

		Game		**Control**	
		Mean	**SD**	**Mean**	**SD**
Within-analysis InfoSecG1 (N=22)	**Pre Marks**	3.23	2.16	2.59	1.71
	Post Marks	6.41	2.34	5.59	3.07
Within-analysis InfoSecG2 (N=22)	**Pre Marks**	2.00	1.15	3.73	1.75
	Post Marks	5.32	2.48	5.68	2.10
Between-Analysis (N=57)	**Post-Pre-tests Mark Difference**	2.80	1.83	1.89	1.89

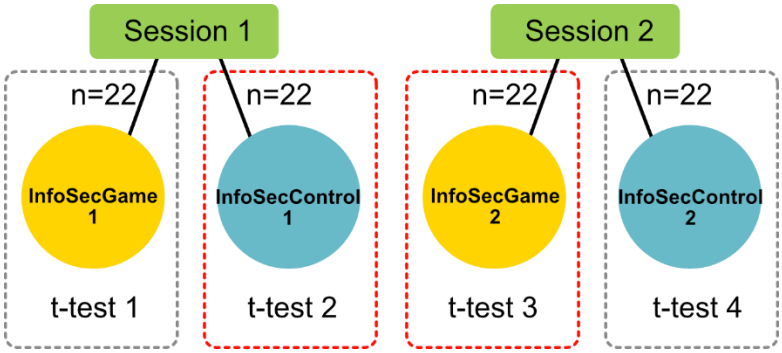


Figure 6.4. Tests to compare learning gains (Within-subjects, Study 2).

Table 6.17. Test results (Within-subjects, Study 2).

	Game	**Non-Game**
InfoSecG1 (n=22)	(Test 1) t(21)=8.34, p<0.001, d=0.8 mean difference=3.18	(Test 4) t(21)=5.49, p<0.001, d=0.6 mean difference=3
InfoSecG2 (n=22)	(Test 3) t(21)=6.19, p<0.001, d=0.6 mean difference=3.32	(Test 2) t(21)=4.51, p<0.001, d=0.5 mean difference=1.95

6.7.2.2. Motivation

Motivation between Game and Non-Game

The first analysis addressed hypothesis 2a (i.e., *Motivation [IMI dimensions] of the students taking part in the SRPG activities is significantly higher than that of those taking part in the non-game activities to learn the same content.*). Table 6.18 and Table 6.19 show the descriptive statistics for the motivation dimensions in the within-subjects and between-subjects analysis respectively.

In the between-subjects analysis, Mann-Whitney U test was used on each of the motivation dimensions. All of the motivation dimensions except "Pressure" was found significantly better in the game (Table 6.20).

In the within-subject analysis, Wilcoxon Signed-rank tests were carried out for both InfoSecG1 and InfoSecG2 (Game vs Control) on each of the motivation dimensions (Table 6.20). In InfoSecG1, all of the motivation dimensions except "Pressure" was found significantly better in the game. In InfoSecG2, only "Enjoyment" and "Competence" were better in the game.

Table 6.18. Motivation's ratings (Within-subjects, Study 2)

Motivation Dimensions	Within InfoSecG1 (N=22)				Within InfoSecG1 (N=22)			
	InfoSecGame1		InfoSecControl2		InfoSecGame2		InfoSecControl 1	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Enjoyment	5.86	0.79	4.14	1.28	5.59	1.22	4.05	1.21
Competence	5.32	1.09	4.68	0.72	4.68	0.78	4.00	0.62
Effort	4.95	1.09	4.19	1.08	4.43	1.12	4.05	0.84
Pressure	2.14	1.04	2.32	0.89	2.64	1.05	2.64	1.36
Usefulness	5.59	0.73	5.14	0.99	5.36	1.00	4.95	1.13

Table 6.19. Motivation's ratings (Between-subjects, Study 2)

Motivation Dimensions	Between Analysis (N=57)			
	InfoSecGame1		InfoSecControl1	
	Mean	SD	Mean	SD
Enjoyment	5.93	0.90	4.00	1.18
Competence	5.36	1.10	4.00	0.62
Effort	4.77	1.07	3.96	0.85
Pressure	2.23	1.10	2.67	1.24
Usefulness	5.80	0.81	4.85	1.10

Table 6.20. Motivation analysis results (Study 2).

	Results		
Motivation Dimensions	Between-subject (N=57)	Within-subject InfoSecG1 (N=22)	Within-subject InfoSecG2 (N=22)
Enjoyment	U=673, p<0.001, d=1.1	V=401, p<0.001, d=1	V=391, p<0.001, d=0.8
Competence	U=642, p<0.001, d=1	V=338, p<0.01, d=0.6	V=363, p<0.01, d=0.7
Effort	U=584, p<0.01, d=0.7	V=317, p=0.01, d=0.5	-

	Results		
Usefulness	U=596, p<0.01, d=0.7	V=306, p=0.05, d=0.4	-

The results lead to the conclusion that the participants found the game more enjoyable, felt more competent, put out more effort, and found it more useful than the control. Hypothesis 2a is accepted for dimensions Enjoyment, Competence, Effort and Usefulness.

Relationship between Motivation and Learning Gains

The second analysis addressed hypothesis 2b (i.e., *There is no significant relationship between students' motivation [IMI dimensions] and learning gains*).

Table 6.21. Relationships between motivation and learning gains (Study 2).

Motivation Dimensions	Pearson's Correlation Coefficient	Simple Linear Regression Results
Enjoyment	r=0.27	R^2=0.12, b=0.42
Competence	r=0.30	R^2=0.10, b=0.70
Effort	r=0.27	R^2=0.10, b=0.55
Usefulness	r=0.30	R^2=0.10, b=0.65

Simple Linear Regression and Pearson's correlation coefficient tests were performed for each of the motivation dimensions against the learning gains for all the participants (N=101) in Study 2, in order to establish whether their learning gains were associated with any of the motivation dimensions. Significant relationships ($p \leq 0.05$) were found with all factors except pressure (Table 6.21). The result leads to the conclusion that the learning gains are associated to the level of enjoyment, perceived competence, effort, and perceived usefulness. Hypothesis 2b is thus rejected for the dimensions Enjoyment, Competence, Effort and Usefulness.

6.7.2.3. Emotion

Emotion between Game and Non-Game

The first analysis addressed hypothesis 3a (i.e., *Emotion [SAM dimensions] of the students taking part in the SRPG activities is significantly higher than that of those taking part in the non-game activities to learn the same content*). Table 6.22 and Table 6.23 show the descriptive statistics for the emotion dimensions in the within-subjects and between-subjects analysis respectively.

In the between-subjects analysis, Mann-Whitney U test was used on each of the emotion dimensions. Significant differences were found for all dimensions (Table 6.24).

In the within-subject analysis, Wilcoxon Signed-rank tests were carried out on each of the emotion dimensions for both InfoSecG1 and InfoSecG2 (Game vs Control). In InfoSecG1, only "Valence" was found better in the game, while all dimensions were better in the game for InfoSecG2 (Table 6.24).

The results lead to the conclusion that the game is better than the control in terms of being more pleasant, exciting, and gives users control over the situation. Hypothesis 3a is accepted for all emotion dimensions.

Table 6.22. Emotion's ratings (Within-subjects, Study 2)

	Within InfoSecG1 (N=22)				**Within InfoSecG2 (N=22)**			
	InfoSecGame1		**InfoSecControl2**		**InfoSecGame2**		**InfoSecControl1**	
Emotion Dimensions	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Valence	7.41	1.37	6.18	1.71	7.27	1.35	5.91	1.57
Activation	5.68	2.90	4.50	2.86	5.91	2.02	3.82	2.28
Dominance	6.18	1.92	5.73	2.39	6.5	1.44	5.5	1.47

Table 6.23. Emotion's ratings (Between-subjects, Study 2)

	Between Analysis (N=57)			
	InfoSecGame1		InfoSecControl1	
Emotion Dimensions	**Mean**	**SD**	**Mean**	**SD**
Valence	7.40	1.43	5.85	1.46
Activation	5.93	2.80	3.93	2.09
Dominance	6.27	2.08	5.52	1.45

Table 6.24. Emotion analysis results (Study 2).

	Results		
Emotion Dimensions	**Between-subject (N=57)**	**Within-subject InfoSecG1 (N=22)**	**Within-subject InfoSecG2 (N=22)**
Valence	U= 624, p<0.001, d=0.8	V=342, p<0.01, d=0.6	V=360, p<0.01, d=0.7
Activation	U=598, p<0.001, d=0.7	-	V=365, p<0.01, d=0.7
Dominance	U=537, p=0.02, d=0.5	-	V=334, p=0.01, d=0.6

Relationship between Emotion and Learning Gains

The second analysis addressed hypothesis 3b (i.e., *There is no significant relationship between students' emotion [SAM dimension] and learning gains*).

Simple Linear Regression and Pearson's correlation coefficient tests were performed for each of the emotion dimensions against the learning gains for all the participants (N=101) in Study 2, in order to establish whether their learning gains were associated by any of the emotion dimensions. No significant relationship was found. Hypothesis 3b is thus accepted.

6.7.2.4. Learning Experience

Learning Experience between Game and Non-Game

The first analysis addressed hypothesis 4a (i.e., *Learning experience [EGF dimensions] of the students taking part in the SRPG activities is significantly higher*

than that of those taking part in the non-game activities to learn the same content). Table 6.25 and Table 6.26 show the descriptive statistics for the learning experience dimensions in the within-subjects and between-subjects analysis respectively.

In the between-subjects analysis, Mann-Whitney U test was used on each of the learning experience dimensions. Significant differences were found for all dimensions (Table 6.27). In the within-subject analysis, Wilcoxon Signed-rank test was used on each of the learning experience dimensions for both InfoSecG1 and InfoSecG2 (Table 6.27). In InfoSecG1, only concentration and immersion were found to be significantly better in the game. In InfoSecG2, all dimensions except knowledge were better in the game.

Table 6.25. Learning Experience's ratings (Within-subjects, Study 2)

	Within InfoSecG1 (N=22)				**Within InfoSecG2 (N=22)**			
Learning Experience Dimensions	**InfoSecGame1**		**InfoSecControl2**		**InfoSecGame2**		**InfoSecControl1**	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Concentration	5.50	1.06	5.05	0.95	5.09	0.81	4.45	1.01
Clarity	5.27	1.20	5.36	1.05	5.18	1.18	3.95	1.43
Feedback	5.27	1.52	5.20	1.32	5.18	1.30	3.32	1.17
Autonomy	4.82	1.33	4.73	1.20	5.18	1.14	3.86	1.36
Immersion	5.18	1.10	3.50	1.14	4.23	1.31	3.45	1.06
Knowledge	5.86	1.13	5.95	1.00	5.45	1.14	5.18	1.10

The results lead to the conclusion that the learning activity in the game is better than the control in terms of making participants more focused with the activity, task goals were more clearly explained, feedback more useful, and participants felt more in control when completing the task, felt more immersed, and felt they have improved their knowledge on the topic being taught. Hypothesis 4a is accepted for all learning experience dimensions.

Table 6.26. Learning Experience's ratings (Between-subjects, Study 2)

	Between Analysis (N=57)			
Learning Experience Dimensions	**InfoSecGame1**		**InfoSecControl1**	
	Mean	**SD**	**Mean**	**SD**
Concentration	5.57	1.07	4.37	0.97
Clarity	5.37	1.16	3.85	1.43
Feedback	5.27	1.39	3.48	1.16
Autonomy	4.80	1.42	3.89	1.25
Immersion	5.10	1.21	3.44	1.05
Knowledge	5.90	1.03	5.15	1.10

Table 6.27. Learning experience analysis results (Study 2).

	Results		
Learning Experience Dimensions	**Between-subject (N=57)**	**Within-subject InfoSecG1 (N=22)**	**Within-subject InfoSecG2 (N=22)**
Concentration	U=639, p<0.001, d=0.9	V=309, p<0.05, d=0.4	V=325, p=0.02, d=0.5
Clarity	U=637, p<0.001, d=0.9	-	V=363, p<0.01, d=0.7
Feedback	U=681, p<0.001, d=1	-	V=411, p<0.001, d=0.9
Autonomy	U=558, p<0.01, d=0.7	-	V=370, p<0.01, d=0.7
Immersion	U=688, p<0.001, d=1.1	V=419, p<0.001, d=1	V=329, p=0.02, d=0.5
Knowledge	U=558, p<0.01, d=0.6	-	-

Relationship between Learning Experience and Learning Gains

The second analysis addressed hypothesis 4b (i.e., *There is no significant relationship between students' learning experience [EGF dimensions] and learning gains*).

Simple Linear Regression and Pearson's correlation coefficient tests were performed for each of the learning experience dimensions against the learning gains for all the participants (N=101) in Study 2, in order to establish whether their learning gains were associated by any of the learning experience dimensions. Only concentration, clarity and knowledge were shown to have significant ($p \leq 0.05$) positive relationship with learning gains (Table 6.28). Hypothesis 4b is accepted for factors Concentration, Clarity, and Knowledge.

Table 6.28. Relationships between learning experience and learning gains (Study 2).

Learning Experience Dimensions	**Pearson's Correlation Coefficient**	**Simple Linear Regression Results**
Concentration	r=0.29	R^2=0.10, b=0.61
Clarity	r=0.30	R^2=0.10, b=0.48
Knowledge	r=0.31	R^2=0.10, b=0.61

6.7.2.5. Impact of Learning Styles

Comparison of the learning gains between the game and control groups when controlling for the learning style co-variate (i.e., active/reflective, sensing/intuitive, visual/verbal, and sequential/global) addressed hypothesis 5 (i.e., *There is no significant difference in learning gains between students taking part in the SRPG activities and those in non-game activities when controlling for learning styles*).

One-Way ANCOVA was used and conducted for all participants in Study 2 (N=101). The assumption of normality was not met (W=0.96, p=0.02). Only the assumptions of independence between variables using correlation tests, and homogeneity of variance (F(1,83)=0.05, p=0.82) were met. There was no significant difference in learning gains between the game and control after controlling for learning style (F(1,78)=0.59, p=0.45). None of the learning styles showed significant impact on learning gains. Hypothesis 5 is thus accepted.

6.7.2.6. Impact of Genre Preferences

Participants' genre preference was another confounding variable that was considered to influence students' motivation, emotion and learning experience when they were engaged with the game treatment. Simple Linear Regression and Pearson's

Correlation Coefficient tests were performed for each of the genre preferences against each dimension in motivation, emotion and learning experience. Data used in the analysis involved all participants in the game group (N=52) during Study 2.

Relationship between Game Genre Preferences and Motivation.

The first analysis is to address hypothesis 6a (i.e., *There is no significant relationship between students' game genre preferences and motivation [IMI dimensions] during the game activity*). Several significant relationships ($p \leq 0.05$) were found (Table 6.29).

Table 6.29. Relationships between motivation and genre preference (Study 2).

Genre Preference	Motivation Dimensions			
	Enjoyment	**Competence**	**Pressure**	**Usefulness**
Mini	R^2=0.17, b=0.59, r=0.44	-	-	R^2=0.13, b=0.44, r=0.39
Action	R^2=0.20, b=0.45, r=0.46	R^2=0.10, b=0.29, r=0.34	R^2=0.11, b=-0.35, r=-0.36	R^2=0.15, b=0.33, r=0.42
Adventure	R^2=0.18, b=0.58, r=0.44	-	-	-
RPG	R^2=0.10, b=0.30, r=0.30	-	-	-
Simulation	R^2=0.10, b=0.32, r=0.31	-	-	-

The factor "Enjoyment" has moderate positive relationships ($r<0.5$) with preferences for Mini-games, Action, Adventure, RPG and Simulation. This indicates that those who like these genres also enjoyed the game treatment. The preference for Action games also has moderate positive relationships with factors "Competence" and "Usefulness", and a moderate negative relationship ($r>-0.5$) with "Pressure". The positive relationship means that those who enjoy Action games will find themselves more competent in completing the activities in the game, and find the activity useful in terms of learning. The negative relationship with pressure means a positive effect, where those who prefer Action games will feel less pressure with the game treatment. Preference for mini-games also have a moderate positive relationship with "Usefulness". Hypothesis 6a is thus rejected only for these significant relationships.

Relationship between Game Genre Preferences and Emotion.

The second analysis is to address hypothesis 6b (i.e., *There is no significant relationship between students' game genre preferences and emotion [SAM dimensions] during the game activity*). Several significant relationships ($p \leq 0.05$) were found (Table 6.30).

Table 6.30. Relationships between emotion and genre preference (Study 2).

Genre Preference	Emotion Dimensions		
	Valence	**Activation**	**Dominance**
Mini	R^2=0.10, b=0.61, r=0.35	R^2=0.10, b=0.38, r=0.31	-
Action	R^2=0.10, b=0.92, r=0.30	-	R^2=0.10, b=0.45, r=0.31
Adventure	-	-	R^2=0.20, b=0.83, r=0.43
RPG	-	-	R^2=0.11, b=0.53, r=0.36
Simulation	-	-	R^2=0.13, b=0.59, r=0.38

The factor "Valence" has moderate positive relationship ($r<0.5$) with preference for Mini and Action games. This means that those who prefer these games will feel pleasant with the game treatment. Mini games also have a moderate positive relationship with the factor "Activation", which means that those who enjoy mini games will feel more excited with the game treatment. The factor "Dominance" has several moderate positive relationships with Action, Adventure, RPG and Simulation genre, which means that those who enjoy these games feel more in control in the situation when engaging with the game treatment. Hypothesis 6b is thus rejected only for the significant relationships.

Relationship between Game Genre Preferences and Learning Experience.

The third analysis is to address hypothesis 6c (i.e., *There is no significant relationship between students' game genre preferences and learning experience [EGF dimensions] during the game activity*). Several significant relationships ($p \leq 0.05$) were found (Table 6.31).

Table 6.31. Relationships between learning experience and genre preference (Study 2).

Learning Experience Dimensions	Genre Preference				
	Mini	**Action**	**Adventure**	**RPG**	**Simulation**
Concentration	-	R2=0.30, b=0.48, r=0.55	R2=0.13, b=0.45, r=0.39	R2=0.10, b=0.31, r=0.35	R2=0.10, b=0.33, r=0.35
Clarity	-	R2=0.30, b=0.56, r=0.55	R2=0.12, b=0.52, r=0.38	R2=0.10, b=0.38, r=0.36	-
Feedback	-	R2=0.26, b=0.58, r=0.52	R2=0.16, b=0.61, r=0.42	-	R2=0.10, b=0.41, r=0.35
Autonomy	-	R2=0.16, b=0.45, r=0.42	R2=0.24, b=0.72, r=0.51	R2=0.10, b=0.38, r=0.35	-
Immersion	R2=0.12, b=0.61, rho=0.37	R2=0.10, b=0.37, r=0.31	-	-	R2=0.10, b=0.46, r=0.36
Knowledge	-	R2=0.24, b=0.49, r=0.51	R2=0.10, b=0.44, r=0.35	-	-

Preference for Action has positive relationships with all of the learning experience factors, while Adventure has positive relationships with almost all of the factors except “Immersion”. Preference for RPG has positive relationships with factors “Concentration”, “Clarity” and “Autonomy”, while Simulation has positive relationships with “Concentration”, “Feedback” and “Immersion”. Those who prefer these genres can feel more concentrated and immersed, can understand task goal more clearly, find the feedback more useful, feel in control and feel better knowledge improvement, when engaged with the game treatment. Hypothesis 6c is thus rejected only for these significant relationships.

6.7.2.7. Impact of Game Playing Experience

Participants’ game playing experience is another confounding variable that was considered to influence students’ motivation, emotion and learning experience when they were engaged with the game treatment. Simple Linear Regression and Pearson’s Correlation Coefficient tests were performed for each of the game playing experience

(i.e., entertainment games playing frequency, entertainment games experience rating, educational games playing frequency, and educational games experience rating) against each dimension in motivation, emotion and learning experience. Data used in the analysis involved all participants (N=52) in the game group during Study 2.

Relationship between Game Playing Experience and Motivation.

The first analysis is to address hypothesis 6d (i.e., *There is no significant relationship between students' game playing experience and motivation [IMI dimensions] during the game activity*). Several significant relationships ($p \leq 0.05$) were found (Table 6.32).

Table 6.32. Relationships between motivation and playing experience (Study 2).

Game Playing Experience	**Motivation Dimensions**			
	Enjoyment	**Competence**	**Pressure**	**Usefulness**
Entertainment games playing frequency	-	-	R^2=0.14, b=-0.39, r=-0.39	-
Entertainment games experience rating	-	-	-	R^2=0.11, b=0.42, r=0.35
Educational games playing frequency	-	-	R^2=0.13, b=-0.35, r=-0.40	-
Educational games experience rating	R^2=0.10, b=0.36, r=0.35	R^2=0.10, b=0.28, r=0.31	-	R^2=0.10, b=0.27, r=0.31

Frequency of playing entertainment and educational games have moderate negative relationship ($r > -0.5$) with "Pressure", which means a positive effect where those who frequently play entertainment or educational games will feel less pressure with the game treatment. Entertainment and educational experience rating have moderate positive relationship ($r < 0.5$) with "Usefulness", which means that better experience with existing entertainment or educational games will lead to finding the learning activity in the game treatment more useful. Educational experience rating also has moderate positive relationships with "Enjoyment" and "Competence", which means

that those who had better experience with existing educational games will find the game treatment more enjoyable and feel more competent with the activity. Hypothesis 6d is thus rejected only for the significant relationships.

Relationship between Game Playing Experience and Emotion.

The second analysis is to address hypothesis 6e (i.e., *There is no significant relationship between students' game playing experience and emotion [SAM dimensions] during the game activity*). No significant relationship was found between any of the game playing experience and emotion factors. Hypothesis 6e is not rejected.

Relationship between Game Playing Experience and Learning Experience.

The third analysis is to address hypothesis 6f (i.e., *There is no significant relationship between students' game playing experience and learning experience [EGF dimensions] during the game activity*). Several significant relationships ($p \leq 0.05$) were found (Table 6.33).

Table 6.33. Relationships between learning experience and playing experience (Study 2).

Game Playing Experience	**Learning Experience Dimensions**			
	Concentration	**Clarity**	**Feedback**	**Knowledge**
Entertainment games playing frequency	-	R^2=0.13, b=0.40, r=0.38	-	-
Entertainment games experience rating	R^2=0.11, b=0.47, r=0.37	R^2=0.24, b=0.77, r=0.51	R^2=0.10, b=0.51, r=0.31	R^2=0.12, b=0.53, r=0.38
Educational games experience rating	R^2=0.15, b=0.39, r=0.42	R^2=0.12, b=0.41, r=0.38	R^2=0.10, b=0.40, r=0.34	-

Frequency of playing entertainment games have a moderate positive ($r<0.5$) relationship with "Clarity", which means that those who frequently playing entertainment games will better understand the task goals clearly in the game treatment. Experience rating with entertainment and educational games have positive relationships with factors "Concentration", "Clarity", "Feedback" and "Knowledge".

This means that those who had better experience with existing entertainment and educational games will be able to concentrate with the activity in the game treatment, find that task goals are clearly understood, feedback useful and they will feel better knowledge improvement. Hypothesis 6f is rejected only for these significant relationships.

6.7.2.8. Positive and Negative Aspects

The qualitative feedback with regards to the positive and negative aspects of the treatments were also collected during the study. The comments are categorised and shown in Table 6.34.

Table 6.34. Summary of comments (Study 2).

	Game (Number of comments)	**Non-Game (Number of comments)**
Positive	**Experience:** Fun (22), Interesting (2), Engaging (5) **Application:** Game (7), Exploration (3), Avatar customisation (5), Game task (6), Easy to play (1), Interactive (8), Interact with virtual characters (1) **Learning:** Informative (13), Real-world scenario (2), Feedback (1), Solving problems (3), Story (2)	**Experience:** Fun (1), Engaging (1) **Application:** Simple (12), Quiz (4) **Learning:** Real-world scenario (4), Informative (10), Feedback (7), Interesting topic (2), Solving problems (2)
Negative	**Experience:** Limited time (6), Dislike game (1), No collaboration (1) **Application:** Difficult to explore (3), Lagging (2), Small game world (2), UI feature (4), Limited avatar customisation (1) **Learning:** Not informative (1), Limited Challenge (8), Too easy challenge (1), Dialog (1), Repetitive challenge (1)	**Experience:** Boring (8), Limited time (1), No collaboration (2) **Application:** Simple (1), Typical activity (6) **Learning:** Too much text (3), Feedback (2)

Comments on User Experience

The first category of comments concerns with participants' experience with the treatments. Most of the positive comments point to the positive experience such *fun*, *engaging* and finding it *interesting*. There were more positive experiences mentioned in relation to the game. For negative experiences, most of the comments for both treatments were related to the *limited time* afforded and *lack of collaboration* between students during the study. These experience however is unavoidable due to the nature and purpose of the study. Several comments were also made on the *boring* aspect of the non-game control, which can be associated to its nature as typical learning activity participants are already accustomed to. With regards to the game treatment, one comment relates to the *dislike of game* in general.

Comments on the Applications

The second category of comments concerns with the overall nature of the treatment platform (i.e., game and quiz). Positive comments with regards to the game relates to the inherent characteristics of games in general, such as *interactivity*, *exploration* and *character customisation*. The fact that the game treatment was a *game* was also mentioned by several participants, perhaps due to their inclination towards playing games. Several comments were also made in terms of the *game tasks*, where these comments generally showed an appreciation of the various type of tasks the players had to perform in the game treatment, such as exploring and searching for objects. For example, one participant commented "*I like the game. It has some form of fetch quests (i.e., explore and find an item) that is found in most (existing) games and personally, I don't really mind it.*". One comment identified that the task *encourages problem solving* "*The tasks challenge us to find out where we should go or what we should do to solve the problem in the clinic (game world).*". There were only few positive comments for the control, which was related to its *simplicity* and *quiz-based* format.

For the negative aspects, there were more comments made for the game compared to the non-game. For the control, there were only a few negative comments made, mostly relates to it being a *simple* and *typical learning activity*. For the game treatment, few of the comments relate to the unavoidable *internet connectivity* issues when first loading the game. Another aspect is concerned with the limitations of the game implementation such as *few character customisation options* and a *small virtual*

world. The remaining aspect relates to the general usability of the game in terms of *missing UI feature* and *difficulty to explore the game world*. The missing UI feature concerns with difficulties faced by few of the participants when trying to find information about the current quest (e.g., quest notification, quest description and current task). Notifications were actually given for new quests and tasks, and further information can also be accessed by pressing on a "Quest" button displayed in the game. Few of the participants could perhaps missed the notification, where they commented that they could not see it being displayed. One possible reason could be due to their inexperience with playing games, as one participant commented: "*I don't particularly enjoy playing game. It is hard to say what I dislike the most, maybe, where I need to find the quest.".* Further comments in this aspect relates to features that participant thought was irrelevant (e.g., life bar, objects that are not interactive).

With regards to the difficulty when exploring the game world, the comments addressed the same issue where few participants find it difficult to find a particular room, as one participant commented: "*The only thing that I had trouble was that the doors were not labelled. You have to enter a room first if you want to know what room it is.".* This type of gameplay is quite common in games. Lack of experience playing this type of games could be one of the reasons for this difficulty. However, these aspects could be further addressed in future improvements of the game UI.

Comments on the Learning

The final category of comments concerns with participants' perceived learning. The positive comments for both treatments mostly relate to the *informative* (i.e., educational) nature, *helpful feedback*, use of *real-world scenarios*, *use of story*, and *solving problems*. For negative aspects with regards to the game treatment, most of the comments relates to the *limited quests* (i.e., small number of quests), which as stated in Study 1, was due to the nature of the small learning content and learning outcome targeted in the study. Other comments relate to the simple and repetitive challenges found in the game treatment. The one comment in terms of simple challenge relates to the quests being too easy for one participant, where suggestion was made to increase the difficulty. This could be due to their level of experience in playing games. Only one participant identified the game as not being informative. With regards to the control, only a few comments were given and they were related to too much text to read and ineffective feedback.

6.7.3 Discussion

The results of the hypothesis tests presented above are summarised in Table 6.35.

Table 6.35. Summary of the hypothesis tests results in Study 2.

Hypothesis		Result
1	The learning gain of the students taking part in the SRPG activities is significantly higher than that of those taking part in the non-game activities to learn the same content.	Accepted.
2a	Motivation (IMI dimensions) of the students taking part in the SRPG activities is significantly higher than that of those taking part in the non-game activities to learn the same content.	Accepted for Enjoyment, Competence, Effort and Usefulness.
2b	There is no significant relationship between students' motivation (IMI dimensions) and learning gains.	Rejected for Enjoyment, Competence, Effort, and Usefulness.
3a	Emotion (SAM dimensions) of the students taking part in the SRPG activities is significantly higher than that of those taking part in the non-game activities to learn the same content.	Accepted for Valence, Activation and Dominance.
3b	There is no significant relationship between students' emotion (SAM dimensions) and learning gains.	Accepted for all dimensions.
4a	Learning experience (EGF dimensions) of the students taking part in the SRPG activities is significantly higher than that of those taking part in the non-game activities to learn the same content.	Accepted for all dimensions.
4b	There is no significant relationship between students' learning experience (EGF dimensions) and learning gains.	Rejected for Concentration, Clarity, and Knowledge.
5	There is no significant difference in learning gain between students taking part in the SRPG activities and those in non-game activities when controlling for learning styles.	Accepted.
6a	There is no significant relationship between students' game genre preferences and motivation (IMI dimensions) during the game activity	Rejected only for relationships between: • Mini games with Enjoyment and Usefulness

Hypothesis		**Result**
		• Action with Enjoyment, Competence, Pressure, and Usefulness • Adventure with Enjoyment • RPG with Enjoyment • Simulation with Enjoyment
6b	There is no significant relationship between students' game genre preferences and emotion (SAM dimensions) during the game activity	Rejected only for relationships between: • Mini games with Valence and Activation • Action with Valence and Dominance • Adventure with Dominance • RPG with Dominance • Simulation with Dominance
6c	There is no significant relationship between students' game genre preferences and learning experience (EGF dimensions) during the game activity	Rejected only for relationships between: • Mini games with Immersion • Action with Concentration, Clarity, Feedback, Autonomy, Immersion and Knowledge • Adventure with Concentration, Clarity, Feedback, Autonomy, and Knowledge • RPG with Concentration, Clarity, and Autonomy • Simulation with Concentration, Feedback, and Immersion
6d	There is no significant relationship between students' game playing experience and motivation (IMI dimensions) during the game activity	Rejected only for relationships between: • Entertainment game playing frequency and Pressure • Entertainment game experience rating and Usefulness • Educational game playing frequency and Pressure

Hypothesis		Result
		• Educational game experience rating with Enjoyment, Competence, and Usefulness
6e	There is no significant relationship between students' game playing experience and emotion (SAM dimensions) during the game activity	Accepted for all dimensions.
6f	There is no significant relationship between students' game playing experience and learning experience (EGF dimensions) during the game activity	Rejected only for relationships between: • Entertainment game playing frequency and Clarity • Entertainment game experience rating with Concentration, Clarity, Feedback and Knowledge • Educational game experience rating with Concentration, Clarity, and Feedback

The SRPGs in Study 2 have a significant better effect than the control in terms of learning gains. Although the between-analysis found no significant difference in learning gains, the within-analysis showed both InfoSecG1 and InfoSecG2 groups had better learning gains in the game.

The better learning improvement could be related to the motivational and learning experience felt by participants. All of the motivation dimensions, except pressure, were found better in the game. Learning gains were also shown to be positively related to these dimensions, thus suggesting that the better motivational aspect in the game is one of the reasons for the better learning improvement in Study 2. All of the learning experience dimensions were also found better in the game, with only concentration, clarity and perceived knowledge shown to be positively related to learning gains, suggesting that the design of the tasks in the game was effective with regards to learning. All of the emotion dimensions were also better in the game group, but none of the dimensions have a positive association with learning gains.

The better motivation, emotion and learning experience could be explained by the gameplay of the games in Study 2, in particular the characteristics that should be

present in SGs (Section 2.4). Several qualitative positive comments were related to the rich tasks found in the game challenges, and exploring the game world while completing tasks. These aspects addressed the "Optimal Challenge" and "Mystery" characteristics. Furthermore, "Learner control" is also present in the games, as shown by the better motivation dimension "autonomy". "Learner Control" is also reflected by the positive comments with regards to the quests, which challenges participants to figure out how to solve the various problems. The use of stories in Study 2's games was also commented as a positive aspect of the games. As noted in Section 2.5, using stories can help learners become more engaged with the learning activity, and is used to add the "Fantasy" characteristics (Section 2.4).

Several positive comments were also made regarding the simulation of real-world scenarios in the games and how it would help them address the same situation in the real-life. This was exemplified in Study 2, where few participants applied their experience from the game when answering one of the questions in the post-test. One of the quests in Study 2's games involved a scenario where a person infected the computer in a clinic's examination room using an infected USB, while the doctor went out of the room. In the post-test, one of the questions asked students to comment on the suitability of the location where a computer hosting a management system is placed in an office room. Only few participants, mostly from the game group, correctly identified the accessibility of the location to unauthorised person. These participants also explicitly mentioned that it would be easy to infect the computer with a USB. This perhaps reflects the effectiveness of the scenarios in Study 2's games in terms of constructivism learning theory (Section 2.5), where learners formed their own knowledge based on their experiences in the scenarios.

The points presented above can be further supported by examining the relationships with genre preferences and game playing experience. Many of the motivation, emotion and learning experience dimensions were positively related to various genre preferences, in particular action, adventure, RPG and simulation games. It was established earlier (Section 2.2) that certain gameplay is shared by these genres, thus suggesting that the gameplay found in the games in Study 2 is familiar to a wide range of game players. Participants appreciated the mix of various tasks found in the game treatment, where they also found the gameplay familiar to existing games, as one participant commented that the gameplay was similar to the RPG Pokemon. Many of

the motivation and learning experience dimensions were also positively related to prior game playing experience. Frequently playing entertainment or educational games, and higher enjoyment when playing these games, are positively related to some of the motivation and learning experience dimensions. This suggests that the high motivational aspect and perceived learning in the game treatment's gameplay could be due to its similarities with existing games.

6.8 SUMMARY

Findings from these studies have answered RQ 4a (i.e., *How effective are educator-authored SRPGs as learning instructions in terms of learning improvement?*), where the games used in Study 2 showed that the educator-authored SRPGs can lead to better learning improvement than the non-game activities.

The games used in Study 1 and Study 2 are different in terms of the learning content and gameplay. Although these games cannot be compared in the context of their learning content, their gameplay characteristics can be used as comparison with regards to motivation and perceived effectiveness as learning tools. For the games in Study 1, the gameplay was limited in terms of the important SG characteristics (Section 2.4), which was identified as the reason for the lack of differences in learning gains, motivation, emotion and perceived learning effectiveness. Gameplay in the games for Study 2 on the other hand possessed all the important characteristics that should be present in SGs, and this was identified as the reason for the better learning gains, motivation, emotion, and perceived learning effectiveness. These findings helped answer RQ 4b (i.e., *What are students' perceptions of learning with educator-authored SRPG?*)

The outcome of the studies shows that SGs do not necessarily outperform non-game learning tools, which support the suggestion by Mayer (2019). The design of gameplay is indeed crucial, especially with respect to creating effective SRPGs. Rich gameplay is an important aspect of RPGs, achieved by including the use of different types of player tasks to complete quests. Replicating learning activities in RPGs, however, is possible for certain learning tasks that involve "physical real-world" actions (e.g., diagnosing an object and fixing it). Although using quiz-based gameplay can be effective for LOTS learning outcomes (Lopez-Fernandez et al., 2021),

predominantly using this conversational mechanics may not be as effective in SRPGs, especially when targeting HOTS learning outcomes, which was the case with the game in Study 1.

The intention of the studies in this chapter was to evaluate the effectiveness of the educator-authored SRPGs, thus validating the proposed ARQS platform. The effectiveness of the game in Study 2 provides evidence on the usefulness of the platform in enabling educators without experience in game creation to create SRPGs as effective learning tools.

CHAPTER 7
GENERAL DISCUSSION

The main research question underlying this thesis is "*How can educators be more actively involved in the creation of SGs as a teaching and learning tool*". To approach this question, several research questions (Section 1.2) were addressed in this thesis. In this chapter, the findings for the research questions addressed in this thesis are discussed.

7.1 COMPONENTS OF THE SRPG DESIGN METHOD

In order to enable educators to be able to design SRPGs, an educator-oriented design method should be based on instructional design, skills that educators should possess. To identify the components that need to be included in this design method, several research questions were answered, which are summarised below:

- *RQ1A: How can instructional activities be incorporated in RPG?*

  This question was answered by identifying the core components of RPG (Section 2.2) and exploring various learning theories (Section 2.5). Aspects of these learning theories were aligned to the components of RPG. Emphasis was put on constructivism learning theory, particularly with AL. Components of AL were mapped to the components of RPG, establishing a theoretical relationship between AL and RPG which serves as the basis on how AL-based instructions can be incorporated in RPG.

- *RQ1B: How are concepts of Instructional Design Principles (IDP) used in existing SG design methods?*

A systematic literature review was conducted to answer this question (Section 2.6.3). Findings from the review resulted in identifying instructional-design focused tasks carried out when designing SGs. The tasks included: *identifying the knowledge*, *designing the learning tasks*, *integrating gameplay into the instructions,* and *evaluating the instructional-aspect*. Tasks 1, 2 and 4 relied mostly on the concepts of designing instructions, which involve knowledge and skills educators should already possess. Task 3 on the other hand relied on input from game designers to design the gameplay, with some design methods incorporating game patterns.

- *RQ1C: How can concepts of IDP be adapted in designing SRPG?*

  Concepts from RQ1A and RQ1B were used for devising the proposed ARQS design method (Section 3.3), an educator-oriented design method for the design of SRPGs. Tasks 1 and 2 involved the design of gameplay in an SRPG, which relied on the design of authentic scenarios and activities as the basis of the gameplay. Task 3 on the other hand adopted the concept of using game patterns. The game patterns were based on entertainment-based RPG patterns proposed by Doran & Parberry (2010), which consisted of player actions (i.e., common actions players can perform in an RPG) and quest pattern (i.e., common sequence of player actions found in RPG quests).

In order to make the design method accessible to educators, the design workflow make use of tasks involving knowledge and skills in designing non-gaming learning instructions, focusing on the design of authentic activities based on real-world authentic scenarios. The method was used to guide the conversion of these scenarios into RPG quests by using the game patterns, by matching suitable game player actions that could be used to represent learning tasks (i.e., as a way for players to perform the learning tasks in the game) required in the scenarios. This process would ensure that the gameplay in the SRPG is always aligned to the intended learning outcomes of the scenarios. The approach was aimed to make the design method simpler to use in terms of designing SRPG gameplay, especially for educators. Most existing design methods presented in Sections 2.6.2 and 2.6.3 involved game design principles and knowledge when designing gameplay, thus requiring game designers with the necessary knowledge. The ARQS design method relied on the design of authentic scenarios, a concept shared by EMERGO (Nadolski et al., 2008), which only required educators'

capabilities in designing instructions. EMERGO, however, was intended for the general design of scenarios, without any explicit integration of game mechanics currently implemented in the ARQS design method.

7.2 SUITABILITY OF THE ARQS DESIGN METHOD FOR EDUCATORS

In order to identify the suitability of the ARQS design method for educators, several research questions were answered, which are summarised below:

- *RQ2A: What is educators' experience when using a design method that focuses on instructional design?*

  A focus group study was conducted to answer this question (Section 3.4). Educators identified the familiarity of the process in the ARQS design method. Educators with experience in using scenarios in their teaching (e.g., using case-studies and practical activities) found it easier to design authentic scenarios and activities compared to those who had no experience. Significant difficulties experienced by educators were related to unfamiliarity with RPGs and lack of creativity.

- *RQ2B: Is using game patterns to represent instructional activities usable for educators?*

  The focus group study also identified the suitability of the game patterns used in the initial concept to the design method. For the player action aspect of the game pattern, educators found the actions usable and were able to replicate most of the learning tasks found in their authentic activities. The use of the quest pattern on the other hand was found not suitable, which was attributed to its extensive nature and focused on entertainment-based RPGs.

- *RQ2C: Can a design method that focuses on instructional design guide educators in designing SRPG?*

  A case study was conducted to answer this question (Chapter 4). Similar findings from RQ2A were also identified in the case study. Educators found the process familiar and were likened to the process of designing a play, which was appreciated by the educators in terms of its understandability. The use of

the design method also relied on educators' experience in the use of real-world scenarios, and their creativity. These attributes were found to affect the complexity of SRPG designs produced by the educators in the case study.

Although no comparison has been made between ARQS and existing SG design methods in the context of educators as designers, it can be assumed that due to the pre-requisite in game design knowledge required for the existing design methods, the use of the ARQS design method would be more accessible to educators. Indeed, the general findings showed that the process in the proposed design method was found familiar and usable by educators, which was anticipated since the process was predominantly based on designing real-world scenarios as instructions. Other key implications from the findings are discussed below.

Application for Various Domains

Educators' experience and abilities in designing authentic scenarios, and the nature of their domains played an important role in the successful use of the design method. This was shown with the game designs produced by educators in the case study, where the different levels in the educators' experience and type of domains resulted in SRPGs that were different in terms of gameplay richness and complexity.

Educators who typically use scenarios (through case-studies and practical activities) in their teaching found it easier to design the authentic scenarios. One possible explanation could be related to their taught domains, which involved procedural knowledge that seems to be more suited for authentic learning due to the specificity of these domain (i.e., concepts learned can be applied to clear and specific situations). This was also exemplified by some of the existing scenario-based SG methods presented in Sections 2.6.2 and 2.6.3, which focused on designing SGs to teach procedural skills within the backdrop of authentic scenarios such as for nurse training in a hospital (Bril & Degens, 2016) and problem solving in various professional settings (Nadolski et al., 2008).

At this point, relevant domains that can be incorporated as SRPGs are still unknown. One possible way to identify the suitability of domain is to identify whether their required learning tasks can be represented in the SRPG through the player actions game pattern (Section 3.3.1). While some educators found the use of common RPG player actions suitable for various learning tasks in their domains, some found the

actions ill-equipped to represent certain complex tasks such as crimping network cables and configuring electronics circuit board. Further studies would need to be carried out to investigate how various domains and their associated learning tasks can be incorporated in SRPGs, and the effectiveness of these games.

Collaborative Work

Other difficulties experienced by educators were related to their unfamiliarity with RPG, and their creativity. In terms of familiarity with RPG, educators without experience in the genre were still able to grasp its concept while discussing with other participants, by drawing on the context of role-playing and using scenarios to teach. This suggests that the concept of role-playing in scenarios is easily understood by educators, especially when framed using the analogy of "Planning a play". Creativity on the other hand is important in terms of devising the scenarios, but the attribute is not possessed by every educator. Collaboration amongst educators can improve creativity amongst group of educators (Horng et al., 2005). This is one potential approach that could be implemented for the real-world use of the design method, where educators with varying level of creativity can work together in designing the scenarios. Fine adjustments and ad-hoc tailoring of games are still possible and can then be done by individual educators as needed.

Iterative Design

In the case study, educators used the design method to design the authentic scenarios and SRPG within one week (Section 4.3). This can be considered a short amount of time, considering they were also involved with their daily work and only spent time with the research during their free time. This could have affected the quality of the SRPGs produced. By taking cue from instructional design models (Seel et al., 2017), iterative design approach should be adopted when designing the SRPGs. This involves an evaluation phase where SRPGs should be evaluated to measure their effectiveness as learning tools, and inform the need for any changes to the designs.

Supporting Educators

Other barriers identified by educators were related to their workload and readiness (personal and institutional). Circumventing these barriers is not the focus of the proposed research, as the emphasis of the research is to explore ways that can enable

educators to create SRPGs. However, successful implementation of this platform will rely on these barriers to be addressed.

Based on these points, it should be clear that the design of SRPGs with ARQS is not straightforward and depends heavily on educators' capabilities in designing effective learning instructions. The findings showed the importance of creativity in terms of identifying and designing relevant learning scenarios, and also familiarity with ARQS design method and SRPG in general. Initial educator training and the use of sample SRPG designs could improve educators' perception and usage of the design method.

7.3 COMPONENTS AND USABILITY OF THE ARQS AUTHORING TOOL

The proposed ARQS platform also consists of an authoring tool to implement SRPG designs into finished games. In order to devise a tool suitable for educators, several research questions were answered, which are summarised below:

- *RQ3A: What are the possible interfaces and workflow suitable for an educator-oriented SRPG authoring tool?*

  Existing SG-specific (Section 2.6.4) and educational-technology (Section 2.6.5) authoring tools were analysed to identify their interfaces and authoring process. These tools commonly target one specific genre, provides editors for the different authoring tasks (e.g., drawing, structuring story), and reduce or eliminate programming. Drawing editors were used in tools that involved the creation of graphical assets, making use of pre-defined templates to allow quick creation of visuals. VPL were used to allow non-programming experts to program various educational technology. Diagram-based VPL is widely used in the existing SG authoring tools, while BBP VPL is widely used in various application developments.

- *RQ3B: Are the interfaces and workflow usable for educators?*

  A prototype of the SRPG authoring tool was built with the interfaces and workflow identified in RQ 3A. Several usability studies were then conducted on the prototype to address this question. The overall findings from the studies

indicated the suitability of the interfaces and workflow for educators. The various component editors presented in the tool provided a structured workflow that guided the educators. The drawing editors implemented simple and familiar drawing tools and the use of pre-defined image library, which were suitable and easy for the educators. The educators with no programming experience were also able to use BBP to program gameplay.

The ARQS authoring tool incorporates simple form controls, drag-and-drop drawing editors, and block-based programming interfaces and workflow. Form controls are commonly used in various SG-specific or educational technology authoring tools. Drag-and-drop drawing editor on the other hand is yet to be utilised in existing SG-specific authoring tools. Few educational authoring tools such as (Suh et al., 2022), however, make use of these drawing editors which educators found useful in creating custom graphics. For block-based programming interfaces, SG-specific authoring tools have yet to incorporate this in the creation of SGs. The concept, however, is used in an educational augmented reality authoring tool (Mota et al., 2018).

Findings from the usability studies showed the high usability of the interfaces and authoring workflow implemented in the ARQS authoring tool. The key implications from the findings are discussed below.

Simplifying assets creation

The drawing tools incorporated in the ARQS authoring tool were found to be easy to use. The character drawing editor in particular was easy due to the use of simple mix-and-match visual library to configure the different aspects of characters. The world drawing editor was generally easy due to the simple and familiar drawing operations. However, based on the observations from the usability studies, time and effort are still required in the creation of assets. Further enhancements would need to be incorporated to further simplify the process.

Block-based programming in Serious Game Authoring Tool

BBP was implemented in the ARQS authoring tool due to its usage in various application development tools (e.g., AR, Robotics), purposes (e.g., education, application development) and target users (e.g., child learners, adults). Its usage in SG development, however, is still lacking. Most existing SG authoring tools implement diagram-based VPL (Section 2.6.6). During the usability studies, educators found

concept of BBP easy to understand and use, even for those who had no experience in programming. One explanation for this is due to the cohesive and understandable text structure when connecting blocks together. The educators generally were able to understand the meaning and purpose of the blocks, and how blocks were related to one another by looking at their labels, colours and shapes. The findings from the usability studies should provide evidence on the potential of BBP within the general area of SG development, and could be used in the creation of various genres. Furthermore, comparative studies would need to be carried out to identify the usability of both BBP and diagram-based VPL in the context of SG development, and to identify the applicability of these VPLs in various aspects of game development.

Automatic block generation

The current implementation requires users to drag and connect blocks together onto the main quest block (Figure 5.4). Certain blocks are designed to be used in conjunction with one another. For example, the "MCQ" block is used to create a conversation dialog in the form of an MCQ. The "Answer Option" block is used to set the dialog options players can choose when interacting in the conversation. When creating the conversation dialog, users would need to drag and add the "MCQ" block on to the main quest block first, then drag and add the "answer option" blocks onto the "MCQ" block. Further simplification in this respect can include the implementation of automatic block generation, which would mean that any blocks added by users would result in relevant blocks added automatically, thus expediting the process even further.

7.4 EFFECTIVENESS OF SRPG AS LEARNING INSTRUCTIONS

The output produced from the ARQS platform was evaluated in terms of its effectiveness as learning instruction. To this end, several research questions were answered, which are summarised below:

- *RQ4A: How effective are educator-authored SRPGs as learning instructions in terms of learning improvement?* (Chapter 6)

Two experimental studies were conducted in order to answer this question (Chapter 6), by comparing the effect of SRPGs and non-gaming learning activities for the domains of *Digital Art and Design* (Study 1) and *Information Security Fundamentals* (Study 2). Effectiveness was measured based on the learning gains acquired by learners. Study 1 showed inconsistent findings, where one within-subject group had better learning gains with the game, while another group did not have better learning gains with the game. Study 2 on the other hand showed more consistent findings where two within-subject groups had better learning gains with the game.

- *RQ4B: What are students' perceptions of learning with educator-authored SRPG?*

  To answer this question, students' motivation, emotion and learning experience were also measured during the experimental studies. Games in Study 1 was found with better emotion experienced by students, but lacking in motivation and learning experience. Games in Study 2 on the other hand showed better motivation, emotion and learning experience. The results were attributed to the gameplay found in these games. The weak motivational and learning experience found in games for Study 1 were associated to the absence of several important SG characteristics, and the use of tasks that led to cognitive overload. Games in Study 2, however, possessed most of the SG characteristics and implemented scenarios that were in line with the concept of AL.

Findings from the experimental studies showed that the educator-authored SRPGs can be effective learning tools. The key implications from the findings are discussed below.

Complexity of SRPGs

The evaluation of the games in the studies involved assessing HOTS amongst learners. Findings from the studies can be used as early indication on the potential of SRPGs in terms of improving HOTS amongst learners, as this area is still under-researched (Section 2.4). However, learners' improvements shown in the studies were small, which could be attributed to the simple games and short duration of the study. As mentioned earlier, few tasks were used in both the SRPG and control activity. This

meant that learners would not have enough opportunities to practice and experience various scenarios which could demonstrate the learned concepts.

Longer Study

As mentioned above, the short study duration was also attributed to the small learning improvement found. During the study, students were only exposed to the interventions for twenty-minutes before attempting the post-test right after. Carrying out post-tests right after engaging with the interventions are typically carried out in SG studies. These studies, however, are mostly assessing LOTS which involves students' ability to remember and understand. In the context of the current studies, the short exposure to the interventions could result in some students not having enough time to create a deeper understanding on the learned content.

7.5 LIMITATIONS

Although every effort was made to ensure that the studies in the thesis were carefully designed, the research are restricted by several limitations presented below.

- ***Game patterns in the design method is bound to limitations***
  Analysis of RPG quests is still limited in the literature. The player actions used in the design method were based on the RPG pattern identified by Doran & Parberry (2010). The pattern was devised by analysing various quest database websites and quest descriptions for only a few prominent RPG at that time, which would limit the patterns found only from these games.
- ***Limited domain and learning tasks in the educator-authored SRPGs.***
  Due to the time constraint of the experimental studies, the game and control activities contained only a few tasks that cover the learning content. This means that participants were only exposed to few scenarios to demonstrate the learning concept. The limited tasks and domain used within the studies would result in findings that are limited and do not fully explore the capabilities of the SRPGs.
- ***Limited Study Time***
  As mentioned earlier (Section 7.4), the short exposure time with the game and control activities during the experimental studies might not be sufficient for

participants to fully grasp the learned information in order to attempt a test that assesses their HOTS, which could have impacted students' performance during the post-tests.

- ***Creating one quest in the usability studies.***

  The tasks during the usability studies involved educators using the different component editors in the authoring tool. For the quest creation task, educators were only required to create one quest. Structuring this quest does not require educators to use all available blocks. While the findings from the studies showed the general usability of using BBP, it does not fully explore the functionality of the complete list of blocks within the proposed authoring tool.

- ***Confounding Variables***

  Although the studies in the thesis were carefully designed to account for possible confounding variables, unexpected and uncontrollable confounding variables could have been introduced and influenced the results and findings. Certain confounding variables were not addressed in the studies, in particular participants' prior knowledge in the respective domains.

- ***Small sample size in the experimental studies.***

  The participants in both experimental studies were less than the calculated sample size, which would reduce the statistical power and affect the results of the analysis.

CHAPTER 8
CONCLUSION AND FUTURE WORK

The overall aim of the research is to identify potential ways for educators to be able to create SGs that can be used as teaching and learning tool. To this end, the thesis has made several key contributions.

The creation of SG has been shown to be a complicated and expensive process, and efforts have been made to improve the accessibility of the creation process. However, the focus on educators' involvement in the creation process has always been ignored. The research undertaken in this thesis is new in the sense that the creation process is structured around putting emphasis on educators as active creator. This research aims to be one of the first few efforts looking into establishing this new research direction in the area of SGs.

The thesis has produced a novel design method for the design of SRPGs intended for educators (Section 3.3), which focuses on the design of real-world scenarios as the foundation of gameplay. While this concept is shared by one existing design method (Nadolski et al., 2008), the method in this thesis further enables educators to incorporate gameplay into the scenarios. Findings from the research identified the suitability of the process found within the design method for educators (Chapter 3 and Chapter 4), mainly due to the familiarity of the process, its focus on the designing real-world scenarios, and the easy conversion of scenarios into quests. As mentioned in previous chapters, the game pattern used in the conversion of scenarios could be limited in terms of the player actions. More studies will be required in order to produce an updated game pattern consisting of game challenges and player actions found in

current RPGs, and other related game genre (i.e., action, adventure, simulation and strategy).

The research also proposed the novel authoring tool for the creation of SRPG (Chapter 5). Findings from the usability studies (Sections 5.4 and 5.5) found the tool was highly usable, which can be attributed to its structured authoring workflow and the use of various suitable interfaces (e.g., drawing editors, BBP). The adoption of BBP was due to its usage in various areas in application development and education, showcasing its capability in simplifying programming, and its ease-of-use for various non-expert target users. But its use in SG authoring tools is still limited, which makes the current research early evidence on the applicability of BBP in SG authoring tools. More evaluation of BBP is also required. A comparative evaluation against other VPLs such as diagram-based is needed to explore the VPLs characteristics, strengths and usability in the field of SG creation and with educators as target users.

The design of the block language was based on the components of RPG, player action and structure of RPG quests (Section 5.2). As mentioned in previous chapter, although the usability studies showed the suitability of the interfaces and workflow of the authoring tool for educators, a more extensive study is required to further explore the functionality of the complete block language currently available in the prototype authoring tool. This would involve a study that require participants to create different type of quests.

Another approach that can further simplify the creation process is the inclusion of Procedural Content Generation (PCG). PCG is a concept where a computer program creates content, such as for games, with limited or no-input from human users (Soares de Lima et al., 2019). Areas where this approach can already be implemented is in the creation of the game visual assets and quests. Gameobjects (e.g., as characters and the game world) involved in an SRPG were already identified when designing the SRPG. Descriptive textual information of these gameobjects (e.g., gender) can be used to automatically generate the graphics without much input from educators. The need for educators to use the drawing editors can thus be reduced, further simplifying and expediting the assets creation process.

Although PCG has been used to generate entertainment-RPG quest, the implementation of PCG in this respect is still lacking (Soares de Lima et al., 2019).

PCG could further reduce educators' task in implementing LQs. For example, educators can simply list out tasks that learners should be able to do. PCG can then be utilised where the necessary information (e.g., player actions and gameobjects) from the descriptions are automatically extracted and used as input to generate a suitable LQ. This would require further investigation, such as conducting an extensive analysis of the different learning activities that are typically used. A large amount of dataset would be needed in order to train this form of PCG to be able to classify learning tasks and allocated suitable quests that are relevant and appropriate for a particular activity and its associated domain.

It is important that the proposed platform can be used to produce effective SRPGs to be used as learning tools. Findings from the experimental studies showed that the SRPGs designed by educators using the design method can indeed be effective in terms of better learning gains, motivation, emotion, and perceived learning experience. The learning outcomes assessed in the studies were HOTS, which is yet to be widely studied in the area of SGs. Although the learning gains were small, they still provide an early indication on the potential of the SRPGs.

However, several studies would need to be carried out to further investigate the use of SRPGs. Studies looking into various domains and topics would inform the suitability of SRPGs for different learning contents and objectives. Further longitudinal experimental studies are also needed to investigate the effect of SRPGs in terms of HOTS, as this is useful in investigating learners' knowledge or skills retention after extended exposure with SRPGs. These studies would need to include more complex learning tasks in the games that can represent multiple topics and deep learning contents. Learners should also be exposed to the games repeatedly within a longer period of time. AL components and how they could be implemented in SRPGs were introduced in Section 2.5. These components focus on exposing learners to real-world situations through various outlets (e.g., authentic scenarios, mentoring). SRPG quests designed to include AL components can improve the chances that the activities given to players in an SRPG causes learning to occur. The effects of each of the components in an SRPG require further investigation in order to identify the suitability of the various RPG components at representing the different AL components (e.g., collaboration using multiplayer feature).

Further improvement on measuring learners' experience during the experimental studies could also be implemented to better triangulate the findings, such as through the use of physiological measurements (e.g., tracking eye movement, brain activity). This can provide an objective measurement of participants' experiential responses, which can enhance self-reported subjective responses and pinpoint participants' cognitive responses to the various stimuli found during gameplay. This can help identify the effects of the features found in SRPGs. Implementing this approach, however, would be challenging in terms of complicated and costly equipment setup.

The recommendations thus far are aimed to provide areas where the current findings in the research can be further improved. The overall concept adopted in the proposed platform has been shown as viable approaches to enable educators in the creation of SRPGs. The concept used for the drawing tools and BBP editor can be adopted and expanded further for other SG genres, or even other forms of educational technology such as virtual or augmented reality, which can improve the generality of the authoring workflow and processes. In terms of targeting other SG genres that do not share the general gameplay of RPGs such as puzzle games, new blocks language would need to be designed based on common gameplay found in these games Studies looking into how learning activities can be incorporated into these genres would also need to be conducted, which can inform on how the blocks would be designed. In terms of targeting virtual/augmented reality applications, one required enhancement would involve the rendering of the virtual world and objects created through the drawing editors as three-dimensional, as 3D visuals are typically used in these types of applications. Simulating the scenarios within a 3D world could provide a more immersive experience for learners.

APPENDIX

A1. Ethics Approval

VII. REVIEWING FEEDBACK

This section is to be filled by the Ethics Reviewers and Ethics Coordinator.

1. First reviewer

Summary: provide a brief summary of the main ethical concerns raised.

There is no risk involved in this research. It involves educators to be participated in this reasearch and all are addressed.

Recommendation: tick the appropriate decision recommended.

☒ Approval ☐ Approval with compulsory changes ☐ Rejection (not approved)

Justification: provide the justification(s) for your decision, and any optional suggestions or compulsory changes to be considered.

Name and Signature — 22-June-22 Date

2. Second reviewer (delete, or add more based on the number of reviewers)

Summary: provide a brief summary of the main ethical concerns raised.

Human participants are included in the study, however they are not categorized as "Potentially Vulnerable". PI has assured that there will be no potential for physical and/or psychological harm/pain/distress to the participants. No sensitive topics will be discussed with the participants during the study. PI has assured that personally identifying information (personal data) of the participants are not collected.

Recommendation: tick the appropriate decision recommended.

☒ Approval ☐ Approval with compulsory changes ☐ Rejection (not approved)

Justification: provide the justification(s) for your decision, and any optional suggestions or compulsory changes to be considered.

Name and Signature — 22 June 2022 Date

Coordinator's Decision

Decision: tick the appropriate decision.

☒ Approval ☐ **Approved with compulsory changes** ☐ **Rejected**

Details: provide any related details or feedback based on the decision and reviews.

Based on reviewers' comment and my observation, I would like to approve this application.

Dr. S. H. Shah Newaz — 23/06/2022

Name and Signature — Date

VII. REVIEWING FEEDBACK

This section is to be filled by the Ethics Reviewers and Ethics Coordinator.

1. First reviewer

Summary: provide a brief summary of the main ethical concerns raised.

Recommendation: tick the appropriate decision recommended.

☐ Approval ☐ Approval with compulsory changes ☐ Rejection (not approved)

Justification: provide the justification(s) for your decision, and any optional suggestions or compulsory changes to be considered.

S_____ _____

Name and Signature Date

2. Second reviewer (delete, or add more based on the number of reviewers)

Summary: provide a brief summary of the main ethical concerns raised.

Recommendation: tick the appropriate decision recommended.

☐ Approval ☐ Approval with compulsory changes ☐ Rejection (not approved)

Justification: provide the justification(s) for your decision, and any optional suggestions or compulsory changes to be considered.

_____ _____

Name and Signature Date

Coordinator's Decision

Decision: tick the appropriate decision.

☒ **Approved** ☐ **Approved with compulsory changes** ☐ **Rejected**

Details: provide any related details or feedback based on the decision and reviews.

After going through the revised version of this application, I do not notice any ethical concern in this explained study and usability test in accordance to the guideline UTB's Research Ethic Policy provides. The applicant has addressed in the revised application all the concerns raised by the reviewer committee based on the earlier application. Therefore, I approve this application.

Dr. S. H. Shah Newaz

_____ _____22/09/2020_____

Name and Signature Date

VII. REVIEWING FEEDBACK

This section is to be filled by the Ethics Reviewers and Ethics Coordinator.

1. First reviewer

Summary: provide a brief summary of the main ethical concerns raised.

Since there is no potential risk involved and also to protect the user's personal data is given and approval is given for the survey.

Recommendation: tick the appropriate decision recommended.

☒ Approval ☐ Approval with compulsory changes ☐ Rejection (not approved)

Justification: provide the justification(s) for your decision, and any optional suggestions or compulsory changes to be considered.

_____ _____

Name and Signature Date

2. Second reviewer (delete, or add more based on the number of reviewers)

Summary: provide a brief summary of the main ethical concerns raised.

No ethical issues are expected.

Recommendation: tick the appropriate decision recommended.

✓ Approval ☐ Approval with compulsory changes ☐ Rejection (not approved)

Justification: provide the justification(s) for your decision, and any optional suggestions or compulsory changes to be considered.

Applicant has clearly stated the scope of work addressing the ethical concerns that may arise from the study. Issues such as anonymity of participants, storage of data and destruction of data after the study period have been addressed appropriately.

_____ _____8/3/2022_____

Name and Signature Date

Coordinator's Decision

Decision: tick the appropriate decision.

☑ **Approved** ☐ **Approved with compulsory changes** ☐ **Rejected**

Details: provide any related details or feedback based on the decision and reviews.

In my opinion, this research complies university's research ethics policies. I have no objection.

DR. S. H. SHAH NEWAZ S.H. Shah Newaz _____March 10, 2022_____

Name and Signature Date

VII. REVIEWING FEEDBACK

This section is to be filled by the Ethics Reviewers and Ethics Coordinator.

1. First reviewer

Summary: provide a brief summary of the main ethical concerns raised.

Recommendation: tick the appropriate decision recommended.

☐ Approval ☐ Approval with compulsory changes ☐ Rejection (not approved)

Justification: provide the justification(s) for your decision, and any optional suggestions or compulsory changes to be considered.

__Dr. S.H. Shah Newaz____ _____
Name and Signature Date

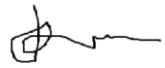
2. Second reviewer (delete, or add more based on the number of reviewers)

Summary: provide a brief summary of the main ethical concerns raised.

Recommendation: tick the appropriate decision recommended.

☐ Approval ☐ Approval with compulsory changes ☐ Rejection (not approved)

Justification: provide the justification(s) for your decision, and any optional suggestions or compulsory changes to be considered.



Name and Signature
Assoc. Prof. Ibrahim Venkat Date 6th Sept 2022

Coordinator's Decision

Decision: tick the appropriate decision.

☒ **Approved** ☐ **Approved with compulsory changes** ☐ **Rejected**

Details: provide any related details or feedback based on the decision and reviews.

This application is the revised version, amended by the applicant according to the feedback from SCI Research Integrity and Ethics board (meeting on 25 Aug 2022) where the committee "Approved the application with compulsory changes"

The following required changes were communicated with the applicant:

The committee gives an observation that the following point is ambiguous:

" Will the data be shared with any other collaborators or institutions? The data might be published in papers/journals. "

Our opinion is it should be clearly stated that the raw data will not be shared with other collaborators/institutions. The insight/analysis gained from the collected data may be used to in your publications. (Note, this was the understanding of the committee about "The data might be published in papers/journals.").

__Prof. Somnuk Phon-Amnuaisuk____ ___1 September 2022_____
Name and Signature Date

A2. Quest pattern based on (Doran & Parberry, 2010)

ARQS Design Method

Quest Pattern

MOTIVATION	STRATEGIES	ACTION SEQUENCE *Action rule (bold), Player action (normal)
KNOWLEDGE	Deliver item for study	**Get, Give**
	Spy	**Go to,** Spy, **Report**
	Interview another NPC	**Go to,** Listen, **Report**
	Use an item in the field	**Get, Go to,** Use, **Give**
COMFORT	Obtain luxuries	**Get, Give**
	Destroy pests or remove obstacles	**Go to, Defeat, Report**
REPUTATION	Obtain rare items	**Get, Give**
	Destroy or defeat enemies	**Go to, Defeat, Report**
	Visit a dangerous/unexplored place	**Go to, Report**
SERENITY	Revenge or justice	**Go to, Defeat, Report**
	Capture criminal	**Go to, Capture, Report**
	Check on NPC 1	**Go to,** Listen, **Report**
	Check on NPC 2	**Go to,** Take, **Give**
	Recover lost or stolen item	**Get, Give**
	Rescue captured NPC	**Go to, Rescue, Report**
PROTECTION	Attack threatening entities	**Go to, Defeat, Report**
	Treat or repair 1	**Get, Go to,** Use, **Report**
	Treat or repair 2	**Go to,** Repair, **Report**
	Create diversion 1	**Get, Go to,** Use, **Report**
	Create diversion 2	**Go to,** Damage, **Report**
	Assemble objects/structure for protection	**Go to,** Repair, **Report**
	Guard entity	**Go to,** Defend, **Report**
	Recruit	**Go to,** Listen, **Report**
CONQUEST	Attack enemy	**Go to, Defeat, Report**
	Take stuff	**Go to, Take, Give**
	Recruit	**Go to,** Listen, **Report**
WEALTH	Gather raw materials	**Go to, Get, Give**
	Take valuables for resale	**Go to, Take, Give**
	Make valuables for resale	**Go to,** Repair, **Give**
ABILITY	Assemble tool for new skill	**Go to,** Repair, Use
	Obtain training materials	**Get,** Use
	Use existing tools	**Go to,** Use
	Practice combat	**Go to,** Damage
	Practice skill	**Go to,** Use
	Research a skill 1	**Get,** Use
	Research a skill 2	**Get,** Experiment
EQUIPMENT	Assemble	**Go to,** Repair, **Give**
	Deliver supplies	**Get, Give**
	Take supplies	**Take, Give**
	Trade for supplies	**Get, Go to,** Exchange

ACTION RULES

Go to	Do nothing
	Go to
	Wait
	Explore
	Follow
	Stealth
	Learn, Go to
	Prepare, Go to
Learn	Do nothing
	Go to, Subquest, Listen
	Get, Read
	Get, Give, Listen
	Go to, Subquest, Examine
Prepare	**Go to, Subquest**
Get	Do nothing
	Take
	Go to, Gather
	Get, Go to, Exchange
	Get, Subquest
Take	**Go to,** Stealth, Take
	Go to, Destroy, Take
	Go to, Take
Capture	**Go to,** Use, Capture
	Go to, Damage, Capture
	Go to, Capture
Defeat	**Go to,** Damage
	Go to, Destroy
Report	Do nothing
	Go to, Report
Give	Do nothing
	Go to, Give
Rescue	Free
	Defeat, Free
	Escort
	Defeat, Escort
Subquest	Go someplace
	Perform Quest, **Go to**

PLAYER ACTIONS

Capture	Make something a prisoner.
Damage	Damage something.
Defend	Defend something from being damaged.
Destroy	Destroy something from existence.
Escort	Something will accompany you.
Examine	Get some information by examining something.
Exchange	Exchange something with someone.
Experiment	Learn what something is for.
Explore	Wander around.
Follow	You will accompany something.
Free	Free something from being a prisoner.
Gather	Collect something.
Give	Give something to someone.
Go to	Go to some location or something.
Listen	Get some information by listening someone.
Perform Quest	Perform some other quest.
Read	Get some information by reading something..
Repair	Fix, built or resolve something.
Report	Give information to something.
Spy	Get some information by observing something in stealth.
Stealth	Sneak up on something.
Take	Take something from someone or somewhere.
Use	Use something that will affect something or the environment.
Wait	Wait for something to happen.

A3. Student Background Questionnaire

Evaluating Learning Activity
Background Questionnaire

Participant ID: _____

- This questionnaire is used to establish your preferences and experience in playing games, and learning styles.
- Please read all the questions carefully before answering them.
- Please answer all questions.

Section A: Game Playing

A1. Game Genre

For each of the following game genres, please indicate (i.e., by placing a tick) how much you enjoy playing them.

	Not at all true		Some what True		Very True
	1	2	3	4	5
1. I like playing **Mini-Games** or **Casual** games. *Short games. E.g., Plants vs Zombies.*					
2. I like playing **Action** games *Games that focus on physical challenges, including hand-eye coordination and reaction time, E.g., Street Fighter, Sonic the hedgehog.*					
3. I like playing **Adventure** games *Games that are story-driven and require exploration and/or puzzle-solving. E.g., Tomb Raider.*					
4. I like playing **Puzzle** games *Games that focus on puzzle solving. E.g., Tetris.*					
5. I like playing **Role-Playing** games *Games that are story-driven and involves character development. E.g., The Witcher, Final Fantasy Series.*					
6. I like playing **Simulation** games.					

Evaluating Learning Activity
Background Questionnaire

Participant ID: ____

	Not at all true		Some what True		Very True
	1	2	3	4	5

Games that aim to simulate real life. E.g., The Sims.

7. I like playing **Sports** games. *Games that simulate sports. E.g., FIFA.*

8. I like playing **Strategy** games. *Games that focus on thinking and planning, logistics and resource management to achieve victory. E.g., tower defense, Starcraft, etc.*

A2. Prior Game Experience

	Never	Yearly	Six-Monthly	Monthly	Weekly	Daily
	0	1	2	3	4	5

9. On average, how often do you play games for entertainment?

	N/A	Very Negative				Very Positive
	0	1	2	3	4	5

10. On average, how would you rate your gaming experience?

	Never	Yearly	Six-Monthly	Monthly	Weekly	Daily
	0	1	2	3	4	5

11. On average, how often do you play games for learning (i.e., educational games)?

Evaluating Learning Activity Background Questionnaire

Participant ID: ____

	N/A	Very Negative				Very Positive
	0	1	2	3	4	5

	N/A	Very Negative				Very Positive
	0	1	2	3	4	5
12. On average, how would you rate your experience with educational games?						

Section B: Learning Style

Please visit https://www.webtools.ncsu.edu/learningstyles/. Complete the questionnaire in that web page. Once you have submitted the questionnaire, your results will be shown. Enter the results below.

Active			Reflective
Sensing			Intuitive
Visual			Verbal
Sequential			Global

Example: If your results are: **Active 1, Intuitive 3, Visual 9, Global 3**, you should enter the results as follow:

Active	1		Reflective
Sensing		3	Intuitive
Visual	9		Verbal
Sequential		3	Global

Thank you very much for your cooperation!

END

A4. Experience Questionnaire

Learning Experience Questionnaire Participant ID:

- This questionnaire is used to measure your perceptions of the tutorial activity.
- Please read through each question carefully before answering it. You can ask any of the facilitators for further clarification.
- Please answer all questions.
- Answer all questions truthfully.
- Your responses are anonymous, and will only be accessed by the researcher.
- For each of the statements in the questionnaire, please indicate (i.e., by placing a tick on the appropriate box) how true it is for you when engaging in the tutorial activity.

Section A: Motivation

For each of the following statements, please indicate how true it is for you, using the following scale:

	Not at all true			Some what true			Very True
	1	2	3	4	5	6	7
1. This tutorial activity was fun to do.							
2. After working at this tutorial activity for a while, I felt pretty competent.							
3. I put a lot of effort into this tutorial activity.							
4. I felt pressured while doing the tutorial activity.							
5. This tutorial activity did not hold my attention at all.							
6. I believe doing this tutorial activity could be beneficial to me.							
7. I think I am pretty good at this tutorial activity.							
8. I didn't try very hard to do well at this tutorial activity.							
9. I believe this tutorial activity could be of some value to me.							
10. I did not feel nervous at all while doing this tutorial activity.							
11. I thought this tutorial activity was quite enjoyable.							

Learning Experience Questionnaire Participant ID:

	Not at all true			Some what true			Very True
	1	2	3	4	5	6	7
12. I tried very hard on this tutorial activity.							
13. I am satisfied with my performance at this tutorial activity.							
14. While I was doing this tutorial activity, I was thinking about how much I enjoyed it.							
15. I was anxious while working on this tutorial activity.							
16. I think that doing this tutorial activity is useful for *<domain specific LO>*.							
17. I was pretty skilled at this tutorial activity.							
18. I would be willing to do this tutorial activity again because it has some value to me.							
19. I was very relaxed in doing this tutorial activity.							
20. It was important to me to do well at this tutorial activity.							
21. I enjoyed doing this tutorial activity very much.							
22. I think this is important to do because it can *<domain specific LO>*.							
23. I think I did pretty well at this tutorial activity, compared to other students.							
24. I think this tutorial activity is an important activity.							
25. I felt very tense while doing this tutorial activity.							
26. I didn't put much energy into this tutorial activity.							

Learning Experience Questionnaire Participant ID:

	Not at all true 1	2	3	Some what true 4	5	6	Very True 7
27. I thought this tutorial activity was a boring activity.							
28. I think doing this tutorial activity could help me to *<domain specific LO>.*							
29. This tutorial activity was an activity that I couldn't do very well.							
30. I would describe this tutorial activity as very interesting.							

Section B: Concentration

This is related to how the tutorial activity aims to encourage you to concentrate while minimising stress from learning overload.

	Not at all true 1	2	3	Some what true 4	5	6	Very True 7
31. Generally speaking, I can remain concentrated in the tutorial activity.							
32. Most of the tutorial activity is related to the learning outcome.							
33. I am not distracted from tasks that I should concentrate on in the tutorial activity.							
34. No distraction from the task in the tutorial activity is highlighted.							
35. Workload in the tutorial activity is adequate.							
36. I am not burdened with tasks in the tutorial activity that seem unrelated.							

Learning Experience Questionnaire Participant ID:

Section C: Goal Clarity

This is related to the goals of the tutorial activity and its tasks.

	Not at all true			Some what true			Very True
	1	2	3	4	5	6	7
37. Overall goals were presented in the beginning of the tutorial activity.							
38. Overall goals were presented clearly.							
39. Intermediate goals (i.e., new goals presented midway through the activity) were presented in the beginning of each task in the tutorial activity.							
40. Intermediate goals were presented clearly.							

Section D: Feedback (FOR GAME GROUP)

This is related to feedback given to you. Feedback is used to determine the gap between your current knowledge and the knowledge required to complete the tutorial activity.

	Not at all true			Some what true			Very True
	1	2	3	4	5	6	7
41. I receive feedback on my progress in the tutorial activity.							
42. I receive immediate feedback on my actions in the tutorial activity.							
43. I am notified of new tasks immediately.							
44. I am notified of new events immediately.							
45. I receive information on my success (or failure) of intermediate goals immediately.							

Learning Experience Questionnaire Participant ID:

Section E: Autonomy

This is related to how you enjoy taking initiative and asserting control over your choices in the tutorial activity.

	Not at all true			Some what true			Very True
	1	2	3	4	5	6	7
46. I feel a sense of control and impact over the tutorial activity. (i.e., my actions mattered and affects the outcome)							
47. I know the next step in the tutorial activity.							
48. I feel a sense of control over the tutorial activity. (i.e., I decide the actions or strategies to take to complete the tutorial activity)							

Section F: Immersion

This is related to how engaged you are in the tutorial activity.

	Not at all true			Some what true			Very True
	1	2	3	4	5	6	7
49. I forget about time passing while engaging with the tutorial activity.							
50. I become unaware of my surroundings while engaging with the tutorial activity.							
51. I temporarily forget worries about everyday life while engaging with the tutorial activity.							

Learning Experience Questionnaire Participant ID:

	Not at all true 1	2	3	Some what true 4	5	6	Very True 7
52. I experience an altered sense of time. *I.e., time seems shorter or faster.*							
53. I can become involved in the tutorial activity.							
54. I feel emotionally involved in the tutorial activity.							
55. I feel viscerally involved in the tutorial activity. *I.e., stronger emotional feeling that causes physical response e.g., heart rate increasing.*							

Section G: Knowledge Improvement

This is related to your improved knowledge or skills, in relation to the learning outcomes, while doing the tutorial activity.

	Not at all true 1	2	3	Some what true 4	5	6	Very True 7
56. The tutorial activity increases my knowledge on *<domain specific LO>*.							
57. I catch the basic ideas of the knowledge taught from the tutorial activity.							
58. I try to apply the knowledge in the tutorial activity.							
59. The tutorial activity motivates me to integrate the knowledge taught.							
60. I want to know more about the knowledge taught.							

Learning Experience Questionnaire Participant ID:

Section H: Emotions

Each of the three scales below is to measure your overall emotional responses to the tutorial activity. Please mark the appropriate one.

61. Please rate the level of Valence in the following scale (i.e., how *pleasant* do you feel when completing the tutorial activity?).

It is unpleasant. I am not happy.				Neutral				It is pleasant. I am happy.
1	2	3	4	5	6	7	8	9

Please rate the level of Activation in the following scale (i.e., how *energetic* do you feel when completing the tutorial activity?).

I am calm and relaxed.				Neutral				I am excited and activated.
1	2	3	4	5	6	7	8	9

62. Please rate the level of Dominance in the following scale (i.e., how much do you feel in control of the situation when completing the tutorial activity).

It is not in my control. I cannot affect it.				Neutral				It is in my control. I can affect it.
1	2	3	4	5	6	7	8	9

Learning Experience Questionnaire Participant ID:

63. Please explain in detail the above three ratings related to your emotional responses to the tutorial activity.

Section I: Positive and Negative Aspects

64. Describe what you like the most about the tutorial activity.

Learning Experience Questionnaire Participant ID:

65. Describe what you dislike the most about the tutorial activity.

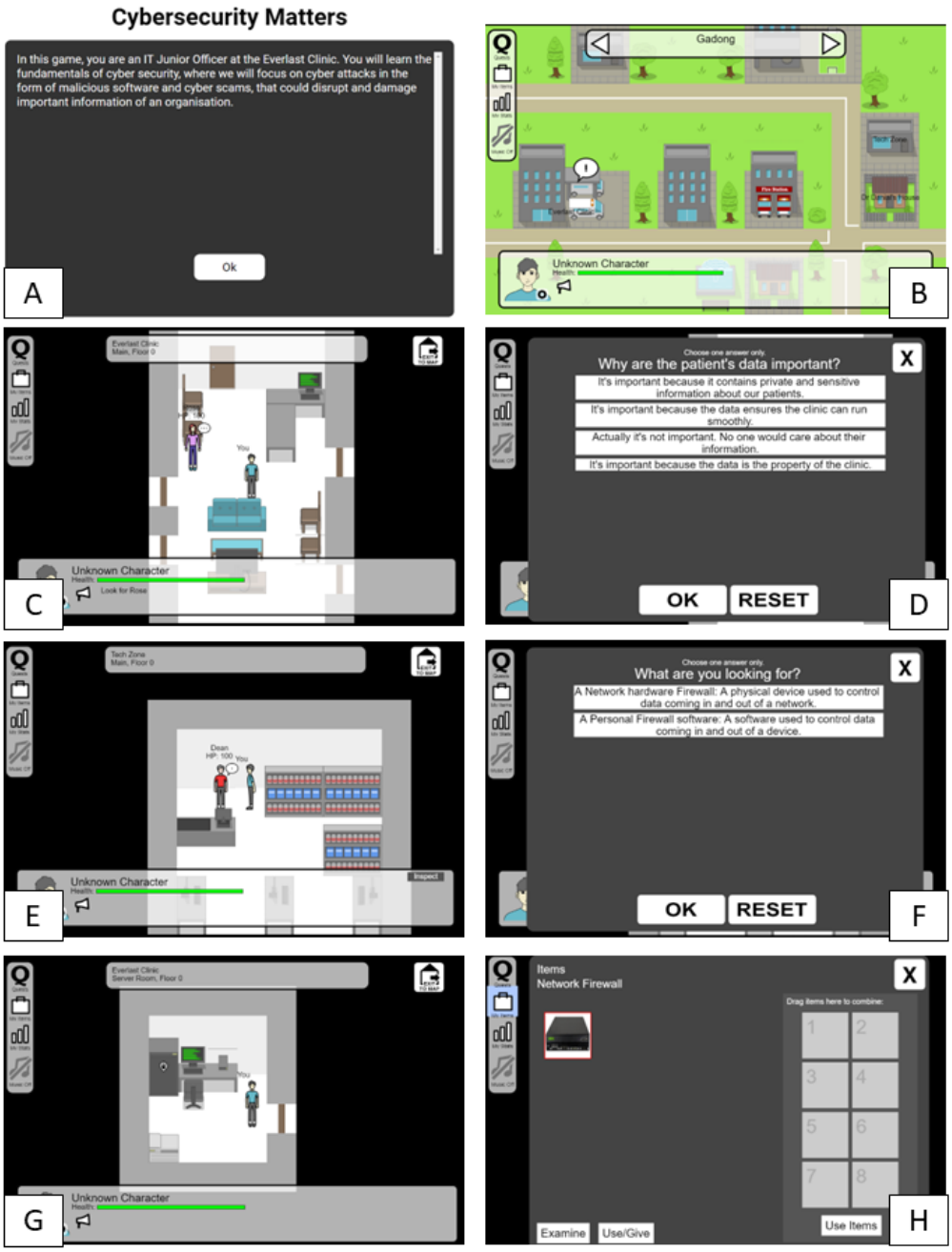
Thank you very much for your cooperation!

END

A5. Game 1 (DigiArt Game) Screenshots

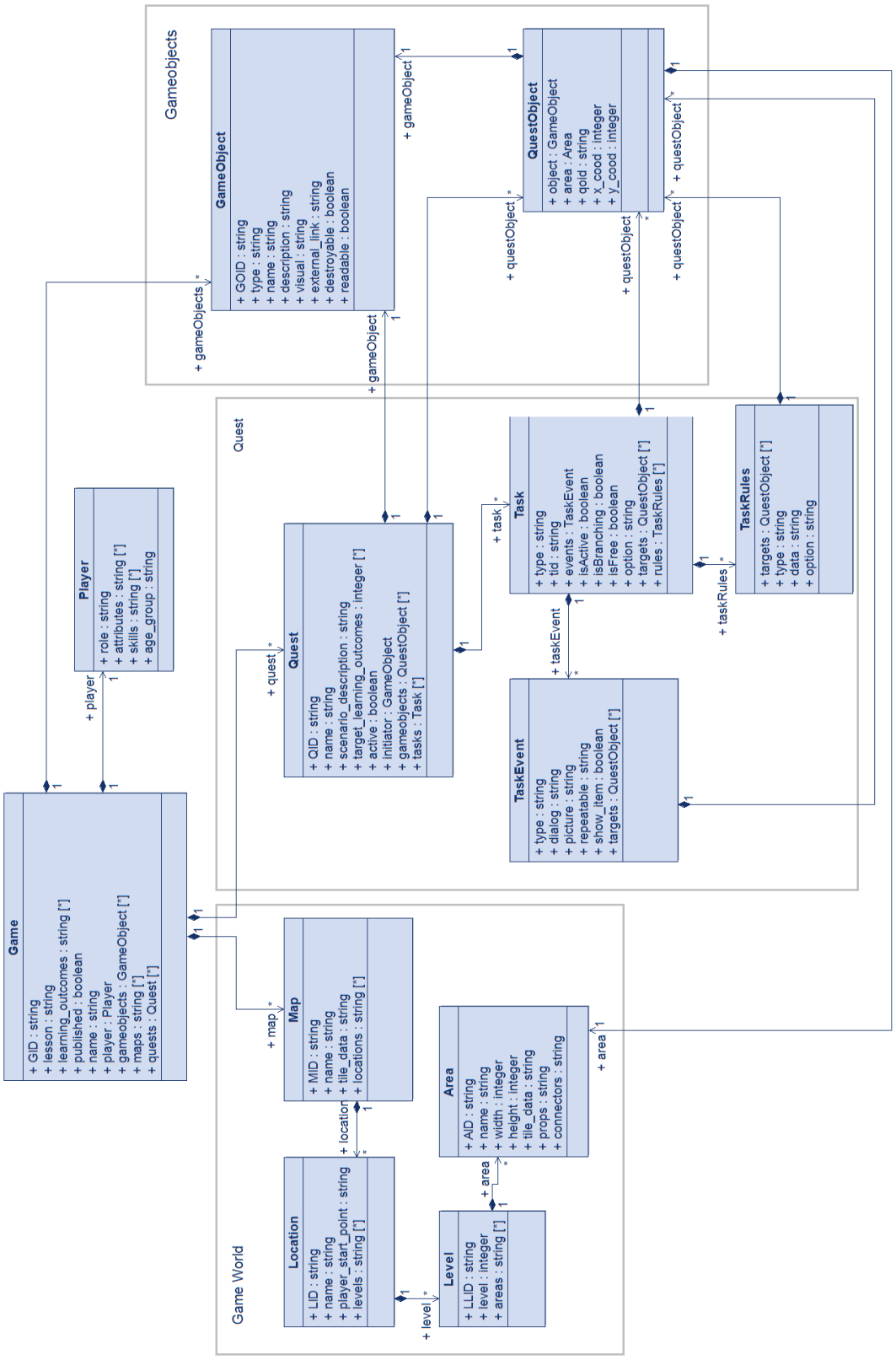
(A): Description about the game, presented to players when running the game. (B): World map showing locations that players can visit in the game. (C): Location scene when players click on a location. Here, players can interact with NPCs to start and complete quests. (D): In the DigiArt games, the gameplay only involves players answering MCQs posed by NPCs.

A6. Game 2 (InfoSec Game) Screenshots

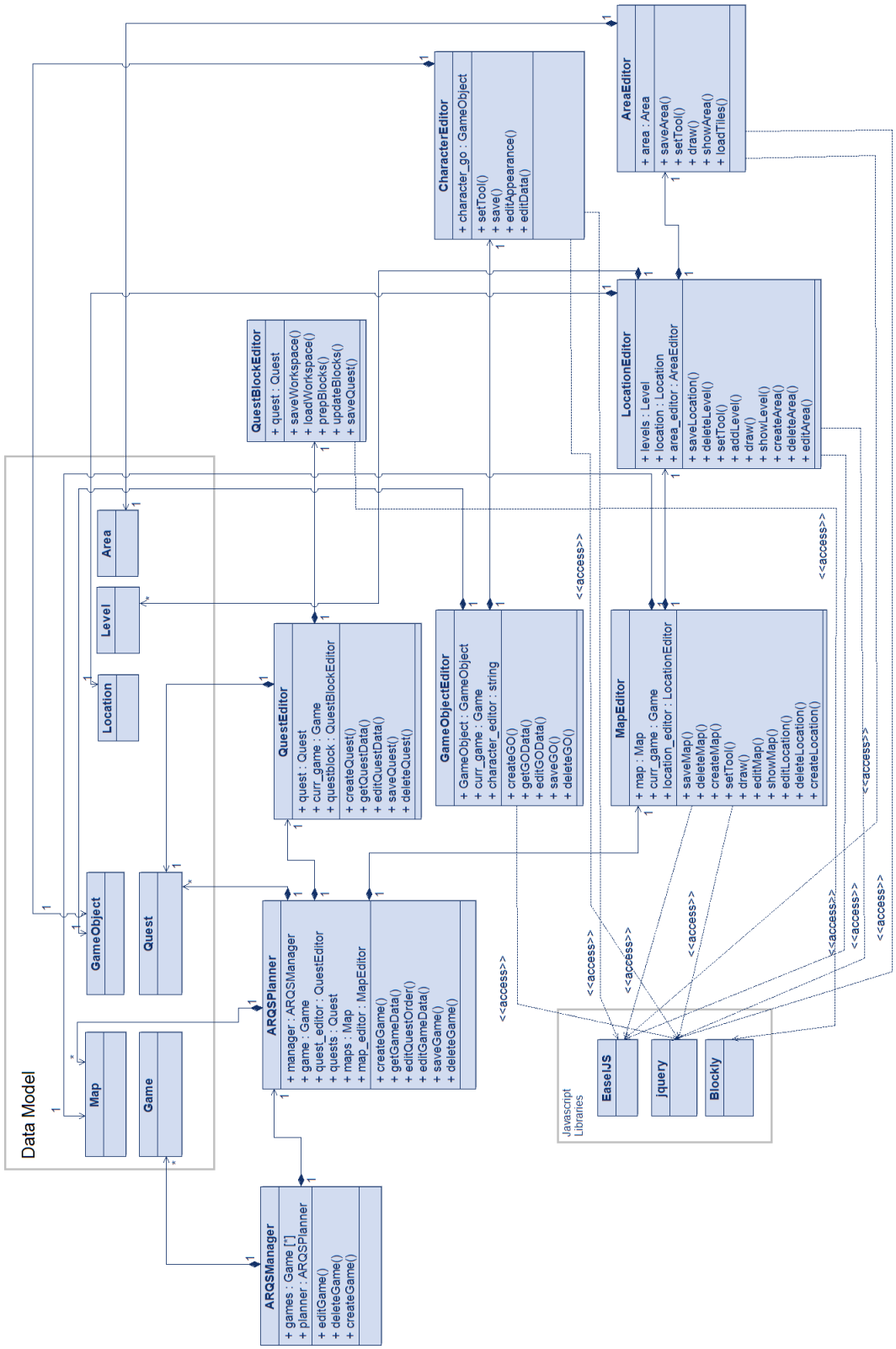


(A): Description about the game, presented to players when running the game. (B): World map showing locations that players can visit in the game. (C): Location scene when players click on a location. Here, players can interact with NPCs to start and complete quests. (D): In the InfoSec games, the gameplay involves players answering MCQs posed by NPCs. (E and F): The gameplay also involves players finding and acquiring required items to complete quests. (G and H): Players are also required to fix certain equipments by interacting and using certain items.

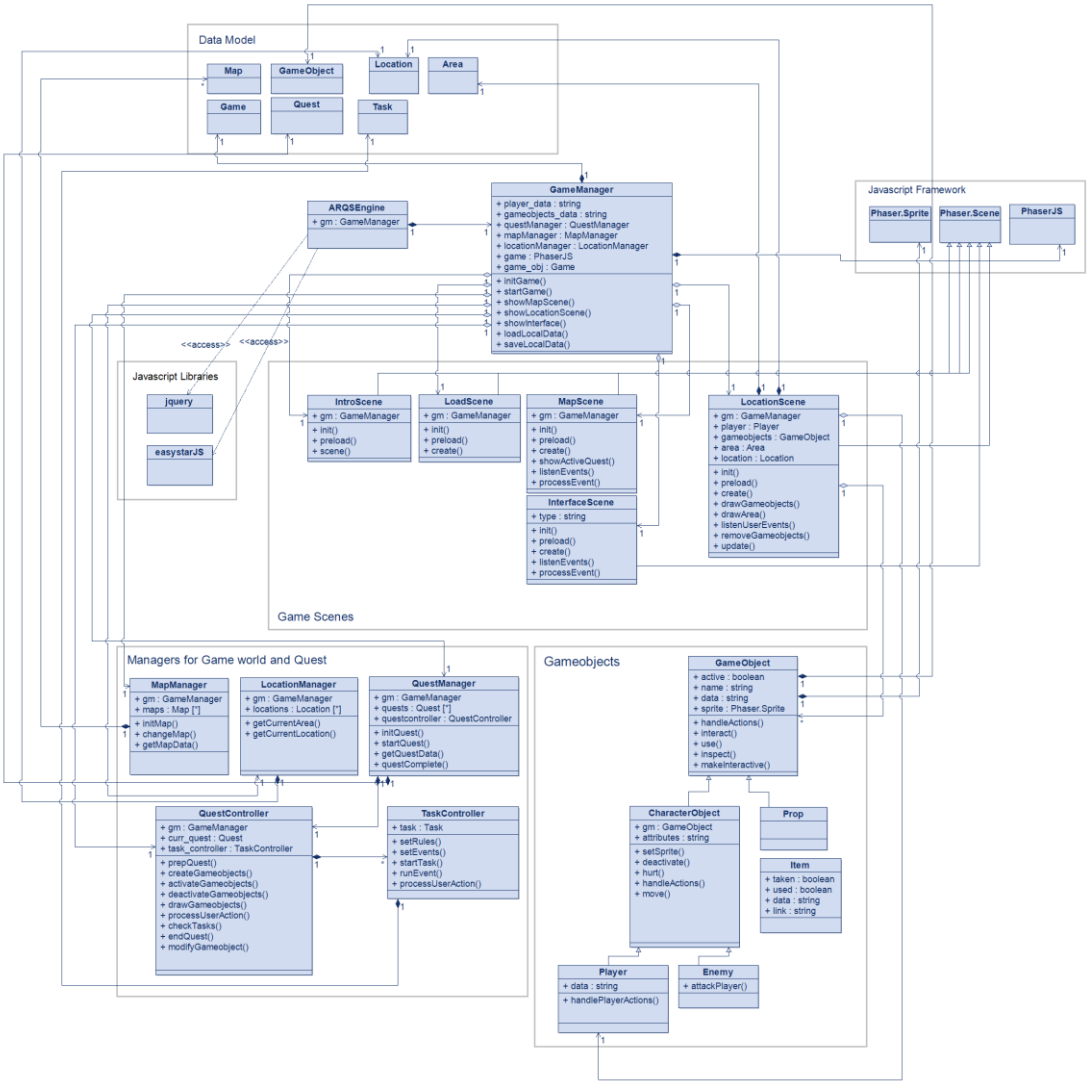
A7. ARQS Data Model



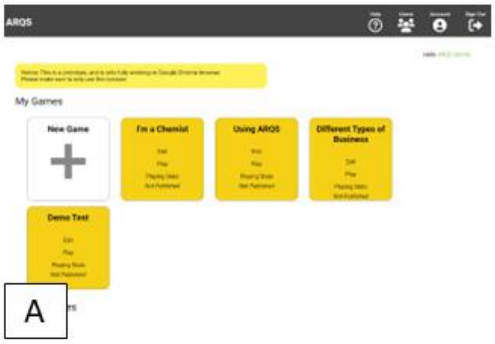
A8. ARQS Authoring Tool Architecture



A9. ARQS Game Engine Architecture



A10. Authoring Tool Screenshot



A

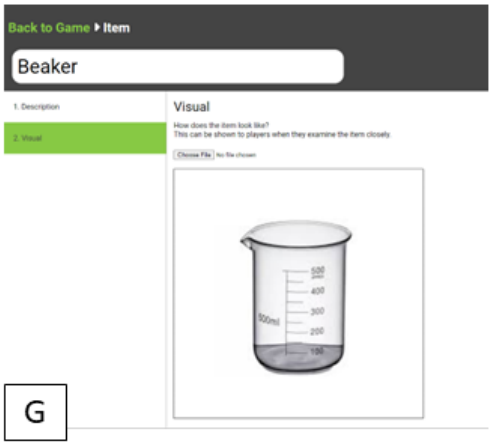
B

C

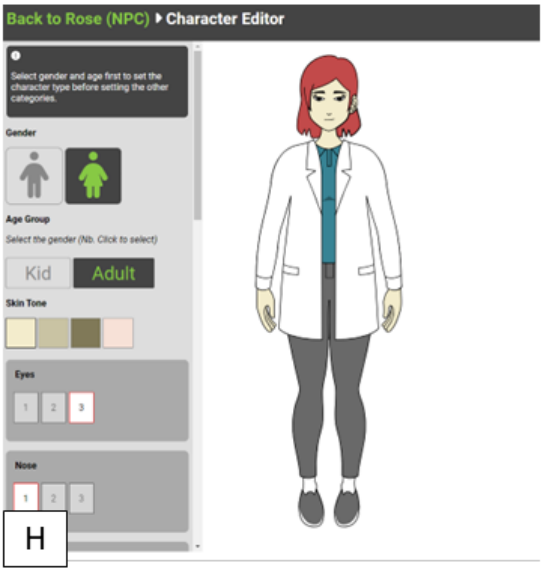
D

E

F



G



H

(A): Dashboard (Main Page) (B): Edit game page: Configuring game components. (C): Game world map editor page: Drawing maps of a game. (D): Location editor: Drawing locations (e.g., buildings) player can visit. (E): Area editor: drawing rooms or outdoor area players can explore. (F): Block editor: configure the structure of quests. (G): Gameobjects page: Configure details and image assets for items, readable items, and props. (H): Character editor page: configure details and visuals of NPC and enemy characters.

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