

# MASTERARBEIT | MASTER'S THESIS

Titel | Title

Between Textbooks and Joysticks 2.0: Fostering Agile Learning  
in IT-Students with an AI-based Adventure Game

verfasst von | submitted by  
Lukas Spreitzer

angestrebter akademischer Grad | in partial fulfilment of the requirements for the degree of  
Master of Science (MSc)

Wien | Vienna, 2024

Studienkennzahl lt. Studienblatt | Degree  
programme code as it appears on the  
student record sheet:

UA 066 977

Studienrichtung lt. Studienblatt | Degree  
programme as it appears on the student  
record sheet:

Masterstudium Business Analytics

Betreut von | Supervisor:

Ass.-Prof. Dott.ssa Dott.ssa.mag. Yllka Velaj PhD

Mitbetreut von | Co-Supervisor:

Dr.techn. Dominik Dolezal BSc BEd MSc

## German Abstract

Software-Projekte haben oft eine besonders niedrige Erfolgsquote und überschreiten häufig zeitliche sowie budgetäre Rahmenbedingungen, was auf eine zunehmende Komplexität von Geschäftsumfelder zurückzuführen ist. Das agile Projekt Management (APM) wurde ins Leben gerufen, um dieser Entwicklung entgegenzuwirken, indem es einem adaptiven statt prädiktiven Ansatz verfolgt. Jedoch fehlt es den Unternehmen an gut geschulten Fachkräften, um die Vorteile der agilen Herangehensweise nutzen zu können. Dieser Arbeitskräftemangel lässt sich durch die Diskrepanz zwischen den Erwartungen von Arbeitgebern und den Fähigkeiten von Absolventen erklären. Bildungsorganisationen haben es immer schwerer sich an den Anforderungen des Arbeitsmarktes anzupassen und stoßen mit den traditionellen Lehrmethoden an ihre Grenzen. Eine interessante Lernmethode namens *digital game-based learning* (DGBL), welche mittels Videospiele interaktive Lernumgebungen kreiert, könnte Abhilfe schaffen. Diese Studie evaluiert das Potenzial von Videospiele agile Fähigkeiten von Studierenden zu fördern, durch die Entwicklung einer DGBL-Intervention für einen Projektmanagement-Kurs. Durch die Recherche von APM-Literatur und Feldstudien zu Lernspielen wurden Anforderungen für eine Lösung erhoben, die das Erlernen agiler Prinzipien ermöglicht. Da sowohl die betrachteten Unterhaltungsspiele als auch Simulationsspiele entweder nicht zugänglich waren oder nicht den Anforderungen entsprachen, fiel die Entscheidung selbst einen Prototyp zu entwickeln. Das Resultat ist das textbasierte Abenteuerspiel "Agile Astro". Die Qualität des Spiels wurde mithilfe des MEEGA+-Modells in einem Workshop mit 30 Informatikstudenten im Bachelorstudium bewertet. Die Ergebnisse zeigen eine überwiegend positive Bewertung sowohl im Hinblick auf Spielerfahrung als auch den wahrgenommenen Lerneffekt. Die Analyse der Reaktionen von Studierenden während und nach dem Lernen mit Agile Astro und die Dokumentation des Entwicklungsprozesses des Spiels sind für Forscher und Bildungspraktiker bedeutend, insbesondere um eine breitere Adaption von DGBL zu ermöglichen.

## **English Abstract**

Software projects suffer from low completion rates, regularly exceeding time and budgetary constraints due to an increasingly sophisticated business environment. Agile project management (APM) was created to counteract these developments by following an adaptive rather than a predictive approach. Nevertheless, companies need more skilled professionals to leverage the new methodology fully. The skill gap between industry expectations and graduate capabilities can explain this shortage. Educational institutions need help meeting the increasing requirements with traditional methods. Digital game-based learning (DGBL), utilising video games to create an interactive learning environment, offers a promising solution. This study is concerned with evaluating the potential of video games to foster students' agile skills by designing a DGBL intervention for a PM course. After a review of APM literature and educational game case studies, requirements for a solution that is a capable instrument for teaching agility have been elicited. Several commercial and serious games have been evaluated but lacked accessibility or did not fit the requirements. Therefore, a self-developed prototype, a text-based adventure game called Agile Astro, was designed. The quality of the game was assessed using the MEEGA+ model in a workshop with 30 undergraduate computer science students. The results indicate an overall positive perception of player experience and perceived learning. The detailed insights into the analysed students' responses to learning with Agile Astro and the described process of developing a DGBL application are meaningful for researchers and educational practitioners in the quest to enable more widespread adoption of DGBL.

# Table of Contents

<b>List of Figures</b>	<b>III</b>
<b>List of Tables</b>	<b>IV</b>
<b>List of Abbreviations</b>	<b>V</b>
<b>1 Introduction</b>	<b>1</b>
<b>2 Definitions</b>	<b>4</b>
2.1 Evolving Didactics: Rise of DGBL in Education	4
2.2 Project Management – Into the New Agile World	8
<b>3 Literature Review</b>	<b>15</b>
3.1 Agile Management Skills	15
3.2 Video Game Elements for Fostering Agile Skills	22
<b>4 Methods</b>	<b>36</b>
4.1 Design-Based Research Approach for Developing a DGBL Solution	36
4.2 Classroom Evaluation of the DGBL Solution	44
<b>5 Results</b>	<b>53</b>
5.1 User Interface of Agile Astro	53
5.2 Students' Perceptions Regarding Agile Astro	58
<b>6 Discussion</b>	<b>70</b>
6.1 Key Findings and Interpretations	70
6.2 Implications	74
6.3 Limitations and Further Research	76
<b>7 Conclusion</b>	<b>79</b>
<b>References</b>	<b>81</b>
<b>Statutory Declaration</b>	<b>106</b>
<b>Appendix</b>	<b>A1</b>
Appendix A. Serious Game Candidates	A2

Appendix B. Commercial Game Candidates	A3
Appendix C. Interview Guideline	A4
Appendix D. Agile Astro React Main Component	A7
Appendix E. Agile Astro Database Structure	A16
Appendix F. LLM Prompts and Responses	A17
Appendix G. Adapted MEEGA+ Questionnaire	A27

## List of Figures

Figure 1. Published DGBL Articles from 2003–2023.....	6
Figure 2. Scrum Framework.....	11
Figure 3. Agile Competence Pyramid.....	16
Figure 4. Frequency of playing Digital-Games among Research Participants.....	45
Figure 5. Frequency of playing Non-Digital-Games among Research Participants.....	46
Figure 6. MEEGA+ Model.....	49
Figure 7. Main User Interface of the Experimental Game Agile Astro.....	52
Figure 8. Character Selection Screen of the Experimental Game Agile Astro.....	53
Figure 9. End of Game Pop-Up of the Experimental Game Agile Astro.....	57
Figure 10. Frequency Diagram of Player Experience.....	60
Figure 11. Frequency Diagram of Short-Term Learning.....	66
Figure 12. Frequency Diagram of Learning Goals.....	66

## List of Tables

Table 1. Difference Between Learning in a Classroom versus the Virtual World .....	7
Table 2. Studies Incorporating DGBL Methods that Foster Agile Competences .....	23
Table 3. Derived High-Level User Stories for an Educational Video Game .....	36
Table 4. Schedule of the Agile Workshop.....	48
Table 5. Descriptive Statistics of In-Game Metrics .....	67

## List of Abbreviations

AI	Artificial Intelligence
APM	Agile Project Management
DGBL	Digital Game-Based Learning
NPC	Non-Player Character
PM	Project Management
PP	Pair Programming
RE	Requirements Engineering
SAFe	Scaled Agile Framework
TDD	Test-Driven Development
XP	Experience Points



# 1 Introduction

Poor project management (PM) leads to a loss of 100 million dollars for every billion dollars that organisations invest. This was stated in the annual report from the Project Management Institute (2017), which questioned 3244 PM practitioners from various industries and regions around the world to capture the current status of the profession. Although PM is becoming increasingly mature in practice, recognisable in long-term statistics being shared, only half of the projects succeed in keeping to the agreed project scope and time frame. This, in turn, contributes largely to the implied budget overruns and adverse effects on the return on investments. Especially, projects that involve implementing information systems show an even lower project completion rate on average. Based on the Standish Group (2020) findings, which evaluated the successes and failures of over 50000 IT projects since 1994, two-thirds of recent projects were deemed a complete or partial failure (Tam et al., 2020). Particularly striking is the high discrepancy between predicted and actual project costs, with failed projects showing an average deviation of 200% from the estimate (Keil et al., 2000). This cost prediction uncertainty, in conjunction with the features of our 21<sup>st</sup>-century globalised market, like heterogeneity of industries, rapid digitalisation and the lack of institutional oversight, boosts the complexity of technology projects to new heights (Matveev et al., 2021). A paradigm shift came in the form of agile project management (APM). This countermovement established a new doctrine to deal with rapidly changing environments by switching from a predictive to an adaptive PM approach (Highsmith & Cockburn, 2001).

According to Denning (2015), being agile is primarily a mindset regarding PM rather than a specific set of practices. The concept has been broadly known for over two decades and has become integral in company strategies and research topics ever since (Hazzan & Dubinsky, 2014). Looking at the resulting definitions over the years that examined industries' implementation efforts the realisation of agility can be described as: "the project team's ability to quickly change the project plan as a response to customer or stakeholders needs, market or technology demands in order to achieve better project and product performance in an innovative and dynamic project environment" (Conforto et al., 2016, p. 667). The switch to APM seems to work, as it was shown that companies using an agile approach to PM achieve higher project completion rates. It does not even matter whether a

strict changeover from traditional to agile approaches has been introduced, the effect remained positive with hybrid integrations (Serrador & Pinto, 2015). The fundamental prerequisite to leverage APM's full potential is well-trained employees accustomed to the agile approach. The problem that PM, like many other professions, is currently facing is the enormous talent gap. The global economy will lack 25 million PM professionals by 2030. Fuelling forces responsible for these numbers are an upcoming wave of retirements, the emerging market in developing countries, and more jobs requiring PM skills (Project Management Institute, 2021a). Agile professionals are characterised by their high level of soft skills, as emphasised by agile principles like "people over processes". This set of skills, which includes communication, teamwork or problem-solving, concerns the human aspect of work. According to industry sources, new employees frequently lack the requisite skills (Bootla et al., 2015; Kropp et al., 2016; Mohan et al., 2018). So, there is not only a talent gap but also a skill gap that has emerged between industry expectations and graduates' capabilities (Radermacher et al., 2014). One reason is that there is a general bias towards teaching technical skills over non-technical skills in schools and universities, which especially becomes apparent in PM education (Pant & Baroudi, 2008; Valentin et al., 2015). The other reason is the rapid change in requirements for graduates' abilities, especially in the IT sector, which is closely linked to emerging technologies. Educational institutions struggle to meet the changing demand for hard and soft skills (Schleicher, 2018). However, a remedy could be found as a learning concept that has been discussed in research for some time. Digital game-based learning (DGBL) has the potential to provide educational practitioners with the flexibility to adapt to increasing expectations and fluctuating skill demands of graduates.

DGBL, in the broadest sense, is the learning within video games (Gee, 2004; Prensky, 2001). Video games are now ubiquitous in our culture and continue to grow in popularity. 53% of the population between 6–64 years old are frequent gamers, with considerable variation across different age groups and genders (Video Games Europe, 2022). A lot of spare time is invested in gaming; communities form around the most prominent game series, and skills are developed that are used to compete in international e-sport tournaments (Llorens, 2017; Ryan et al., 2006; Van Eck, 2006). It is, therefore, unsurprising that the potential for education has been recognised due to these phenomena. Many researchers have highlighted the advantages of learning with the medium instead of the traditional lecture setting (Granic

et al., 2014; Squire, 2003). Higher motivation and engagement with learning contents are proposed effects on the learner (Papastergiou, 2009). Teachers could benefit from a more autonomous learning style with DGBL, which would free up resources to improve learning environments continuously and mentor students more individually (Gee, 2004; Toh & Kirschner, 2020). These improvements are only theoretical, as DGBL has not yet seen a systematic, widespread breakthrough. Although there are case studies that present integrations of complete learning processes into the virtual world of a game, the research field still lacks sufficient data to enable generalisation (Calderon et al., 2017; Lui et al., 2015; O'Farrell et al., 2021). Recent technological advancements, like artificial intelligence (AI), have the potential to boost the efficiency of developing DGBL solutions (Westera et al., 2020). Therefore, the aim of this current study is to investigate whether and how a modern DGBL solution can be designed to promote agile competencies in students and thus counteract the shortage of skilled labour.

To reach the desired research results, the first chapter will lay the foundation by defining the main topics of the study, APM and DGBL. In the next chapter, the literature is reviewed in a two-step process. The first part is dedicated to gathering the competencies necessary to become an agile professional. The second part evaluates the implementation of video games in education to find game elements that fostered previously gathered agile skills. Afterwards, the methodology chapter defines the scope of the DGBL solution, teaching the agile framework Scrum and the embedding context, being an undergraduate PM course for IT students. Based on the described conditions and the insights of the literature review, a set of requirements for the envisioned DGBL solution is specified, and the design process of the actual application is documented. Next, the method to assess the quality of the video game and evaluate the learning effects is introduced. In the subsequent chapter, the video game development and intervention results are analysed and discussed according to the research questions to extract implications for DGBL researchers and educational practitioners. In addition, the study's limitations and further research opportunities are outlined. Finally, a conclusion is constructed.

## 2 Definitions

This chapter will focus on defining the two key aspects of this master thesis: digital game-based learning (DGBL) and agile project management (APM). It will go into more detail about the respective histories, provide term clarification and give an overview of the current state of research.

### 2.1 Evolving Didactics: Rise of DGBL in Education

The term DGBL was first made popular by Prensky (2001), who defined it simply as "the marriage between educational content and computer games" (p 145). The word *digital* in the term refers to the medium being used, computer games, which are also referred to as video games. There is considerable diversity among video games, and they are therefore divided into serious and entertainment games in the educational literature. Serious games are created with the intent of transmitting knowledge or training abilities. Authenticity is the aspect that distinguishes serious games from other games, evident in both their explicit educational intent and the accurate modelling of environments that closely resemble non-virtual contexts. Entertainment games, often also referred to as commercial games, on the other hand, are an easily accessed consumer product that tries to optimise fun and excitement with the primary goal of maximising the producer's revenue (Kikot et al., 2013). The *Microsoft Flight Simulator* developed by Asobo Studio (2020), where players are in the role of a pilot and complete flights in a highly realistic environment, can be classified as a serious game. In contrast, within the aircraft theme, the multiplayer game *Star Wars Squadron* developed by Motives Studios (2020), featuring five-against-five space battles in the well-known Star Wars setting, is a prime example of an entertainment game. This system of classification has limited utility with respect to outcomes, as serious games can provide enjoyment and entertainment games can lead to learning educational content. Researchers created a hybrid called edutainment to combine both aspects in the best possible way. The plan failed in most cases as educational researchers had little expertise in video game design and thus combined the worst of both worlds (Van Eck, 2006). Meanwhile, the video game industry has not stood still and has continued to advance. The overall revenue of the global gaming market in 2023 was \$384.9 billion USD and is expected to experience annual growth rates of 7.9% until 2027 (Statista, 2024). According to the report of the Entertainment Software Association (2023), which gathers data from roughly 4000 Americans, video games appear to be a

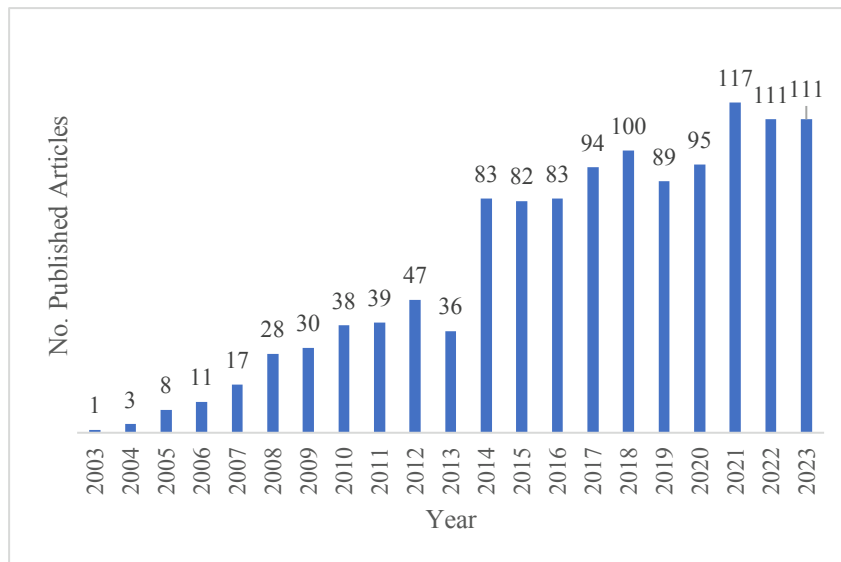
pastime that appeals to all segments of the population, with an average player age of 32 and an almost equal distribution between genders. Additionally, questioned players stated that they spent an average of 12.8 hours per week playing video games on multiple platforms. Furthermore, nearly half of the respondents expressed a preference for video games over television series, movies, and music. The medium can no longer be described as a trend but is now ubiquitous in our modern society (Gee, 2004; Oblinger, 2004). New technology in the form of generative AI, virtual reality, and mobile cloud gaming will shape the development of video games even further (Di Domenico et al., 2021; Ma & Zheng, 2011; Treanor et al., 2015).

The *game-based* part of DGBL is connected to its history. The overarching construct of DGBL is game-based learning (GBL), which dates back much further in research. According to Salen and Zimmerman (2004) a game is "a system in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome" (p. 80). Therefore, GBL leverages board games and other non-virtual games to transmit knowledge. Games like *Chess* or *Go* are several hundred years old and have been theorised to be used as abstract representations for battle formations (Peterson, 2012). These so-called simulation games have their origin in the military but gained popularity in the second half of the 20<sup>th</sup> century in formal education. These simulations adopt a playful approach utilising cards, dice, or playing fields, for example, to simulate complex issues such as the stock market in the classroom. They have long been endorsed by educational authorities (Capaul & Ulrich, 2010; Kühl et al., 2009).

The word "learning" in DGBL stems from research that seeks to define and measure the learning effects that occur during interactions with video games. Fig. 1 depicts the development of this field of research over the last twenty years.

**Figure 1**

*Published DGBL Articles from 2003-2023*



*Note.* Data was sourced from Semantic Scholar (n.d.). About 1,240 results for "digital game-based learning". <https://www.semanticscholar.org/search?q=%22digital+game-based+learning%22>

This chart illustrates the continual growth of studies that have adopted the keyword DGBL and the overall growing interest in leveraging video games for educational purposes. Not only have many researchers reported the enormous potential of DGBL, but can also already claim many success stories in its implementation in educational practice (Chung & Chang, 2017; Denham, 2019; Hamari et al., 2016; Salen, 2008; Spires et al., 2011). The positive effects have been proven in a wide variety of subject areas, especially computer science, which can, according to Papastergiou (2009), benefit massively from DGBL. Numerous advantages are attributed to video games compared to traditional knowledge transfer, as can be seen in Table 1.

**Table 1***Difference Between Learning in a Traditional Classroom versus the Virtual World*

<b>Learning in Video Games</b>	<b>Aspect</b>	<b>Learning in the Traditional Setting</b>
Players are free to choose the conditions in which they interact with the game.	<b>Student-Centricity</b>	Learning is centered around the teacher and students have little influence on learning time, frequency or method.
Players are actively engaged in the video game and are constantly formulating hypothesis, testing and revising them, enhanced with rapid and frequent feedback (Oblinger, 2004; Van Eck, 2006).	<b>Interactivity</b>	Students passively absorb information in routine activities, such as lecture.
Players can adjust the difficulty in video games depending on their progress and take all the time they need to mastering the environment (Prensky, 2001).	<b>Adaptiveness</b>	Students have to adapt to the lowest common denominator in terms of both speed and difficulty in order for lessons to take place.
Players experience just-in-time learning, by receiving information about the video game and being able to immediately apply it, to manifest what was learned (Prensky, 2001).	<b>Scaffolding</b>	Students learn asynchronously and abstract, as there is often a long time between knowledge acquisition and application.
Players join diverse communities. This interactivity between companies, technologies and players leads to knowledge sharing and opportunities to improve social skills (Gee, 2004).	<b>Sociality</b>	Students are isolated, especially in exams they cannot draw on other resources. They also lack the incentive to join a non-school network.
Players can compete against their own ability as the video game provides several visual inputs to monitor their performance and progress (Kikot et al., 2013; Toh & Kirschner, 2020).	<b>Transparency</b>	Students grading is often non-transparent, final assessment only takes place at the end of a course and is normatively.
Players while immersed into the virtual world feel an increased intrinsic motivation to learn and master the realities of the game (Kiili, 2005).	<b>Motivation</b>	Learning in the school environment is driven by extrinsic motivation, like good grades or fear of failing a class.
Players take on projected identities (Avatars), this interaction between the video game role and their own identity leads to immersion and motivation to learn (Gee, 2004).	<b>Identification</b>	In schools the possibility of taking on identities to engage the student into a subject domain is usually disregarded (Gee, 2004).

*Note.* Table modified from "Video games in education" by K. Squire (2003), *International Journal of Intelligent Games & Simulation*, 2, 49–62.

According to Prensky (2001), these attributes of learning in video games, when used in proper synergy with additional didactic methods in a controlled educational environment, promise a leap into a new pedagogical era. Well-known companies have already recognised video games' value and established them in their training processes (De Vin et al., 2018). However, the widespread adoption of DGBL in educational institutions faces several challenges. On the one hand, the bad reputation of video games as violence-promoting and a waste of time is still deeply rooted among the general public (Ferguson, 2011). On the other hand, many sceptics of DGBL claim that the linkage between learning content and video game reality is too abstract. Furthermore, the adaptability of the medium to the limitations of the classroom, such as infrastructure and time, is identified as a barrier (R. Clark, 2007; Hébert et al., 2021). However, video game advocates such as Gee (2004) and Kapp (2012) would attribute a lack of imagination and expertise in the implementation of learning content in the game context to the reported disadvantages. Kapp is better known for his research in the field of gamification. The distinction between DGBL and gamification is important, as they are related concepts often used inconsistently in the literature. Gamification borrows video game design elements, such as leaderboards, storytelling, or badges, and transfers them into a non-gaming context to achieve better learning effects. In contrast, DGBL tries to embed the entirety or parts of the learning content into the virtual world to improve abilities or convey knowledge. Both gamification and DGBL share the underlying premise of leveraging the capabilities inherent in video games to enhance motivation and commitment to learning (Khan et al., 2017).

## **2.2 Project Management – Into the New Agile World**

The history of project management (PM), as described by Seymour and Hussein (2014), is as old as humanity itself. In view of monumental constructions such as the pyramids of Giza or the Colossus of Rhodes, humans have always tried to create an environment in which the collective effort of people can be efficiently directed towards a common goal. However, the systematic development and the emergent research only came about at the beginning of the 20<sup>th</sup> century. Fayol and Gantt were the forefathers of the discipline, and their findings were soon put into practice to coordinate the huge logistical efforts that occurred during the two world wars. After this initial phase, we speak of the four periods of modern PM, which were characterised by external influences such as historical events, globalisation, and technological progress (Seymour & Hussein, 2014). What is particularly noteworthy is the



establishment of the Project Management Institute (PMI) in the second period, which gained worldwide recognition for standardising PM practices. The Project Management Institute (2021b) defines PM in their well-known guide Project Management Body of Knowledge as:

The application of knowledge, skills, tools, and techniques to project activities to meet project requirements. It refers to guiding the project work to deliver the intended outcomes. Project teams can achieve the outcomes using a broad range of approaches, for example predictive, hybrid, and adaptive. (p. 4)

The adaptive approach to PM has become more important over the course of history. Adaptive is the opposite of predictive project development and is becoming increasingly iterative and incremental depending on the volatility of requirements (Project Management Institute, 2021b). The drivers of this uncertainty have been the exponential development of technologies, rapidly changing market conditions and a shift toward customer-centricity (Ruhe & Wohlin, 2014; Schwaber, 2004). These influences caused traditional PM to reach its limits, and many large-scale projects failed. This failure stemmed from the wrong assumption that a company could eliminate change when investing enough time and resources in anticipation of future requirements (Highsmith & Cockburn, 2001). The response to outdated plan-driven approaches, such as the waterfall model, came from the software industry and was called agile software development (ASD) (Matharu et al., 2015). Although the origins of ASD go back further, as agile thinking can be traced back to the Japanese manufacturing industry, the widespread breakthrough only came after the turn of the millennium (Moran, 2015). In the fourth period of PM history, the Agile Manifesto was published in 2001. It is all about embracing change, and it ultimately signals the start of a new era of PM (Highsmith & Cockburn, 2001; Seymour & Hussein, 2014).

The agile way of working has nowadays arrived in the industry mainstream. Almost every leading company in the technology sector uses agile methods to deliver projects in one way or another (Winter, 2014). The basic idea of ASD is to collaboratively develop working software at short intervals in a customer-centric way in order to embrace change (Beck et al., 2001; Crowder & Friess, 2015). The keyword *software* in this definition can now be generalised to service or product, as agile methods have also found their way into many other professions outside of software development (Conforto et al., 2014; Hazzan & Dubinsky, 2014). The transformation from a plan-driven waterfall approach to APM often poses

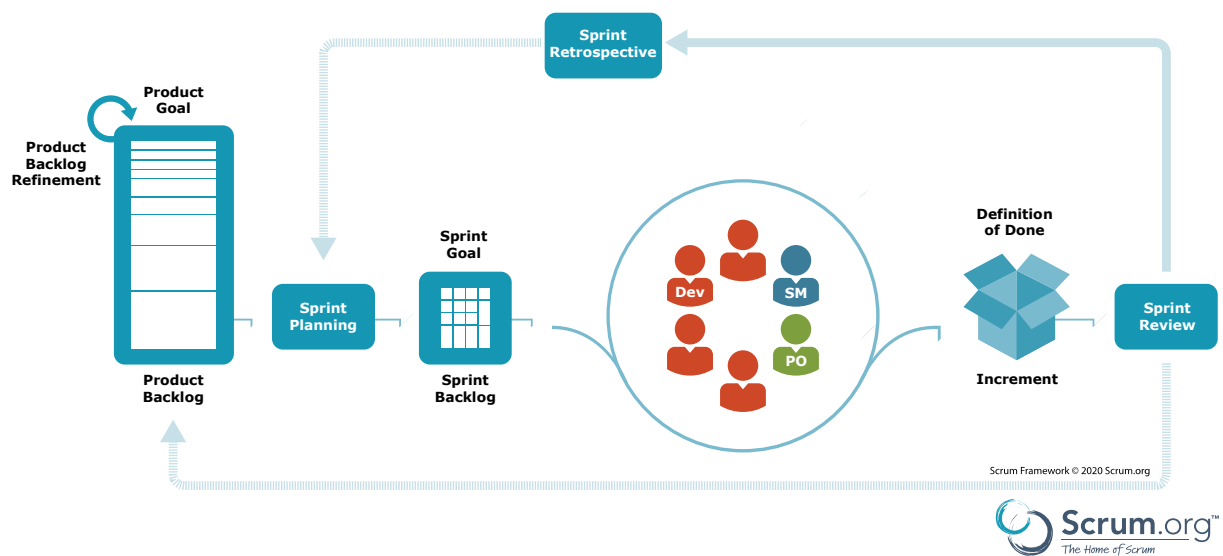
challenges, as agile approaches are less stringently defined than their traditional counterparts. Agility is a philosophy that was shaped by the principles and core values of a group of 17 developers in the Agile Manifesto (Misra et al., 2012). This way of thinking acknowledges that a company is a socio-technical system and that there are several optimal solutions for handling a project (Ruhe & Wohlin, 2014). Uncertainty and complexity are no longer countered by a high degree of formalisation but by people's creativity and intensive cooperation (Conboy et al., 2011; Dyba, 2000). The project risk is not mitigated by standardised processes and documentation but by short development cycles and frequent exchanges with the customer. This leads to faster identification of failures and quicker change of directions and helps to avoid incurring sunk costs associated with later modifications (Crowder & Friess, 2015). However, the agile principles represent only loose patterns of behaviour. Agile frameworks are built upon these principles to implement them organizationally in a company. The most popular frameworks are Scrum, Kanban and Extreme Programming (Brechner & Waletzky, 2015; Moran, 2015).

### **2.2.1 Scrum – Game-Changer in Software Development**

Scrum is the most prominent framework and the learning content that was selected for the video game intervention in this study, therefore examined in more detail in this section (Gloger, 2010). The term *Scrum* stems from a game itself, namely rugby. The authors Takeuchi and Ikujiro (1986) and, later, Schwaber and Sutherland (2012) draw parallels to software development. They argued that the different players collaboratively trying to move the ball forward within the field symbolise the cross-functional and highly connected Scrum Team that tries to deliver customer value incrementally. To optimise this generation of customer value, the Scrum process is structured as an iterative skeleton. Within this structure, two feedback loops are present, as can be seen in Fig. 2. The primary development cycle, called sprint, typically lasts one to four weeks and is concluded with stakeholder dialogue. The smaller loop represents the daily consultation facilitated through the daily stand-up meeting among Scrum team members (Rubin, 2012).

**Figure 2**

*Scrum Framework*



*Note.* The Scrum Process with the two-loop structure, roles, ceremonies, and artifacts. From *What is Scrum?*, by Scrum.org, n.d. (<https://www.scrum.org/resources/what-scrum-module>). Copyright [2024] Scrum.org All rights reserved.

The Scrum team enjoys complete autonomy in its activity area, and the management responsibility is divided into three roles. Within the team, there is no hierarchy; all members are considered equals. The product owner is the link to users, higher-up management and the customer and has a strategic view of the future of the product or project. The developers are self-organised and collectively responsible for iteratively implementing the planned functionalities. The Scrum Master is a facilitator and tries to embed the Scrum mindset and practices in the company's culture. A Scrum team consists of no more than nine persons, and decisions are made jointly within the team. At the same time, the influence of outsiders is tried to be minimised (Gloger, 2010; Matharu et al., 2015). The Scrum process is intentionally designed for repeatability, incorporating identical events scheduled consistently, referred to as Scrum ceremonies. The team meets for the sprint planning, during which the tasks that can and should be carried out within this increment are selected from the product backlog. The product backlog is a dynamic list of product requirements maintained and prioritised by the product owner. Once the sprint scope has been set, the implementation of the high-level requirements, called user stories, assigned to each team

member begins. Daily standups are held frequently to present progress to each other, offer help, and adapt the procedure if necessary. Additionally, in the course of a sprint, a backlog refinement can take place to concretise requirements for the subsequent iterations and to take effort from the next sprint planning. Continuing with the development, the effort to implement functionalities is measured in story points. The user stories are completed one by one as the sprint progresses (Schwaber, 2004). Several visualisation tools help to monitor the team's performance within the process transparently. For instance, the Scrum board shows the status of the respective user stories, and the burndown chart indicates open user stories measured in story points over time (Srivastava et al., 2017). At the end of the sprint, the Sprint Review evaluates the increment, one of the three artefacts in Scrum and involves participation from the stakeholders. It is usually organised as an interactive demo session and intended to encourage feedback from external parties, which can then be incorporated into the next iteration. This is followed by the final ceremony, the Scrum Retrospective, where the team's collaboration over the last few weeks is reflected upon, and a learning effect for continuous improvement is established. The sprint is thus completed, and a new iteration of the Scrum process begins (Hazzan & Dubinsky, 2014).

### **2.2.2 Effectiveness of Agile Methods in Practice**

Lightweight agile methods such as the Scrum framework promise numerous advantages over extensively documented and plan-driven traditional methods. This theoretical superiority is explained by Matharu et al. (2015): "Agile-based software development methodologies offer systematic software production, resulting in enhanced quality software products. Also, Agile-based methods are characterised by improved productivity, flexibility, enhanced customer engagement and responsiveness to changes in user requirements" (p. 3). Recognising these advantages in practice is a subject of investigation for many researchers exploring the effects of deploying agile frameworks. For instance, Lei et al. (2017) were determined to gather statistical evidence to measure the proclaimed effectiveness of agile methods against budget handling, risk control, quality of the project, available resources, having clear project scope, and schedule handling. They surveyed 35 agile practitioners in different roles. They concluded that the considered frameworks, namely Scrum and Kanban, perform effectively in the mentioned traditional PM factors and thus enable the successful development of projects in practice. These results were further supported by the research of Serrador and Pinto (2015), who analysed 1002 projects and found that agile methods

significantly positively influence project efficiency and stakeholder satisfaction. It is worth mentioning that a significant proportion of projects in their sample originated from non-IT companies. Further groundbreaking effects of agile transformations are stated by Jeff Sutherland, one of the founding fathers of the agile manifesto. In several case studies, he reports that deployed agile methods have outperformed waterfall approaches 5-10 times after only a short introductory period. This is achieved by creating an environment with the Scrum framework in which the project team is enabled to enter a hyper-productive state. This state is characterised by increased velocity and enhanced product quality (Sutherland et al., 2009). The companies with these agile success stories are diverse, from different industries to different cultures and company sizes. This suggests that agile methods can be used efficiently everywhere, yet 90% of companies fail to achieve these rapid performance improvements. The problem lies in the many challenges an organisation faces when adopting agile, often resulting in partial implementations that contain the worst of both worlds (Jakobsen & Sutherland, 2009; Sutherland et al., 2009; Sutherland & Altman, 2010).

### **2.2.3 Challenges in Implementing Agile Methodology**

Despite the numerous benefits of agile methodologies, not all implementation efforts succeed, and not all companies are even devoted to making the transition. This reluctance stems from the challenges inherent in adopting this new way of working, which impact all stakeholders, not solely the development team. For instance, unlike traditional PM approaches, agile methodologies require extensive client involvement throughout the project lifecycle (Inayat et al., 2015). This means that the client needs a representative with the necessary skills and time resources available, posing a challenge, as projects are usually initially outsourced for the absence of these two factors (Aitzaz et al., 2016; Beath & Walker, 1998). Furthermore, the stiffness of the legal contract between client and contractor presents another problem when adapting agile methods. The existing contractual arrangements in a company must be restructured to reflect and allow for flexible changes in requirements and the variability of the agreed costs (Cao & Ramesh, 2008). The management level, especially in large international corporations, also faces the hurdle that many autonomous agile teams must be organised to work synchronously towards an overarching goal (Moran, 2015). Critics have frequently dismissed this endeavour as unfeasible, prompting extensive studies examining the feasibility of agile global software development teams (Marinho et al., 2019; Rolland et al., 2016; Yagüe et al., 2016). Despite the existence of many pitfalls, there are, in

fact, several examples of large companies successfully transitioning to APM (Kalenda et al., 2018). To achieve this, management staff need to undergo comprehensive training to learn the skills required to lead and coordinate agile teams (Crowder & Friess, 2015). Especially as the strategic organisational level has fallen behind while operational development has been dealing with agile methods for decades (Goodpasture, 2004). Turning now to the core of the projects, the developers themselves. Even though they have been using agile methods for some time, the labour market is still immature. The workforce largely lacks the soft skills needed to maximise the benefits of frameworks such as Scrum (Bootla et al., 2015). Therefore, finding employees with the fundamental attributes to integrate them into an agile team is already a formidable challenge (Misra et al., 2012). These challenges can be mitigated mainly by promoting an understanding of agile methodologies and sharpening agile skills in training employees across various specialisations (Kropp & Meier, 2013).

### **3 Literature Review**

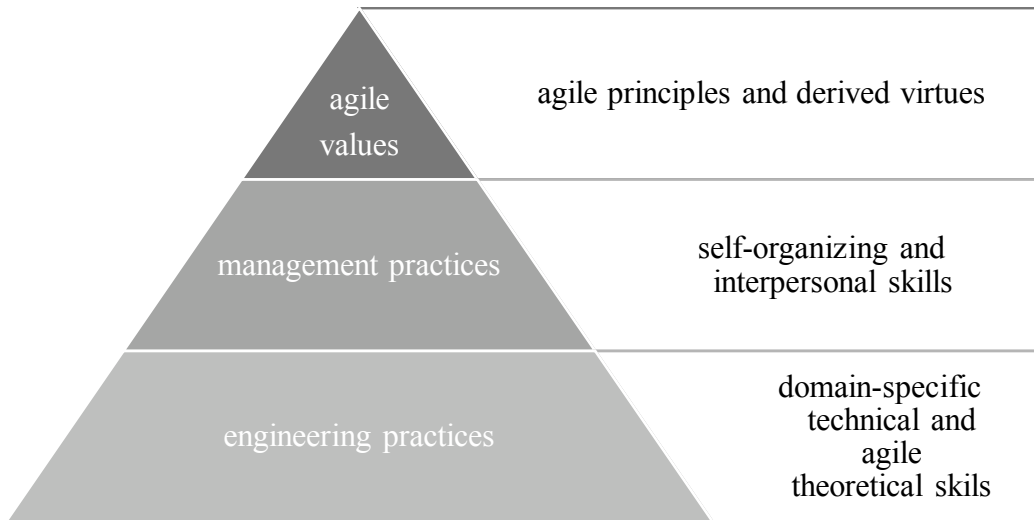
To evaluate how video games can improve APM learning later, it must be defined what skills need to be created to speak of a good learning outcome. Therefore, the first part of this chapter considers the current literature to determine the most critical competencies an employee needs to develop to work effectively in an agile environment. In the second part of the study, the current corpus of DGBL research is analysed to identify video game implementations that have successfully fostered these competencies.

#### **3.1 Agile Management Skills**

The first step was to review the current state of the literature on the competencies required for agile methodologies. The search was conducted by using the keywords "agile methodology" or "Scrum" in combination with "skills", "abilities", "knowledge", "education", "learning" or "training". The search period was constrained to the last 20 years since research into implementing agile methodologies became more widespread after the publication of the Agile Manifesto (Misra et al., 2012). The filtered outcome was a conglomerate of 16 studies from various settings, both industry training and formal education. This diversity was desired after recognising variability in the proficiency of implementing agile methodologies across different work domains (Alam et al., 2018). The agile competence pyramid of Kropp and Maier (2013) was chosen as a guiding framework, which can be seen in Fig. 3. They arrived at this classification of skills as a foundation for developing a curriculum for teaching agile methodologies in the university setting. The pyramid shape illustrates the few but hard-to-teach skills at the top and the numerous but easy-to-convey skills at the bottom.

**Figure 3**

*Agile Competence Pyramid*



Note: Adapted from "Teaching agile software development at university level: Values, management, and craftsmanship" by M. Kropp and A. Maier (2013), *26th International Conference on Software Engineering Education and Training (CSEE&T)*, p. 183.

The three categories, engineering practices, management practices, and agile values, represent the skillsets required for an effective agile software developer. In the following sections, the definitions of these competencies will be further validated and enriched using the insights of the previously identified papers.

### **3.1.1 Engineering Practices**

Engineering practices refer primarily to the single individual and contain domain-specific technical skills combined with APM know-how. Theoretical knowledge of agile frameworks, such as Extreme Programming and the respective technology implications, like version control systems or continuous integration methods, form the core structure and are usually one of the first skills learnt (Kropp & Meier, 2013). Engineering practices can also be called hard skills, which are necessary knowledge and competency prerequisites to perform a job. However, the boundaries to soft skills become indistinct, especially in an agile environment, where regular exchange with peers is heavily promoted. For example, the knowledge of how a sprint in Scrum is structured is an engineering practice. Still, to carry



out a successful sprint as a team, management practices such as leadership or time management are also required (Omar et al., 2018).

The *theoretical agile knowledge*, for instance, regarding Scrum, encompasses various concepts. These include the structure of a sprint, the objectives and guidelines governing the five ceremonies, the distinct roles and their respective responsibilities within a Scrum team, and the artifacts employed to facilitate and document the work process (Lee, 2016; Valentin et al., 2015). Outside the framework's formalities, data analysis is beneficial to understanding and monitoring agile metrics over several iterations. Examples of these kinds of KPIs are sprint burndown and team velocity, which are especially relevant for managers in agile development environments (Moran, 2015).

Proficient handling of agile practices represents the next grouping of engineering skills. However, these no longer represent theoretical agile knowledge, as they have a solid link to domain-specific technical abilities. For instance, testing with particular emphasis on *test-driven development* (TDD) stands out as the most frequently mentioned skill in the studies considered. TDD is a practice "about the determination of tests before the solution is created to clarify acceptance criteria" (Moran, 2015, p. 145). Learning these approaches, practitioners like Kinberg (2007) agree that "TDD is hard, it takes a while for a programmer to get it" (p. 82). The mindset of determining erroneous and permissible behaviour of features in advance is usually not present with novice developers. In addition to TDD, new emerging developments for automated testing of requirements, such as automated acceptance testing and behaviour-driven development, represent a consistent evolution to the principle of early testing in the development process (Kropp et al., 2016). However, TDD does not only incorporate the skill of writing unit tests for single features against acceptance criteria; the functionality of the encapsulating system must also be understood and validated using integration tests with every release (C. H. Tan & Teo, 2007). In the context of code releases, *continuous integration* is another cornerstone practice that originated in agile development. Developers must adopt the mentality that code changes shall be integrated with the shared repository as often as possible to avoid idle time between team members and to make progress transparent (Ruhe & Wohlin, 2014). Another competency to master is *refactoring*, which also has its roots in agile development and is tightly entangled with TDD. According to Fowler and Beck (2019), "refactoring is a change made to the internal structure of software to make it easier to understand and cheaper to modify without changing its observable

behavior" (p. 53). For these three practices, a certain amount of foresight and routine is essential, which is why Omar et al. (2018) count the *experience* gained in Scrum teams as a skill for a good developer, even if this is not attainable through formal education. In an agile environment, there are even methods that also need to be mastered to accelerate the build-up of experience. One of these methods is *pair programming* (PP). In PP, junior developers can capitalise on the extensive knowledge of seniors. This effect is achieved by PP being "a practice in which two programmers work side-by-side at one computer, continuously collaborating on the same design, algorithm, code, or test" (Williams & Kessler, 2000, p. 109). Consequently, PP is essentially a facilitative skill, which is to be adopted by the more experienced team members and is held in high regard in Extreme Programming (Steghöfer et al., 2016).

Lastly, there are *technical skills* that cannot be pinpointed exclusively to the agile way but are nevertheless crucial for the software engineering domain. These are, for instance, the clean code approach, familiarity with design patterns, or computative thinking, which were mentioned in the work of several researchers (Bootla et al., 2015; Hidayati et al., 2020; Kropp et al., 2016; Tan & Teo, 2007). These skills are essential in every software development environment, whether agile or traditional. Another general technical capability that requires further explanation is *requirements engineering* (RE), which resembles a hybrid between engineering and management practices. RE is, according to Lucia and Qusef (2010), "the process of establishing the services that the customer requires from a system and the constraints under which it operates and is developed" (p. 212). RE in an agile development environment differs mainly from the traditional approach regarding the time requirements are collected and documented. In waterfall-like projects, the goal is to collect detailed and complete requirements before the design phase is initiated; with agile, it is even encouraged to have more concrete or changing requirements after delivering an increment (Lucia & Qusef, 2010). The theoretical knowledge and understanding of the methodologies used to elicit stakeholder requirements fall into the engineering practice. However, the successful execution of RE, which relies on the exchange between persons, is dependent on soft skills that will be covered in management practices.

### **3.1.2 Management Practices**

Management practices refer to the manifestation of agile principles that are regarded as team efforts. The overall goal is to deliver small increments that centre around ever-changing

customer needs while working as effectively as a group as possible by maintaining a flowing information exchange (Kropp & Meier, 2013). For that endeavour a toolbox of self-organising and collaboration skills is necessary.

*Self-organisation* is one of the critical characteristics of an agile team. It is so omnipresent in the literature that educational researchers like Steghöfer et al. (2016) use it as a measure for evaluating the learning outcomes of agile methodology courses. Many of the self-organising skills needed are capabilities that were previously only attributed to higher-up managers and leaders within a traditional PM company setup. However, an overall shift can be experienced when entering an agile environment. The demand for traditional managerial and leadership skills defined by Alvarenga et al. (2019), such as time management, troubleshooting, delegation, decision-making and commitment, is now more equally distributed across all team roles. Therefore, the significance of those skills doesn't decline; instead, it becomes increasingly crucial for a greater number of people to internalise them. These skills are notably lacking in the current workforce since most developers were never trained in formal education to be that autonomous (Kropp et al., 2014). For instance, with a sprint structure, where specific output is expected within a short interval, *time management* becomes an even more critical task. Proficiency in strategic planning, slicing backlog items into actionable tasks, and employing advanced techniques for effort estimation and prioritisation are vital for contributing meaningfully to the daily administrative functions of an agile team (Bootla et al., 2015). Also, *troubleshooting* continues to play a significant role in APM, with the original interpretation having undergone only minimal changes. For example, if a developer within an agile team encounters a time-consuming bug or has overestimated their work capacity, other team members will collaboratively work to address the issue. After all, the team has committed to a specific sprint goal, and everybody is accountable for achieving the defined outcome (Ruhe & Wohlin, 2014). The capability of *delegating* is still necessary to know the strength of every team member, assigning people to tasks that lay in their respective expertise, supporting them to finish their tasks effectively and trusting the team (Crowder, 2015). However, the classic delegation term is no longer used in the agile management literature; it is attributed to *teamwork* skills (Omar et al., 2018; Tan & Teo, 2007). *Decision-making* is no longer a solitary endeavour; decisions are made through discussion about the appropriate interventions and result from opinions from people with various expertise who have come together to bring the team toward the previously

defined goal. Outside of the solution development teams, there are still decision-makers who primarily decide independently. On this level of the perspective on agile methodologies, it is important to know when to make landmark decisions and when to let agile teams steer their wheel. Conversely, for agile team members, it is also essential to know when to outsource a decision to a leader in a project-level role (Moran, 2015). To make good decisions, solve complex problems while troubleshooting, and, generally, be self-organised, a certain level of *analytical thinking* must be present in every agile team member (Hidayati et al., 2020; Omar et al., 2018). The last skill worth mentioning, despite its controversies, is *framework fitting*. Opinions of researchers and practitioners differ, but it is customary in practice to tailor for example Scrum to fit a specific company context. Therefore, it is also an important skill for a self-organised team (Kropp et al., 2016).

The skills listed so far, and the knowledge of agile frameworks' tools are essential for a team to be autonomous, empowered and, therefore, self-organised as desired in the guides to agile methodology. However, the most critical discipline consistently mentioned as a priority in the literature is missing, *interpersonal skills*. These collaboration skills are crucial to every agile framework. They are deemed so necessary that the creators of the agile competence pyramid, Kropp et al. (2016), later named the second layer after them. Among these skills, *communication* repeatedly stands out in the literature. It are these soft skills that both agile beginners and experts agree stand on top of the requirements list for an agile developer (Hidayati et al., 2020). Although agile tools like Scrum ceremonies are designed to disseminate knowledge, a daily, retrospective or sprint review doesn't guarantee effective communication or collaboration. The competency depends on the people, environment and content and remains a valuable skill that every person in an agile team needs to improve. Because frameworks like Scrum offer so many opportunities for exchange, a developer must be proficient in: "giving and receiving feedback, willingness to talk about problematic issues, openness concerning problems and impediments, active participation, and a general understanding of the scope of the meetings" (Kropp et al., 2014, p. 141). Communication as a skill set must be considered in several directions. Primarily internally with the agile team, where efficient collaboration and knowledge exchange must take place both in person as well as remotely. In the case of a classic hierarchical structure, a reasonable basis for communication with management must also be established. Finally, maintaining a close and frequent line of communication with the customer aligns with the tenets of agile

methodology. The sound external communication, paired with keeping a *customer relationship*, plays a particularly vital role in RE and is the missing link to the previously mentioned theoretical knowledge of the RE process in the engineering practices (Kropp et al., 2016). With good written communication skills, user stories can be created from the requirements survey, forming the basis for quick and qualitative development cycles (Valentin et al., 2015). Other interpersonal skills, encompassing *emotional intelligence* for adeptly handling diverse personalities and effectively managing one's emotions, are pivotal. *Motivation* is essential, ensuring each team member can be a driving force when needed. At the same time, *commitment* plays a crucial role in being accountable for the entire team process, creating a positive feedback loop that fosters compassion and drives towards a shared team goal (Moran, 2015). Lastly, the skill to be a *facilitator*, both in terms of agile values and project-related development knowledge, helps to fulfil the continuous improvement aspect of agile and is indispensable for good collaboration in a team (Crowder & Friess, 2015; Omar et al., 2018).

### **3.1.3 Agile Values**

Agile values are the attitudes that form the foundation of the agile way of working. All other methods within the agile framework merely serve to preserve and reinforce these basic principles. It is the most difficult endeavor to teach them (Kropp et al., 2014).

In the original agile manifesto, four principles were defined which underline the agile values (Beck et al., 2001):

- "individuals and interactions over processes and tools"
- "working software over comprehensive documentation"
- "customer collaboration over contract negotiation"
- "responding to change over following a plan"

The derived values from these statements are necessary to let the agile way of thinking find its way into the heads of the developers. In the literature, there are a lot of valuable suggestions that try to characterise the agile spirit. Many are related concepts, derivatives, or synonyms from each other. However, Kropp et al. (2016) describe the agile values with completeness and distinction, highlighting openness, transparency and craftsmanship as the most prominent ones.

*Openness* to experience is needed to embrace the fast-paced software development world. Being adaptable and flexible in the face of ever-changing customer requirements is critical to being a valuable team member and motivated by everyday work. It is an openness to new technology, to alternative opinions of team members, and to learn from mistakes (Crowder & Friess, 2015; Kropp et al., 2016; Moran, 2015; Steghöfer et al., 2016). *Transparency* is a virtue that enables an agile team to monitor their progress towards the desired goals consistently. It builds trust and respect as everybody knows exactly what each team member does at any certain moment. Exchange and synergies are created between experts from different areas because everyone can see the entire system and not just an encapsulated subtask (Kropp et al., 2016; Valentin et al., 2015). As researchers such as Steghöfer et al. (2016) and Moran (2015) suggested, this informed atmosphere becomes instrumental in shaping another critical value: courage. Informed team members are likelier to communicate truthfully, readily seek help when needed, and openly admit mistakes. *Craftsmanship* involves developers taking pride in their work, committing to stringent quality standards, and relentlessly pursuing mastery in their field. The cultivation of such expertise not only establishes a growth mindset but also facilitates continuous learning, increment after increment (Bootla et al., 2015; Kropp et al., 2014; Ruhe & Wohlin, 2014).

The crafted Agile Competence Pyramid represents a hierarchical skills profile for a proficient agile developer capable of enhancing any agile team. These comprehensive skills include technical expertise, proficiency in management practices and internalised agile values that ensure the individual can significantly contribute to the team.

### **3.2 Video Game Elements for Fostering Agile Skills**

In the second part of this literature review, a new corpus of related studies regarding DGBL is investigated. Several online databases were searched for the keywords "digital game-based learning" or "gamification" in connection with "management", "project management", "agile", "programming", "computer science", and "education". The original selection resulted in 43 documents. This new literature selection identified particular video game elements that can enhance one or more agile skills defined in the prior section. Therefore, after an initial review, studies that gave no insights into the connection between video game elements and agile skills were excluded. The remaining studies have been listed in a matrix in Table 2 compared with the agile competencies and their respective subcategories.



**Table 2***Studies Incorporating DGBL Methods that Foster Agile Competences*

References	Agile Competences				
	Engineering Practices		Management Practices		Agile Values
	Agile Knowledge	Technical Skills	Self-Organizing	Interpersonal Skills	Principles & Virtues
Chang and Chou (2008)		x			
Barab et al. (2009)		x		x	
Papastergiou (2009)		x	x		
Liang et al. (2010)			x	x	
Spires et al. (2011)			x		
Liu and Chen (2013)		x			
Lui et al. (2015)	x		x	x	x
Misfeldt (2015)			x		
Wernholm and Vigmo (2015)			x	x	
Olsson et al. (2015)		x			
Spires (2015)			x		
Miler and Landowska (2016)	x				
Darvasi (2017)		x	x		
Becker (2017)		x			
Calderón et al. (2017)		x	x	x	
Barr (2017)		x	x	x	x
Petri et al. (2018)	x	x	x	x	x
Rumeser and Emsley (2018)		x	x	x	x
Denham (2019)		x			
Abdullah and Saeed (2020)			x	x	
Holbrey (2020)		x		x	
O'Farrell et al. (2021)	x				x
Jääska and Aaltonen (2022)			x	x	x
Jääska et al. (2022)		x	x	x	

The matrix shows that agile theoretical knowledge and agile practices have been recorded the least within the literature. This absence can be explained by the few studies examining the specific intersection of APM and DGBL. Furthermore, the internalisation of agile practices and their overarching values is complex based on the existing studies that have yet to directly use rating scales to measure, for example, the agile value of openness. In contrast,



DGBL methods have been particularly effective for domain-specific and self-organising skills. This is because many serious games are available in widely used domains such as history, mathematics or language learning, providing a firm foundation for research. Additionally, self-directed learning that takes place in all types of video games, which represents a contrast to the teacher-centred learning in traditional classroom settings, already subconsciously promotes self-organising skills (Toh & Kirschner, 2020). Regarding developing interpersonal skills, embedding the DGBL method and providing opportunities for contact with other players in the video game appear to be crucial. Detached from the specific application area and skills, the majority of the studies found an increased engagement of students concerning the learning content, which shows that video games can at least fulfil a supportive pedagogical function in various applications (Holbrey, 2020; Jääskä et al., 2022; Liang et al., 2010; Liu & Chen, 2013; Papastergiou, 2009). However, Papastergiou (2009) points out that even the medium of video games will lose its novelty in the educational environment and should, therefore, not be seen as a silver bullet for motivating students.

Overall, after reviewing the literature, it is clear that numerous researchers have already shed light on video games' positive effects on agile skills. To benefit from the findings of these influential studies, the video game elements that led to the promotion of the respective agile competence were extracted. Since there is no consensus on naming video game elements in the literature, the extracted elements were grouped, categorised and generalised to obtain a standardised set. This inductively generated selection of elements largely coincides with the game-based learning framework evaluation matrix of Tan et al. (2007) and will be described in more detail in the following sections.

### **3.2.1 Interaction, Immersiveness and Identification – Catching Attention**

The first conglomerate of video game elements establishes an environment where learning can occur, which differs from other media and traditional schooling. It increases attention and engagement with new learning content. This is achieved through the novelty of using video games in the classroom and the possibility of interacting as a fictional character in an alternative world where knowledge is acquired bidirectionally. Researchers have found that players engage in an active learning process when implemented correctly (Barab et al., 2009; Calderón et al., 2017; Jääskä & Aaltonen, 2022). From the DGBL literature reviewed, three constructs seem particularly relevant for creating such a state.

### **3.2.1.1 Interaction**

Most frequently, the number and scope of interaction possibilities for the player in the video game are mentioned in this group of video game elements. The various control mechanics influence all other video game elements the player is offered within the virtual world. These dynamic interactions lay the foundation for player engagement and, in the case of DGBL, the learning process (Prensky, 2001). In their study, Miler and Landowska (2016) examined the serious game *graPM*. They found a positive correlation between perceived control when interacting with the game and increased effectiveness of PM content learning. This link also emerged in other studies; on review, it was found that there are two triggers. On the one hand, it can be stimulated by interesting gameplay mechanics, such as in *Portal 2*, where it is up to the player to solve a puzzle, as there are several equally valid approaches. These types of gameplay mechanics give control and contribute to the player's entertainment and creativity but do not affect the further course of the story (Becker, 2017). On the other hand, in many video games, decision points allow the player to influence the story of the fictional scenario significantly (Spire et al., 2011). For example, in the puzzle simulation game *Papers, Please*, which revolves around moral dilemmas encountered as an immigration officer, a player's decisions have both short-term and long-term consequences, ultimately determining the story ending they achieve (Barr, 2017).

### **3.2.1.2 Immersion**

The second construct, immersion, frequently appears together with interactivity, which suggests a correlation or a prerequisite relationship between the two. Immersiveness ensures that the boundaries between the game and reality become blurred, allowing players to forget that they are in a fictional scenario (Salen & Zimmerman, 2004). According to the studies, immersion is created by orchestrating different video game elements. The narrative quality plays a crucial role in enhancing immersion in the virtual world, which captures the players' attention and makes them participate in the learning process, as it has implications for unravelling storylines (Spire et al., 2011). The narrative is enriched by creating an atmosphere through rich media content such as 3-D looks, harmonious soundtracks, or animated cutscenes to draw the player inside the fictive world. Commercial games, in particular, are optimised for these video game aesthetics (Barr, 2017; Becker, 2017). However, some precautions must be taken so as not to break this immersion, especially in

the DGBL context. For instance, prioritising educational content at the expense of entertainment can pose a risk. Therefore, there must be a way to adapt the game gracefully to the student's needs and learning objectives. In their paper, Caledron et al. (2017) reported successfully implementing an administration tool for a PM video game, which enables trainers to customise game scenarios for different educational purposes. Another immersion risk that needs to be avoided is that the game, regardless of educational motives, violates its own logic and thus takes the player out of the focus state. Video games can be unrealistic, but they must remain true to their rules and have persistent worldbuilding; otherwise, attention pitfalls can occur (Jääskä et al., 2022). The aforementioned positive correlation between immersion and interaction lies in the fact that players can establish a personal connection to the story when they are given decision points in video games. Based on players' judgement and preferences, a unique experience is crafted. This can be referred to as "branching narratives" or "player-driven storytelling", depending on its form and maturity (Jääskä & Aaltonen, 2022). In contrast to other media, such as television, where the story unfolds linearly, video games allow players to see the consequences after each decision, assess them and reflect on their thinking, which can train self-organising skills like decision-making (Darvasi, 2017). Combined with Becker's (2017) general design recommendation that every game should have additional random components, this results in unique experiences from player to player. In a DGBL classroom setting where synchronous interaction with the video game occurs, improved facilitative skills have already been observed due to the different experiences made by students in their playthroughs (Abdullah & Saeed, 2020). However, there is also a contradictory relationship between immersion and interactivity. This becomes visible in the study by Jääskä et al. (2022), involving 319 students from six European educational institutions, where unexpected events in the project-based business game felt overwhelming because of the interaction possibilities. Despite this, students stated that this felt like the reality of day-to-day PM, and the scenario was very vivid and, therefore, immersive. This immersive experience contributed to developing domain knowledge in risk management within the project context. In summary, the literature shows that when elements for immersion are present and the aforementioned anti-immersion influences are minimised, agile knowledge, technical and self-organising skills can be promoted (Barab et al., 2009; Chang & Chou, 2008; Darvasi, 2017; Misfeldt, 2015; Petri et al., 2018).

### 3.2.1.3 Identification

The final construct that occurs, particularly when both interactivity and immersion are present, is identification with the role in the video game. Reaching identification through DGBL offers numerous educational benefits, as highlighted by Gee (2004) in his book "What games can teach us about learning and literacy":

... in taking on a projective identity, the player projects his or her own hopes, values, and fears onto the virtual character that he or she is co-creating with the video game's designers. Doing this allows the player to imagine a new identity born at the intersection of the player's real-world identities and the virtual identity of the character he or she is playing in the game. In turn, this projective identity helps speak to, and possibly transform, the player's hopes, values, and fears. (p. 199)

Predominantly, video games from the role-playing genre try to achieve a strong identification with the virtual identity through game elements such as selecting a character class, character appearance editors or learning skills based on mastered challenges (Blumberg et al., 2008; Granic et al., 2014; Lawson & Lawson, 2010). The relationship between identification and the two previously mentioned constructs is reaffirmed in this context. Decisions and connection to the narrative appear together in the video game elements fostering identification; however, the precise nature of influence among each other remains unclear. In PM video games, such as *Scrum'ed*, where players assume roles like that of a Scrum Master, studies have shown that participants gain additional knowledge in agile practices, e.g. agile ceremonies, roles, and artefacts, and technical skills, e.g. mathematics (Papastergiou, 2009; Petri, Calderón, et al., 2018). Furthermore, other PM games with identification elements have demonstrated to facilitate awareness of agile values, such as craftsmanship (Jääskä & Aaltonen, 2022).

### 3.2.2 In-Game Support, Simulation and Challenge – Serving Learning Content

The second collection of video game elements acts primarily as a delivery vehicle for the content to be learned. It is intended to accompany the students through all phases of the DGBL, providing rich learning opportunities and creating an experience that is easily transferable to the real world.

### 3.2.2.1 In-Game Support

Usually, the first in-game support measure that a player encounters is a tutorial that most video games implement to provide the player with information about the context of the scenario, familiarise them with the new rules in the fictional world and explain the game interface. Tutorials come in various forms, from text-based instructions and explanatory videos to interactive walkthroughs. A mixture of these different variants is usually employed (Andersen et al., 2012; Becker, 2017). It is comparable to an onboarding process in a company; the aim is not to overwhelm the beginner in this initial phase but to gradually provide them with new information. However, to create an optimal learning environment and transfer knowledge, not only the amount of information presented to the learner is essential, but above all, the timing and relevance (Plass et al., 2015). In video games, knowledge is often served as explicit information chunks just in time so that the player can use them in the right situation and thus internalise them better (Gee, 2004). In Papastergiou's (2009) DGBL experiment, it was found that this way of providing information is an incentive for exploratory learning; the player begins to actively seek knowledge that covers their interests and needs. The 88 students were divided into gaming and non-gaming groups. The gaming group showed better computer science learning outcomes and heightened motivation. Also, based on the exploratory learning environment, Holbrey (2020) observed a different learning outcome, suggesting that the resulting active exchange among students promotes interpersonal skills, particularly in peer-to-peer facilitation. Beyond the tutorial phase, video games also provide tools to support the player's self-directed learning path. A consequence-free safe space is established, encouraging a trial-and-error approach while leveraging rapid feedback to provide players with hints about their knowledge or skill gaps. Non-playable characters (NPC) are also particularly popular for this purpose, acting as story-embedded advisors and thus avoiding a break in immersion (Toh & Kirschner, 2020). This learning loop is further reinforced by reward systems such as experience points, which positively affect the plot or game mechanics as the player progresses. The interface of the video game also serves as a supporting element; overlay displays, such as progress bars and other additional visuals, are commonly used to track various game states or point to interaction possibilities. This enhances self-control and provides an overview of the learning process (Olsson et al., 2015). With all the scaffolding mechanisms in place, it's crucial to ensure that the learning instrument maintains its accessibility and ease of use (Liu & Chen,

2013). The selected DGBL studies show that this dynamic feedback and scaffolding can successfully promote domain-specific and agile knowledge while also effectively practising self-organisation, especially decision-making (Holbrey, 2020; O'Farrell et al., 2021; Papastergiou, 2009).

### **3.2.2.2 Simulation**

Simulation in the DGBL context can be interpreted in two ways. On the one hand, there is the commercial game genre of simulation, in which games are "a digital imitation of something real that has the character of a game: Competition, rules, etc." (Kikot et al., 2013, p. 14). On the other hand, pure computer simulations serve no entertainment purpose. These are merely "an implementation of a model, and a model is a consistent representation of some system. That model does not need to represent reality; it merely needs to describe a system consistently" (Becker, 2017, p. 12). This literature research only considered the latter if integrated into a video game. In the studies that examined video games with simulation elements, the players mentioned the word realism particularly frequently in connection with learning success. For example, in the experimental research by O'Farrell et al. (2021), which developed the 3D game *playSAFe* to investigate whether and how employee training can be realised with DGBL. This study is particularly relevant as it attempts to translate the Scaled Agile Framework (SAFe) into a video game and thus also tries to promote agile competencies. The research participants stated that the authentic atmosphere of an office environment that was generated and the imitation of an agile working day resulted in more engagement and a sense of presence during COVID-19. This also suggests a relationship between simulation and immersion, as, for example, the appealing 3D look, an immersive tool, was repeatedly mentioned as a driver of the learning experience. The verdict of SAFe practitioners was that the game is best suited for newcomers to play in advance of their classroom training, as it was found to promote awareness of agile values and teach both agile framework knowledge in theory and practice (O'Farrell et al., 2021). This is in line with the work of other researchers who have investigated PM simulation elements in edutainment games (Lui et al., 2015; Petri, Calderón, et al., 2018). When talking about simulation elements, balance is essential. The video game should include enough points of contact with reality to allow the player to apply previously learned knowledge in the virtual world but not incorporate the mundane aspects of the real world that would detract from the game's enjoyment. If a DGBL environment achieves this balance, the learning process feels

relevant, enhances commitment, fosters analytical thinking, and promotes the development of domain-specific skills (Chang & Chou, 2008; Jääskä et al., 2022).

### 3.2.2.3 Challenge

Of all the game elements, challenge was mentioned most frequently in the literature reviewed. We humans have a finite number of learning methods, one of which is increasing challenges. Video games are nothing but a collection of systematically placed problems (Prensky, 2001). The cause of the problems can be manifold; it can be a conflict with another human player, like in the multiplayer game *Team Fortress 2* or an AI-controlled NPC, like in the role-playing shooter *Borderlands 2*. It can also be another obstacle that has nothing to do with conflict, like the puzzles in *Portal 2* or a self-created challenge, like the construction of a sophisticated building in *Minecraft* (Barr, 2017). According to Kiili (2005), video games are meaningful frameworks for introducing students to problems that are relevant to the learning process. In his established experimental gaming model created to facilitate flow experience in the DBGL context, challenges are the centrepiece. It is a dynamic model that consists of two loops in which the player repeatedly formulates ideas based on the current challenge, tests them in the experimental learning environment and receives immediate feedback. The model also holds in promoting agile competencies, as various experiments in the inspected literature prove. The studies of Chang and Chou (2008), and Barr (2017) show that computer science skill promotion was triggered by increasing difficulty in challenges. Tailoring the difficulty of the challenges to the player's current abilities proved essential to maintain the flow state and avoid frustration or boredom. Furthermore, it is important to bring a certain novelty to challenges in order to be able to apply knowledge in new situations, which is equivalent to the positive impact of unexpectancy mentioned in the immersion section. In addition, challenges are usually wrapped up in an overarching quest, which puts the problem in a context that fits the narrative and usually presents a final goal to which the player can always measure their progress. These three added aspects of challenges can contribute to promoting self-organizing skills (Calderón et al., 2017; Papastergiou, 2009). The type of challenge is also decisive, depending on which agile skills are to be promoted. The popular video game element of crafting, where the player constantly has to deal with resource scarcity, represents a challenge or is at least a constraint for possible solutions to other problems. The player begins to practice resource management; a similar phenomenon is also visible in limited time, which leads to self-organising and contributes to the formation

of agile values such as craftsmanship (Barr, 2017; Rumeser & Emsley, 2018). Wernholm and Vigmo (2015) reported identical effects in studying children's knowledge-building dialogues. They added to the observation that using resources can trigger synthesising content from the real world. Challenges also act as triggers to promote other game elements. For example, collaboration was encouraged on problems that had to meet a specific time pressure or quality requirements (Jääskä & Aaltonen, 2022).

### **3.2.3 Competition, Cooperation and Community – Staying Engaged**

The game elements assigned to the third category all contain a certain social component. Examining user behaviour within the video game industry reveals that interaction with other human players is a significant attraction. Steam, the world's largest video game platform, continuously publishes data on the average number of users of individual games. As of January 2024, eight of the ten most-played games are multiplayer titles (steam250, 2024). This trend has prompted numerous researchers to explore the social side of gaming. They argue that video games establish social networks and emphasise that the design of player-to-player interactions within the game is essential for sustaining long-term motivation and, consequently, in DGBL, also for achieving learning success (Ducheneaut & Moore, 2004; Yee, 2006).

#### **3.2.3.1 Competition**

In multiplayer video games, players frequently encounter conflict situations that must be resolved. These interactions are valuable, as social competition is shown to be one of the major determinants for both player enjoyment and rapid feedback on user actions (Vorderer et al., 2003). Popular video game features that create competition are rankings, different game modes and the so-called matchmaking, where the game automatically matches the player with players of the same skill level. It should be noted that implementing these elements involves a trade-off, so the flow created by immersion loses its effect as uncontrolled elements of the real world, such as human interaction, are brought into the virtual world (Sweetser & Wyeth, 2005). However, competition also creates new dynamics that can promote agile competencies. The DGBL studies examined showed that implementing scoreboards and player-generated obstacles increased fun and attention to learning content. The results of the studies showed increased agile knowledge and improved self-organising skills (Misfeldt, 2015; O'Farrell et al., 2021). Caution for DGBL



practitioners is advised, as it is important to recognise that students have different affinities for competitive situations. Some students thrive on competition; for some, it's a stress trigger (Rumeser & Emsley, 2018; Vorderer et al., 2003). Additionally, competition in video games is a predictor of aggression, even well beyond the video game exposure time (Adachi & Willoughby, 2011). This does not mean that competition has no place in an educational environment; it is just more important to pay attention to the scaffolding of students during competitive situations. Holbrey (2020) is a positive example, reporting establishing a learning culture where domain skills could be enhanced. Despite the presence of competitive elements, failure did not result in negative emotions.

### **3.2.3.2 Cooperation**

The concepts of competition and cooperation are usually considered alongside each other in the literature. However, in contrast to competition, cooperation leads to predominantly positive outcomes. For instance, cooperation can trigger group flow, which creates a new dynamic that also harbours significant potential for the learning process. The emergence of group flow is illustrated by a statement from a focus group participant in the study of Kaye and Bryce (2012): "While playing WoW, I play with a group of friends, and often play cooperatively with 10, or 25 people. I have an important role in the group and feel useful, and enjoy working with a team to overcome obstacles" (p. 30). Other researchers underlined this opinion and were able to determine the same dynamic, especially in massive multiplayer online role-playing games. It was also shown that players develop long-lasting relationships and cultural knowledge and express themselves more freely in the game than in real life through cooperative elements (Cole & Griffiths, 2007; Liang et al., 2010). In addition, a significant positive correlation was found between playing hours and friendships in the game, which adds to the game's longevity (Cole & Griffiths, 2007). These cooperative virtual environments were also shown to positively affect agile competencies. For instance, in cooperative shooters, it was found that interpersonal skills are promoted through the establishment of a common goal, various forms of communication and the frequent stressful situations that force the players to work as a team (Barr, 2017). In combination with the fast feedback loop of games, it is possible to constantly reevaluate team performance after every decision and adapt tactics to the new conditions within the game (Rumeser & Emsley, 2018). A player's mindset to perform this approach efficiently is analogous to the values associated with agility, as the iterative process is similar. Consequently, the capacity to adapt as a team

in response to external conditions is cultivated through interaction with the video game environment.

### **3.2.3.3 Community**

Tacit knowledge is essential in all domains; as a new worker, it is vital to acquire it over time. Building this knowledge can only come from participating in a community of practice that is constantly adapting to the current conditions of our fast-paced world. Unlike in school environments, these communities appear frequently in video games (Gee, 2004). Beyond the generation of hands-on knowledge, people fundamentally desire to belong to a social group (Baumeister & Leary, 1995). This desire can be met in video games through institutional features such as clans or guilds and outside the game through support networks. If a video game fulfils these community aspects, it can motivate the player and offer additional incentives to play it in the long term (King et al., 2010). In the search for the promotion of agile competencies, it was found that especially support networks are beneficial. Through participating in forum discussions, being part of mod communities and watching others play on streaming platforms, a network teaching effect can be observed, and facilitation, teamwork and communication are fostered (Gee, 2004; King et al., 2010; Liang et al., 2010; Wernholm & Vigmo, 2015). Determinants for community effects in games are anonymity, identification with virtual roles, extensive player outreach and the self-controllable time and place in which the game is played (Liang et al., 2010). Nevertheless, even if games are integrated into the classroom, where these aspects are present to a limited extent or absent altogether, the fundamental role of video games in fostering communities and consequently improving interpersonal skills through shared group experiences remains evident (Jääskä & Aaltonen, 2022).

### **3.2.4 Further Considerations When Selecting Video Game Elements**

The systematic literature analysis shows which video game elements are influential factors in promoting agile competencies. However, it should be noted that not all individual elements should be maximised to optimise learning success. Inverse relationships exist, for example, between immersion and competition, where increasing one results in decreasing the other (Sweetser & Wyeth, 2005). Furthermore, the characteristics of the learners are decisive as to which game elements are appealing. The most significant influencing factors are age, video game experience, learning style and social value orientation (Calderón et al.,

2017; Misfeldt, 2015; Olsson et al., 2015; Rumeser & Emsley, 2018; Vorderer et al., 2003). The gender of the player, by contrast, is irrelevant to the learning effectiveness in DGBL (Chung & Chang, 2017; Papastergiou, 2009). In conclusion, there is no universal approach for implementing video game elements for DGBL; specific requirements should be elicited based on educational circumstances.

## 4 Methods

The following chapter outlines the research design of this thesis, which is divided into two subsequent phases. In the first phase, the design process of a DGBL solution that aims to promote students' agile competencies is described. The second phase presents the evaluation method that is dedicated to assessing the found DGBL solution within an experimental classroom setup.

### 4.1 Design-Based Research Approach for Developing a DGBL Solution

This section depicts the process of crafting a DGBL solution to address the following research question:

- *RQ1: How to design a DGBL solution that fosters agile competencies in undergraduate computer science students?*

First, the context in which a video game shall be implemented to promote agile skills is described. Afterwards, based on the findings of the literature review, the requirements for a video game application are defined. This is followed by a description of the decision-making process for the possible implementation solutions. Three options, namely integration of a commercial game, a serious game and a self-developed experimental game, are considered and assessed based on the requirements specification. The rest of the section is dedicated to documenting the development of the experimental game.

#### 4.1.1 DGBL Context – Project Management Course

The PM course is offered to undergraduate informatics and business informatics students at the University of Vienna. The course is divided into eight sessions, comprises three ECTS points and is only offered in German. In the summer semester 2024, during which the course was held, 45 students were enrolled. The learning objectives were to teach students technical and interdisciplinary skills in traditional PM and APM. The University of Vienna (2024) published the following topics as subject content to be learned in the course:

- Project Initiation and Requirement Elicitation
- Project Planning, including Structuring and Organizational Techniques
- Effort Estimation

- Risk Analysis
- Project Controlling
- Classical and Agile Methods
- Working in/with Groups and Teams; Communication; Conflict

The main methods used to develop these skills and convey learning content were practice-based lectures and project work, where students are expected to carry out their own projects as a team from start to finish. This semester's novelty was the video game exposure within a DGBL workshop at one of the eight sessions. The assessment method was continuous coursework based on active participation, project work, final project presentation and the writing of a focus topic (University of Vienna, 2024).

#### 4.1.2 Requirement Specification

The requirement specification served the purpose of evaluating potential video game options to simplify the decision-making process. The nine video game elements from the literature review, an interview with a student who already participated in the PM course (Appendix C), the course framework's context and the workshop setting's constraints have been used to define the requirements. Following the Scrum approach, the requirements are documented in Table 3 as high-level user stories. The different roles that were considered within the user stories are player/student (01), teacher (02) and researcher (03).

**Table 3**

#### *Derived High-Level User Stories for an Educational Video Game*

ID	User Story
01.01	As a player I want to have meaningful interaction possibilities to learn inductively about the Scrum framework (Steghöfer et al., 2016).
01.02	As a player I want to be immersed in the virtual world by means of an engaging narrative, aesthetic visuals, and branching-storylines to effortlessly learn about Scrum while playing.
01.03	As a player I want to have the possibility to identify myself with a virtual Scrum role, to understand more about their tasks and responsibilities within the Scrum team.
01.04	As a player I want to receive immediate feedback and be able to track my progress, to evaluate whether my chosen strategies were successful or not.
01.05	As a player I want to receive support at the beginning of the game in the form of a tutorial, to be informed about the elements of the user interface and the rules of the game.

<b>01.06</b>	As a player I want to receive both guidance when needed regarding the learning content and the narrative, to prevent dead ends and loss of focus.
<b>01.07</b>	As a player I want to feel like I am engaging in a relevant project setting, so that I get hands-on Scrum practice.
<b>01.08</b>	As a player I want to engage in challenges that fit my experience level, so that I am neither bored nor overwhelmed.
<b>01.09</b>	As a player I want the game to have a competitive aspect, so that I can compare myself to my friends.
<b>01.10</b>	As a player I want the opportunity to cooperate with other human players, so that I feel like I am a member of a Scrum team.
<b>01.11</b>	As a player I seek inclusion in a community where I have a platform to communicate, so that I can exchange insights about my Scrum learning and in-game experiences.
<b>01.12</b>	As a player I want to play the game on my own device, so that I am flexible in terms of time and place.
<b>02.01</b>	As a teacher I want reduce the complexity of the video game mechanics to a minimum, to reduce the distractions for my students and save lecture time.
<b>02.02</b>	As a teacher I want the game to be an abstraction of only the most important scrum topics, so that students quickly recognize progress in their knowledge and skills (Scharff et al., 2010).
<b>02.03</b>	As a teacher I want a game that is available for free or at low cost, to make it accessible to as many students as possible.
<b>02.04</b>	As a teacher I want a game that requires no or minimal setup time and has a fast pacing, to prevent lecture hours being wasted.
<b>02.05</b>	As a teacher I want the game to be compatible with school infrastructure, to make it accessible to as many students as possible.
<b>02.06</b>	As a teacher I want to easily embed the video game into my curriculum, so that I can transfer learning contents without having to spend a lot of time building a pedagogical framework.
<b>02.07</b>	As a teacher I want to monitor the progress of my players, so that I can offer guidance at the right time and track knowledge acquisition (Calderón et al., 2019).
<b>03.01</b>	As a researcher I want to extract data from the game, to get generate quantifiable measurements about students' interactions during playthroughs.
<b>03.02</b>	As a researcher I to swiftly modify global parameters within the game, to efficiently adapt to different experiment settings (Calderón et al., 2017).
<b>03.03</b>	As a researcher I want the game to be open source, to generalise the game to other domains and contribute to its further development.
<b>03.04</b>	As a researcher I want to be able to scale the game, to prevent the experiment's setting solely to in-person workshops.

*Note:* This list of requirements is only intended to serve as a guideline for assessing DGBL solutions and does not claim to be a complete specification for an industry-level software product.

### 4.1.3 Video Game Selection Process

Once the evaluation criteria had been defined in accordance with the requirement specifications, the search for potential candidates began. A selection was made for both serious and entertainment games. The serious games were identified by examining studies dealing with the connection between video games and PM learning or by searching for providers of digital simulation solutions for PM training. The result was 17 serious games, found in Appendix A, included in the selection for a more detailed evaluation. Accessibility had been the exclusion criterion for 13 of them, as they were neither public nor available with university access. In the case of the research papers, no form of obtaining the game was available or the link was no longer up to date. The researchers were contacted, but there was no response. In the case of the institutionalised simulation offers, the companies provided only minimal demo versions, which did not meet the requirements resulting from the experiments workshop setting. When contacted, only the option to purchase a university license was mentioned, which was incompatible with user story ID (UID) 02.03 due to the costs involved. Additionally, one more game was eliminated because it was only available in Portuguese. After the evaluation, three serious games remained in further consideration.

Next, a search was carried out for possible entertainment games, for which the Steam library was scoured for games with PM similarities. The identified candidates can be found in Appendix B, including mainly construction simulation games like *Project Highrise* (Valve Corporation, 2016). However, there were also games selected containing only partial aspects of PM activities, such as *Keep Talking and Nobody Explodes*, which offer opportunities to improve team communication (Valve Corporation, 2015). After a more detailed analysis based on the requirements, seven games were eliminated because they were either too complex (UID 02.01) or contained pacing that was too slow (UID 02.04). One game was sorted out because it was too cost-intensive (UID 02.03), and another because of the few opportunities to embed learning content (UID 02.06) it offered. In the end, three commercial game candidates were left in the final round of comparisons.

The third option for integrating a DGBL solution into the workshop was the independent programming of an experimental game. A short feasibility study was carried out to estimate how long it would take to fulfil the most critical requirements and to obtain a functioning game as a final product. The segment of text-based adventure games was quickly identified as a possible genre, as it is associated with low development efforts due to the reliance on

textual descriptions instead of visual input and offers homogeneous interaction possibilities, reducing development effort (Hausknecht et al., 2020). With this kind of game, the most time-consuming feature would have been to process the various user inputs and resulting branching storylines in an appealing way. However, a closer examination of the core mechanics of a text-based video game revealed that new AI technologies could be used to reduce this complexity (Yao et al., 2020). Open-source reference projects that produced similar applications were consulted, and an estimated development time of two months was set for an experimental version that sufficiently met the requirements (Web Dev Cody, 2023).

The candidates for the three implementation options were then compared with each other. The commercial games performed particularly poorly in embedding learning content, as the interview with the former PM student and test designs for a DGBL workshop indicated. It was revealed that the connections to agile PM were difficult to establish. The risk of offering too little relevance for the students in their learning process was particularly heightened due to the low exposure time resulting from the one-time session. This constraint distinguishes this study from successful implementations of entertainment games; therefore, all of the remaining three games were not taken into further consideration. The *Project Management Game* was ruled out of the remaining serious games due to a lack of interaction possibilities, immersion and identification. Next, the MIT Sloan *Project Management Simulation* is a suitable tool for the workshop setting and allows for configurations. However, it does not focus on agile competencies, but mainly deals with aspects of PM that were already sufficiently covered by other learning methods in the course and was therefore excluded. The final decision was between the remaining serious game, *SimSe*, and the self-developed solution, which had been researched. *SimSe* was the game that covered the requirements most comprehensively, particularly in terms of open source, adaptability, and additional materials for integration into educational curricula. However, the software architecture was somewhat dated, and this was affecting the modularity for further development, integration with new technologies, and scalability of the user base. Conversely, a greenfield environment promised exciting new approaches, mainly due to the technological advancements that have occurred since the release of *SimSe*. These advancements have been particularly notable in the fields of AI, serverless architecture and web apps (Malavolta,



2016; Rajan, 2018; Treanor et al., 2015). For this reason, the decision was taken to pursue the self-developed DGBL solution.

#### **4.1.4 Experimental Game – Agile Astro**

The experimental game developed, called Agile Astro, is classified as a text-based adventure game; in literature, it is often referred to as interactive fiction (Hausknecht et al., 2020). Video games within this genre are defined as "complex, interactive simulations in which text describes the game state, and players make progress by entering text commands" (Côté et al., 2019, p. 41). The titles *Adventure* and *Zork* are the forefathers of using dialogue systems to create engaging virtual worlds. The latter was produced by the formative game manufacturer Infocom, which contributed significantly to further developing text-based adventures (Montfort, 2009). Like another of their works, *A Hitchhikers Guide to the Galaxy*, Agile Astro similarly immerses the player in a science fiction-fantasy setting. More contemporary projects that served as inspiration, especially for the user interface and game mechanics, are *WrittenRealms* from Morel software (2018) and *AI Dungeon* from Latitude (2019). The unique proposition of Agile Astro is the mixture of interactive fiction and agile elements. The player selects a character from the roles in the Scrum framework and subsequently determines the further course of an agile-managed project in the sci-fi narrative through decision points that simulate typical events within a sprint. The application is web-based, making it highly accessible, variable in time and place and minimal in implementation effort to fulfil the requirements UID 01.12, 02.03, 02.04, 02.05. In addition, the infrastructure is cost-efficient and scalable through backend-as-a-service and Next.js to conform with UI 02.03, 03.04. In the following sections, the development process, the AI-enhanced aspect of the game and the user interface are explored in more detail.

#### **4.1.5 Development Process**

Through the proof-of-concept phase carried out during the video game selection process, a foundation in terms of software architecture was already available. For the chosen technology stack and game idea, Web Dev Cody (2023) must be acknowledged, as he gave the main input with his prototype of a text-based adventure game with AI support. Building on his basic framework, the pure entertainment motives could be expanded to include the educational aspect of promoting agile competencies. The development process was carried

out in a Scrum fashion, where a one-week sprint duration was chosen. The first sprint was dedicated to setting up the project. Agile Astro is a web application written in TypeScript that uses Next.js, a React framework, as its front end (Microsoft, 2024; Vercel, 2024). The backend functionalities and database are covered by Convex, a backend-as-a-service that enables pushing real-time data updates to clients (Convex Systems Inc., 2021). The ubiquitous reactivity achieved by Convex is particularly important for the video game use case and the various interaction options available to the player. The following three sprints were spent developing the individual features that represent the video game elements that were previously defined with the help of the literature. For each feature, a frontend component had to be developed to present the game mechanic to the user. An extract of the source code regarding the main component can be found in Appendix D. The business logic had to be programmed on the backend using serverless functions. In addition, depending on the respective feature, a database structure and tables had to be created to store the player's game progress (UID 02.07, 03.01). The model of the database structure can be found in Appendix E. After each iteration, adjustments and new features based on findings made through developing the video game were implemented in the subsequent sprints. From the beginning of the second month, however, there was a feature freeze, which meant that no further functionalities were added to ensure a focus on quality and delivering the application on time. The exception was the tuning of the AI parameters, which represented the sprint goals in the fifth week; more on this in the following section. The user interface was designed, and graphics were generated in the next iteration. This was followed by code refactoring, bug fixing and testing. The testing encompassed usability tests to gather feedback on the user experience and load tests to ensure the game's performance even under higher traffic in the workshop setting. For this purpose, ten students not enrolled in the course were gathered to do a final test run in the same setup as the workshop. This resulted in several adjustments and insights that were integrated before the video game was finally deployed. The deployment took place in the last sprint to a website hosting, facilitating easy access through a public URL (UID 01.12, 02.02, 02.05, 02.04).

#### **4.1.6 Large Language Model – the Heart of Agile Astro**

As mentioned previously, the challenge in creating an engaging user experience when developing a text-based adventure is to manage branching storylines effectively. This becomes particularly relevant when gradual knowledge accumulation and skill practising

need to be injected into the narrative. AI, one of the most disruptive technologies of the 21st century and currently preoccupying companies, researchers, and legislators alike, is leveraged to outsource the complexity of balancing player entertainment, fostering a sense of self-determination, and fulfilling learning objectives (Collins et al., 2021). The European Commission (2018) defines them as "systems that display intelligent behaviour by analysing their environment and taking action — with some degree of autonomy — to achieve specific goals" (p. 1).

There are special forms of AI for different tasks. Large Language Models (LLMs) are used to solve problems involving processing and generating textual content. The best-known provider of such a solution is OpenAI, which recorded the fastest-growing user base in history with the release of their product, ChatGPT (Kasneci et al., 2023; Wu et al., 2023). Generative pre-trained transformers (GPT) like ChatGPT are LLMs "trained on massive amounts of text data and can generate human-like text, answer questions, and complete other language-related tasks with high accuracy" (Kasneci et al., 2023, p. 1). The advantages of integrating such a model into video game design are manifold and have already been recognised by some researchers (Gong et al., 2023; Hausknecht et al., 2020). In the case of Agile Astro, the goal was to use a GPT to create a virtual game master to guide the player through the sci-fi adventure. The tasks of the game master were to create a storyline for each new game session, offer the player interaction possibilities, react to these actions and answer the player's questions about the game or technical topics.

The GPT integration process began with a collection of the various possible candidates. Based on the scores from Chiang et al. (2024) Chatbot Arena, which incorporates a preference model and 800,000 human ratings to evaluate over 92 of the most common models continuously, the potential GPT providers were identified. These included Meta (2024) with their open-source model Llama, Anthropic (2024) with Claude, Google (2024) with Gemini and OpenAI (2024) with ChatGPT. The most important decision characteristics for fulfilling the video game requirements are context window, governing the amount of past game history the model can retain, inference time, dictating the latency between the player action and game master response, and API price structure determining scalability potential. In addition, the simplicity of the implementation was considered a vital evaluation criterion, as it should be noted that training LLMs and provision of models was not a main part of this thesis and would be a topic for further research. From this selection, the decision was made

in favour of ChatGPT, which was chosen despite a partly poorer performance-to-cost ratio than Gemini and Claude and missing customizability of the parameters as in LLAMA models. The decisive advantages were accessibility, fast response times and low implementation effort. Regarding the competitors, Claude's API was unavailable in Europe at the start of development, custom Llama models would have required custom endpoint development, and Gemini was still in the training stage. However, the GPT integration is designed so that at least Claude, Gemini and ChatGPT are easily interchangeable as the models advance, and thus, the prevalence of the providers varies from week to week.

After selecting ChatGPT, the version and parameters were specified. OpenAI has several versions of models that vary in performance, price, and additional features. Their model ChatGPT 4o achieved optimal results in providing meaningful learning opportunities while offering low latency and was therefore chosen. The next step was to create a prompt responsible for how well the responses are in the context of the game master role and how authentically the agile elements are integrated into the story. Prompts in the GPT context are one or more instructions in the natural language provided to the LLM to narrow the possible solution space, thereby aligning responses more closely with the problem at hand. Prompt engineering is the discipline of systematically finding the most appropriate one for a specific use case (P. Liu et al., 2021). For this sake, the various required use cases were first defined. This resulted in different prompts for the LLM for each possible player interaction; more on this in the results chapter. OpenAI provided a prompting guide that was utilised to create templates for each prompt. These templates were dynamically enriched with the metadata of the respective game session to give the model more context about the current player, game progress, past actions and initial scenario. Testing was conducted via the playground application of OpenAI; prompts were versioned and refined until a qualitatively replicable result was achieved. An example of the resulting prompts with the respective responses from the model can be found in Appendix E. Subsequently, various backend data preprocessing steps were implemented to optimise cost savings when calling the LLM.

## **4.2 Classroom Evaluation of the DGBL Solution**

From the previous chapters regarding agile competencies, evaluation of related work, and requirements of the developed game, two main research dimensions for the evaluation of the DGBL solution Agile Astro are defined: The player experience of the DGBL tool and the

perceived learning effects from the intervention. The research design from Petri et al. (2018), which was frequently used in literature to evaluate educational games, was leveraged to examine those domains in further detail. Based on the described systematic model and the foundational work of PM researchers who evaluated their digital games, the following additional research questions were proposed:

### **Player Experience**

- *RQ2: How do undergraduate computer science students rate the overall player experience of Agile Astro?*

### **Perceived Learning**

- *RQ3: How does Agile Astro contribute to computer science students' perceived learning in a course on project management?*
- *RQ4: How does Agile Astro contribute to computer science students' agile competencies in a course on project management?*

A mixed-method approach, consisting of an experiment in the form of an agile workshop and a post-test survey, was used to answer these research questions. This route was chosen based on partnership with the PM course and the prevalence of this research method in the DGBL literature. Most serious game evaluations were conducted in a university environment, featuring 40 or fewer participants, focused on examining learning outcomes and usability and used a simple research procedure with predominate questionnaires after a game-playing session (Calderón & Ruiz, 2015). The detailed research methodology will be presented in the following sections, including research participants, intervention procedure, data collection and analysis framework.

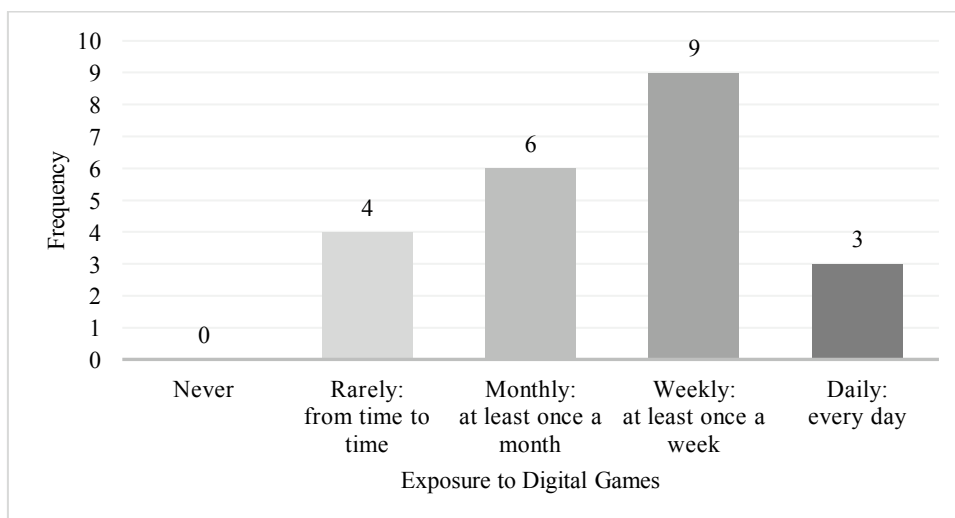
#### **4.2.1 Participants**

The participants for the study were sampled from the above-mentioned PM course offered at the University of Vienna. The rationale for sourcing the participants from the ongoing PM course was to measure the complementary synergy of learning through video games and other forms of teaching. This approach aimed to evaluate the integration of a blended-learning method that is often claimed to be beneficial by DGBL researchers (Farooq et al.,

2022; Holbrey, 2020). Of the workshop attending 30 undergraduate students, 22 also agreed to provide their feedback within the post-test questionnaire. Of these respondents, 18 were enrolled in the Informatics program, and four were enrolled in the Business Informatics program. Almost all students (18) were 25 or younger; three were between 26 and 30, and one was older than 30. A bias regarding gender is present in the sample, as only 6 (27%) of the students were female, 2 (9%) were non-binary, and the remaining 14 (67%) were male. Most students (95%) had at least some form of work experience, and ten students were in active employment at the time of the survey. Regarding their familiarity with agile methodologies, half of them stated they have little or no prior knowledge about frameworks like Scrum or Kanban, and the other half reported having a basic or moderate understanding. In contrast, the participants are experienced gamers, as seen in Fig. 4. Over 50% stated playing digital games at least once a week. Non-digital games are not as popular as their digital counterpart, as indicated by Fig. 5; among the participants, only one person plays them more than once a month. When asked about DGBL as a teaching method, 20 out of 22 students expressed their general openness to learning course content with video games.

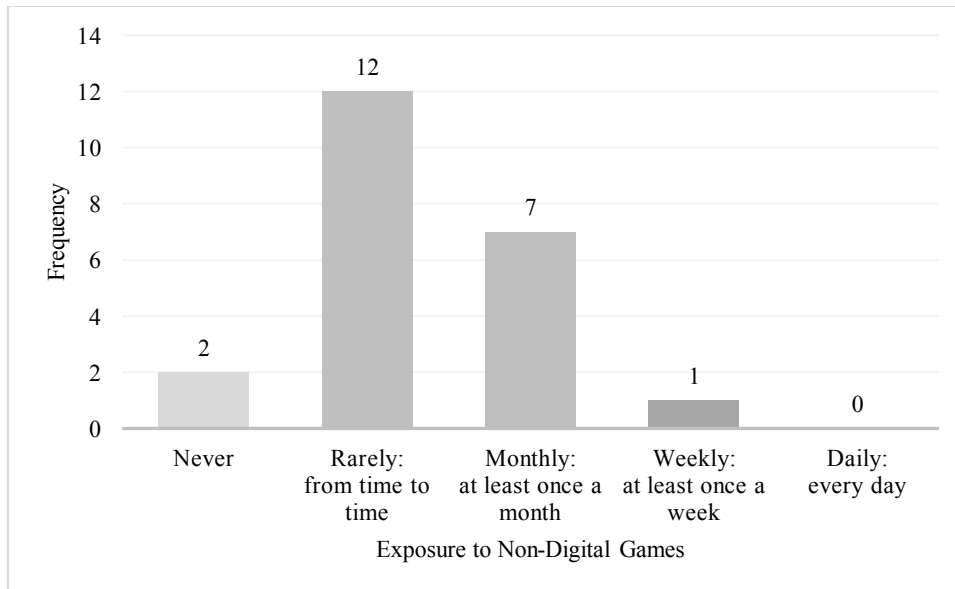
**Figure 4**

*Frequency of Playing Digital Games among Research Participants*



**Figure 5**

*Frequency of Playing Non-Digital Games among the Research Participants*



#### **4.2.2 Intervention Procedure - Agile Workshop**

An agile workshop was conducted, as one lecture from the PM course was described in the last chapter. The date for the intervention was set three months after the start of the course. Holding the workshop at a later point in the semester was to ensure a general understanding of PM among the students. Additionally, familiarity with each other in a group setup was advantageous. The workshop's core was the experimental intervention with the developed game Agile Astro. Where an experiment is "a study in which an intervention is deliberately introduced to observe its effects" (Shadish et al., 2001, p. 12). This kind of experiment is classified as a quasi-experiment, as there was no split of the sample between the experimental and control groups present. All students received equal treatment by playing Agile Astro for the same duration and under identical settings. Due to the limited number of participants, a grouping was omitted because it would be difficult to show statistical relevance and bias traps are more easily introduced (Shadish et al., 2001). The structure of the workshop procedure with the respective time allocations can be seen in Table 4. First, the research motivation and workshop agenda were presented to the class. Afterwards, the instructor carried out a live Agile Astro demonstration to walk the students through the video game's interface. Next, teams were formed as the video game was played by a group of three

students. However, the laptop, the device through which the game was played, was only operated by one of the students. This was done purposefully to stimulate discussions and collaboration and compensate for the limited in-game contact with other human players. Then, the teams started the video game by entering the URL to the publicly facing domain where Agile Astro was deployed. The configuration of Agile Astro was set to a playtime of 15 minutes, 14 in-game days as the sprint duration and 50 story points that needed to be completed as the winning condition. The students were given time to read the introduction to APM and the tutorial on the game's interface that appears at the start of each game session. The students played through the first session and were allowed to acquire help from the instructor in case of unclear gameplay mechanics or unexpected errors. When every team has completed their first playthrough, students could ask questions that came up during the first contact with the video game. After this, the students were prompted to play the game a second time with a different character class (Scrum role), meaning they had to think from a new perspective when making decisions regarding their tasks and responsibilities. The students were instructed that the team members who do not control the PC imagine themselves as the other Scrum roles that were not selected in this session. This should further give the players the feeling of being part of a real Scrum team. Upon completing both Agile Astro sessions, the students were asked to complete the post-test questionnaire; more information on the evaluation framework chosen can be found in the following section. To conclude the workshop, sufficient time was allowed for debriefing about the intervention. Several researchers have proposed that this last activity of DGBL sessions can maximise learning outcomes by giving the students a platform to exchange experiences and share their opinions to learn from each other (Becker, 2017; Jääskä & Aaltonen, 2022; Kaye & Bryce, 2012).



**Table 4***Schedule of the Agile Workshop*

<b>Agenda Item</b>	<b>Duration</b>
Introduction to the Workshop	5 Min
Gameplay Walkthrough	15 Min
Team Formation	10 Min
Video Game Setup and In-Game Tutorial	10 Min
1st Gameplay Session	15 Min
Interim Questions	5 Min
2nd Gameplay Session	15 Min
Questionnaire	25 Min
Debrief	20 Min

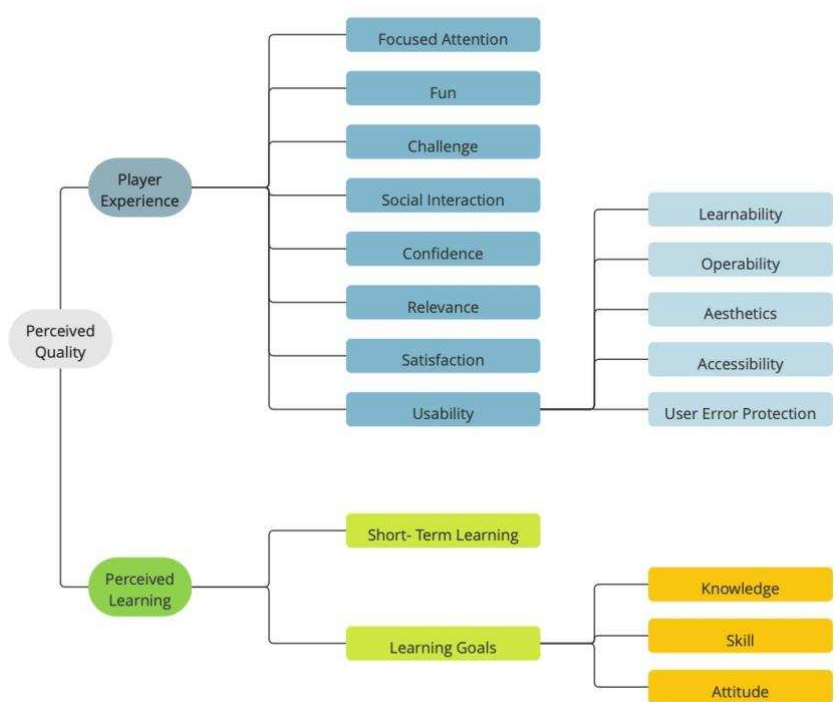
**4.2.3 MEEGA+ Model**

The MEEGA+ model from Petri et al. (2016) was chosen to assess the game's overall quality and learning potential. It is a popular evaluation method among DGBL researchers and has been validated multiple times in various application areas (González-Tablas et al., 2020; Tsiotras & Xinogalos, 2021; Venigalla & Chimalakonda, 2020). Assessment is carried out from students' perspective and was predominantly applied in computer science courses. The model is an advancement to the MEEGA model created by Savi et al. (2011), which was also designed to evaluate digital and non-digital educational games. The enhancements made to the model resulted from a systematic literature review that integrated best practices from other existing evaluation frameworks and insights from a large-scale validation test. Major changes from the previous to the new model involved reformed evaluation dimensions and improvements in the measurement instrument. The MEEGA+ model from Petri et al. (2016) comprises two main quality factors: player experience and perceived learning. Player experience is divided into the dimensions of focused attention, fun, challenge, social interaction, confidence, relevance, satisfaction and usability. Usability, in turn, is composed of the subdimensions learnability, operability, aesthetics, accessibility and user error protection. However, the other quality factor that is particularly decisive for selecting this model and version is perceived learning, which is determined by the dimension of short-term learning and learning goals. Short-term learning is used to measure the effect of the intervention of the impact on the students learning in the course. Learning goals, on the other

hand, leverage a revision of Bloom's learning taxonomy by Anderson et al. (2001) to classify educational outcomes in terms of the levels of knowledge, skills and values. This categorisation also resembles the agile competencies pyramid described in Chapter 2.1 and was therefore considered appropriate for answering the research questions. The measurable items of the learning goals dimension in the questionnaire are freely adaptable to the context in which the educational game is deployed. The entire conceptual model can be seen in Fig. 6.

**Figure 6**

*MEEGA+ Model - Decomposition of Quality Factors and Evaluation Dimensions*



*Note.* Adapted from "MEEGA+: An Evolution of a Model for the Evaluation of Educational Games ", by G. Petri, C. Gresse von Wangenheim, A. Borgatto, 2016, Brazilian Institute for Digital Convergence, p. 24 ([http://www.incod.ufsc.br/wp-content/uploads/2016/07/Relatorio-Tecnico-INCoD\\_GQS\\_03\\_2016\\_Ev11.pdf](http://www.incod.ufsc.br/wp-content/uploads/2016/07/Relatorio-Tecnico-INCoD_GQS_03_2016_Ev11.pdf)).

#### 4.2.4 Data Collection

The MEEGA+ model uses a post-test questionnaire with 35 items to measure the above-mentioned evaluation dimensions. The pool of items was enriched with six questions to evaluate the contribution towards the learning objective stated in RQ4. Each question is

dedicated to one derived agile competence and was formulated in line with the customisable learning goal template provided by the creators of the model. All items in the questionnaire are answered according to a five-point Likert scale response format, where the answer options range from strongly disagree to strongly agree. In addition, three qualitative questions are asked at the end of the survey, prompting students to name three strengths of the game, three suggestions for improvement, and an optional field for further comments. To contextualise and enable a more profound analysis of the responses, participants were required to provide demographic information about their age, gender, job experience, prior agile knowledge and digital and non-digital game preferences. The detailed questionnaire with all items can be found in Appendix G. The data collection happened anonymously via the university online survey tool and ensured that each participant was informed of their rights and the motives for the study. In addition, the session data of each team was retrieved from the database after the workshop to include the in-game activities in the analysis.

#### **4.2.5 Data Analysis**

After the students had filled out the questionnaire the next task was to analyse the data to extract insights about the game's quality and perceived learning effects on students. The analysis was carried out in line with the recommendation provided within the article "MEEGA+, Systematic Model to Evaluate Educational Games" by Petri et al. (2018). They proposed to analyse the dimensions and, subsequently, quality factors according to central tendency and frequency distribution with a standardised spreadsheet as an instrument to automatically visualise the results as bar graphs. However, the tools provided had to be adapted to the MEEGA+ version of Petri et al. (2016), as the independently delimited quality factors "perceived learning" and "player experience" were better suited to answering the research questions. To understand the sample characteristics better, the demographic items were first analysed in isolation via descriptive statistics and visualisation to identify potential biases and to evaluate generalisability. Further descriptive statistics that were not yet present in the standardized spreadsheet were calculated for the ordinal data items from the model. Furthermore, the data set was explored by means of comparative analysis with the non-parametric Mann-Whitney U test and correlation analysis with Spearman's Rank Correlation (Mann & Whitney, 1947; Zar, 2005). Additionally, the game quality rating from Petri et al. (2018) that leverages Lord's (2012) Item Response Theory (IRT) was determined to make the categorization of the game in relation to other works easier and provide an accessible

overview verdict. The teams' in-game performance data that was retrieved from the backend was analysed descriptively. This second manual data analysis procedure was carried out in Python and R (Python Software Foundation, 2023; R Core Team, 2024). For the open questions, only the frequent themes found were extracted and documented to get a general qualitative picture of the students' impression towards the DGBL implementation. The recognized patterns, differences and insights with regard to research questions RQ2-4 are presented in the next chapter.

## 5 Results

This chapter follows the same structure as the methods chapter. First, the results from the DGBL solution development process are presented in the form of detailed descriptions and screenshots of the Agile Astros' user interface and game mechanics. This is followed by the results of the analysis of the data collected during the DBGL workshop to provide insights into the evaluation of Agile Astro from the user perspective.

### 5.1 User Interface of Agile Astro

The user interface of the completed video game Agile Astro is presented in this section and can be seen in Fig. 7. The individual features for fulfilling the requirements profile are described below and cross-referenced to the user stories. The video game consists of a start screen and a main interface, plus two pop-ups displayed at the game's start and end. The layout consists of three columns, with immersiveness support features on the left, interaction with the unfolding story in the middle and scaffolding elements on the right to support the learning process.

**Figure 7**

*Main User Interface of the Experimental Game Agile Astro*



### 5.1.1 Character Selection Page

The start of the adventure is the character selection screen, where players can choose a role from the Scrum Framework, as can be seen in Fig. 8. There are Scrum Master, Product Owner and Developer, each with their own sci-fi character image, different agile skills and influence on the storyline. When hovering with the mouse, information about the roles is displayed to provide knowledge and make the selection more accessible for the player. The player then selects a name for personalisation and can enter the virtual world. Based on User Story ID (UID) 01.02, 01.03.

**Figure 8**

*Character Selection Screen of the Experimental Game Agile Astro*



### 5.1.2 Tutorial

The game's tutorial is designed as a pop-up and is divided into two parts. At the time of the character selection, an overlay of several information pages appears in the form of a slider to efficiently introduce players to the basic concepts of Scrum and to enable a head start in learning agile principles. In addition, when entering the main game, another pop-up introduces the interface and the game's rules to the player. Based on UID 01.05, 02.01.

### 5.1.3 Main Interface – Left Column

The *visualisation component* is placed in the top left of the main screen. To provide players with a rich media experience that goes beyond the textual description of the narrative, DALL-E, another OpenAI (2022) product, was implemented. It allows the creation of an image from a text prompt based on machine learning methods (Marcus et al., 2022). The feature was implemented so that whenever a day changes in-game, the last entry of the story is summarised by ChatGPT as an image description and serves as input for the image model. This gives the player frequent visual input into the current events. *Based on UID 01.02.*

The *player progress display* is in the left-hand column in the second position on the main screen. Its primary purpose is to allow players to monitor and evaluate their actions in the game. It includes a progress bar, a display of experience points earned and the current level. When players progress by making decisions in the game, they can evaluate their learning process. In addition, the selected class, player name and avatar are displayed to promote identity with the virtual role. *Based on UID 1.03, 1.04, 1.06.*

The *skill control panel* is the third element on the left column. Each character role has three unique skills. They represent a mixture of scrum practices and sci-fi elements, which bring advantages to the game when activated. At the story's beginning, one ability is unlocked, and the remaining two are only unlocked when completing side missions. Each technique is described with a tooltip. This unlocking is intended as a reward and long-term motivation for players to make progress in the game and to introduce them to agile methods and tools in a playful way. *Based on UID 01.01, 01.04, 01.07.*

The *team interaction panel* is the last element in the left column. It is intended to convey the feeling of a Scrum team dynamic; each displayed character has an avatar, a name, a description, and a common Scrum job position, for example, Quality Assurance Engineer. The team's composition is optimally determined by the player's role selection so that there are not, for instance, two Scrum Masters. Interacting with the team members is another use case for the GPT. When the players click on an icon of one of their colleagues, the LLM receives a prompt to put itself in the role of the respective team member and provide information about the current status of the tasks, as would be the case in a Scrum daily. For more details, see Appendix E. This should give the player a sense of cooperation despite the

single-player modularity and uphold the agile values of transparency and openness. *Based on UID 01.02, 01.03, 01.10, 02.02.*

#### **5.1.4 Main Interface – Middle Column**

The *story logbook* is placed as the first element in the center of the user interface. It shows the complete course of the story and represents the main connection with the virtual world. It consists of the LLM's responses as the game master, teacher, or scrum team member resulting from the player's various types of interaction, be it decision, skill use, question, or team member interaction. *Based on UID 01.01, 01.02, 01.04.*

The *main interaction controls* are defined at the bottom of the middle column. They consist of a drop-down menu that allows the player to switch between the interaction options. On the one hand, there is the question mode, where the player can ask open questions about the story or scrum content, and the GPT can act as a teacher to help the player. On the other hand, there is the action mode, where the player chooses from the decision options provided by the GPT. Once the player has made their choice, they must use a dice to determine the quality of the execution of the action, which is a common theme in many RPGs. This game mechanic is intended to present the player with playful challenges that may occur in everyday Scrum environments and thus create an understanding of agile practices and values. *Based on UID 01.01, 01.03, 01.06, 01.08, 02.02.*

#### **5.1.5 Main Interface – Right Column**

The *burn-down chart* can be found in the right column as the first element. It is one of the most important visualisation tools in the Scrum environment and shows the current progress of the Scrum goal in the form of burned story points, which measure completed tasks. This display in the game is used to show the current day in the sprint as the X-axis and the remaining story points as the Y-axis. The day is determined by the time played so far, which is tracked by the timer, and the story points are determined by the quality of the player's decisions and luck when rolling the dice. It also allows the player to monitor their learning process. *Based on UID 01.04, 01.06.*

The *Scrum glossary* is placed in the right column as the second element. The LLM responses are analysed in the backend, and an entry including a note for the player is added to the



glossary when new Scrum-specific keywords are encountered. This entry includes the respective Scrum keyword and a description displayed when the player clicks on it. This supports players in building up their knowledge of Scrum by dynamically offering help if players recognise gaps in their knowledge. *Based on UID 01.06, 02.02.*

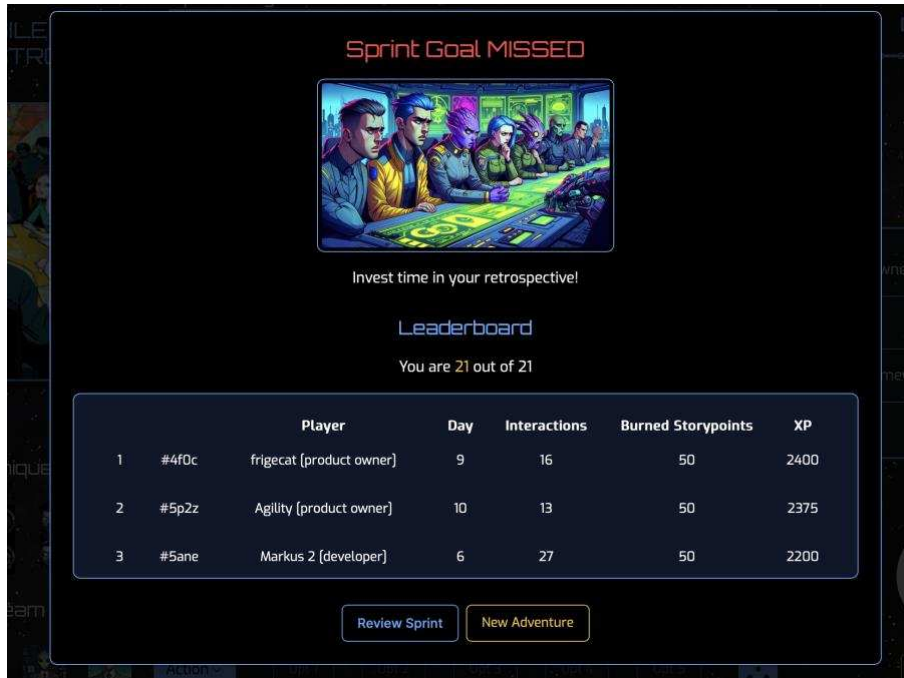
The *sprint duration timer* is the last element in the right-hand column. It shows the remaining playing time, which can be defined in advance by the teacher. It is a constraint that gives the player an additional sense of challenge, provides the teacher with more control over the learning interaction and adds another dimension to the players' results. *Based on UID 01.08, 01.09, 02.04, 02.06.*

#### **5.1.6 End of Game Pop-Up & Leaderboard**

The end-of-game pop-up is triggered when the timer runs out or when the sprint goal is reached, meaning the remaining story points are zero. An overlay opens, which shows whether players were successful in the sprint or not, depending on which condition was fulfilled first, as can be seen in Fig. 9. It also includes a display of the resulting rank on the global list of players who have played the game based on experience points earned. In addition, there is a leaderboard with various metrics that describe the game's performance and on which other players can be searched. This should encourage competition, stimulate the exchange of game experiences and generate knowledge among fellow students. Finally, players can either go back to the character selection page or review the course of the game. *Based on UID 01.04, 01.09, 02.07.*

**Figure 9**

*End of Game Pop-Up of the Experimental Game Agile Astro*



### 5.1.7 Backend Dashboard & Open Source Codebase

Convex's out-of-the-box backend dashboard allows monitoring each player's action and extracting data from the class as a whole for subsequent analysis due to the created database schema. This is useful for educational researchers to analyse the effect of adjustments to the game and for teachers to monitor students' learning process. As the game will be provided as open-source software, it is possible with only a few programming skills to adapt the game conditions, for example, game duration or initial story points, to different classroom or experiment set-ups. With a little more effort, it is also possible to create entirely new scenarios in other training domains, such as a Western setting for learning criminal law, due to the decoupled character of the application. Also, developing new features is easily possible due to the accessible frontend framework. *Based on UID 02.07, 03.01, 03.02, 03.03.*

### 5.2 Students' Perceptions Regarding Agile Astro

The general finding of the data analysis described in Chapter 4.2.5 was that the reliability of the MEEGA+ model could yet again be proven. As the value for Cronbach's alpha

coefficient, used to assess the internal consistency of questionnaire items, for the composite measure player experience was good with  $\alpha=0.87$  (Taber, 2018). This also reflects the same value as the original creators, Petri et al. (2018) reported. The quality factor perceived learning, also measured with a composite structure that includes two standardised questions from the model and six newly defined APM-specific items, is rated as acceptable ( $\alpha=0.75$ ) in terms of reliability. The other main result that was derived from all standardized question items was the MEEGA+ game quality level, which rates educational games on a scale of low, good and excellent quality by averaging the IRT scores. The Agile Astro reached a score of  $\theta=46.1$  on this measurement and can, therefore, be classified at the good quality level. Petri et al. (2018) who provided detailed descriptions for each quality level based on the responses of 1031 students, therefore classified games with this rating as follows:

At this level, the game sometimes presents challenging activities, offering new challenges for students. It provides moderately focused attention to the players, although students do not forget about their surroundings. Sometimes the game also provides feelings of confidence and satisfaction in the players. Frequently the game presents moments of social interaction and fun among the players. Often the game is considered relevant to the students' interests and, usually, the students recognize that the game's content is related to the course. Frequently the game contributes efficiently to student learning. In terms of usability, the game usually has the clear rules and is easy to play, although, usually does not present a fully attractive design. (p. 38)

This standardised characterisation of the game already provides information about the answer to RQ2 and RQ3. However, as the scale only generalises sentiments regarding the game's features, the following chapters will statistically analyse the individual quality factors in more detail. The results of the items not included in the game quality measurement, the self-defined APM learning goals, will be presented to provide comprehensive data to answer RQ4. Finally, evaluating the teams' in-game performance data provides some insights into the playing behaviour of students in Agile Astro.

### **5.2.1 Agile Astro's Player Experience**

The perception of the 22 students in regards to the player experience (PE) of Agile Astro was captured by visualising the frequency distribution of responses per item (U1-PE21), as can be seen in Fig. 10. Each Likert-scale item value was converted to the numerical representation to calculate the central tendency where -2 means strongly disagree and 2 means strongly agree. The median of almost all dimensions is calculated to be 1, indicating that the students agree that the necessary traits that model PE are present. This is further confirmed by looking at the distribution of the average score of all items; 86% (19) of the students reported a positive PE.

**Figure 10**

*Frequency Diagram of Player Experience (N=22)*

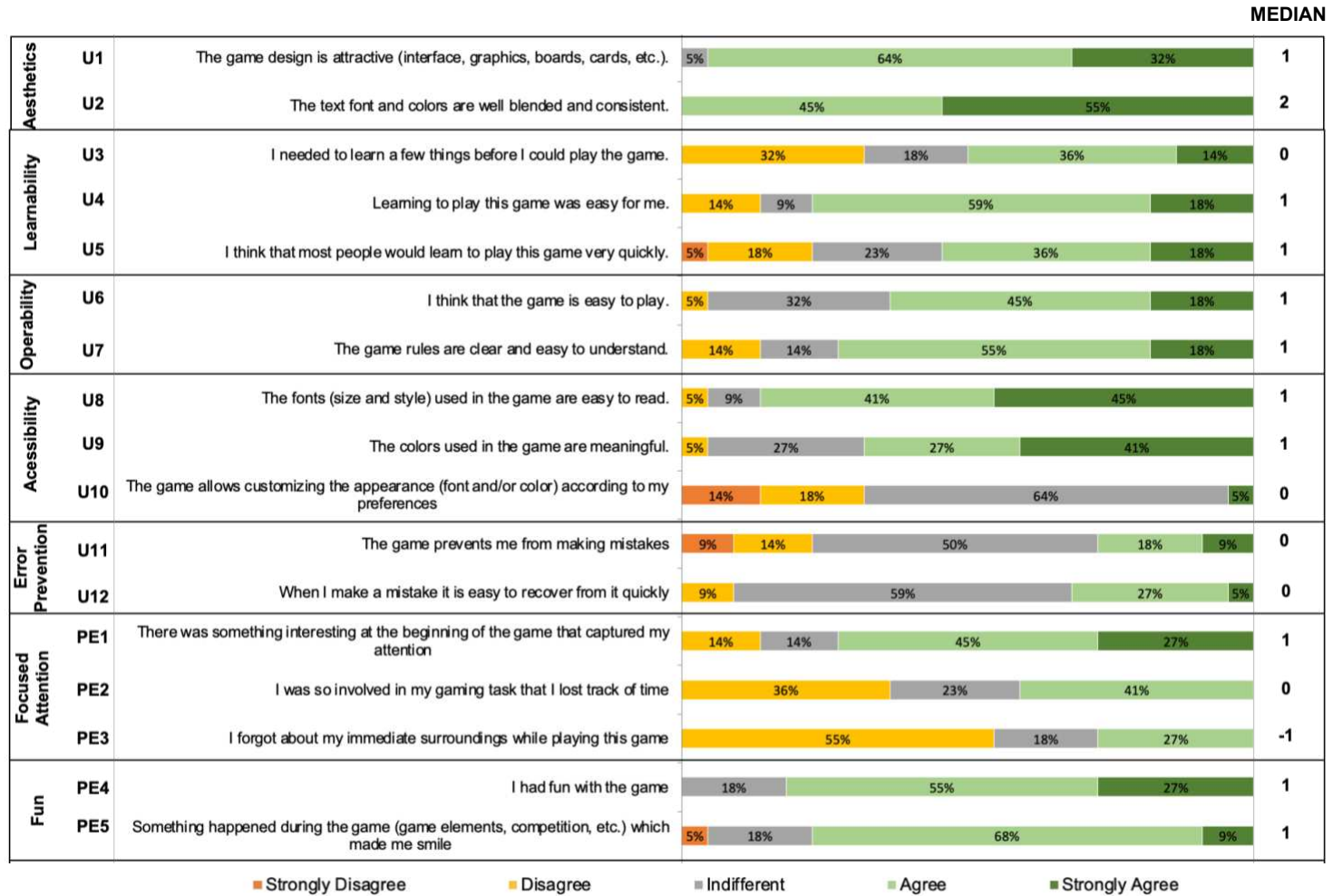
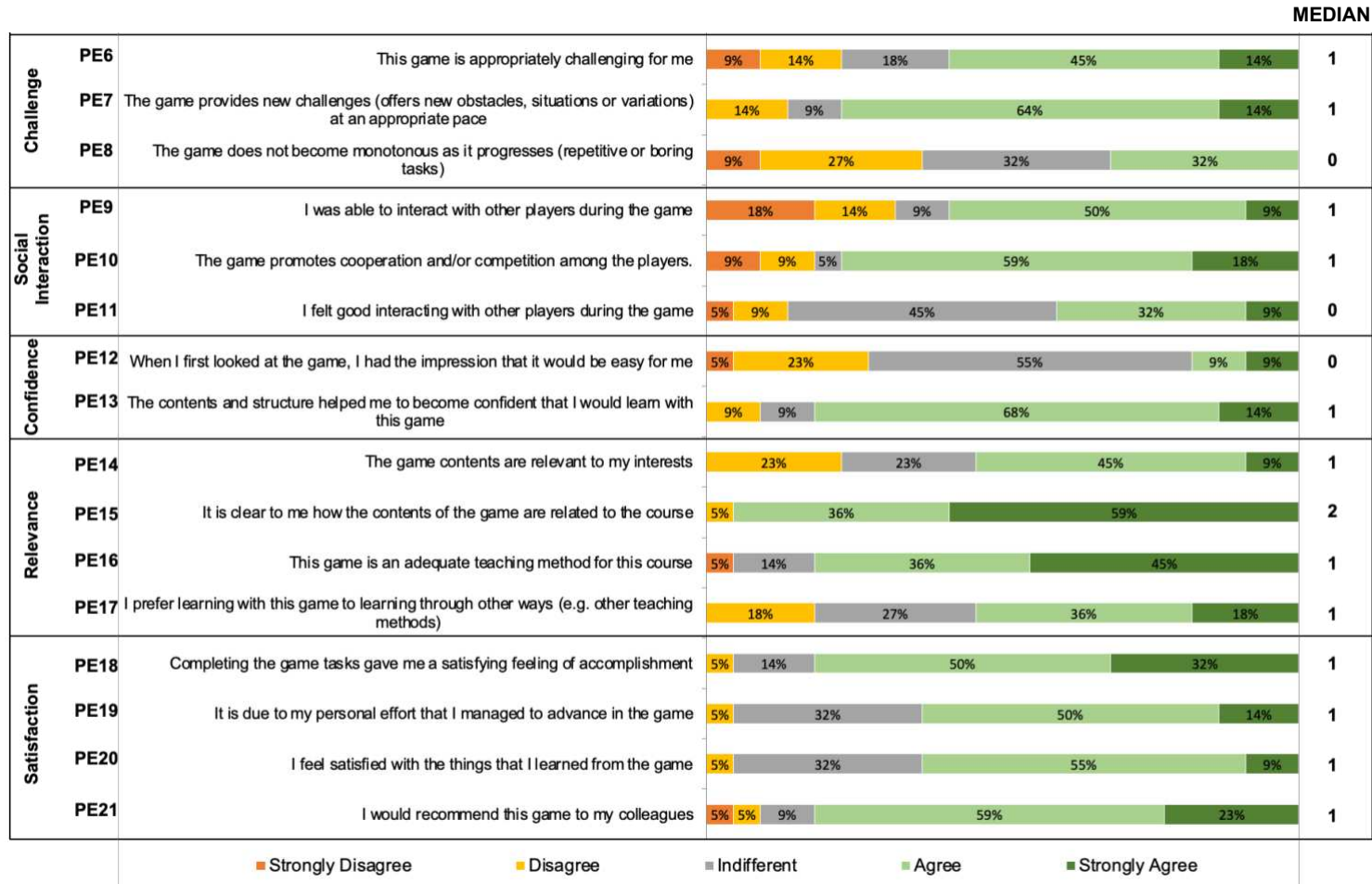


Figure 10 continued

Frequency Diagram of Player Experience (N=22)



When evaluating the results in more detail, the aesthetics of the video games interface and the relevance to student's learning seem to be the biggest strengths of Agile Astro. Overall, the style of the game in regards to fonts and colours (U2) and the apparent parallels to the APM content of the course (PE15) were rated the best with 100% and 95% of agreement, respectively. This is also indicated by several responses from the open questions, e.g. one student highlighted the authentic look by saying: "...the design of the game is great and suits the storyline", while another also commented on the embedding of the learning content: "...The setting in space is fun and really feels like it fits with the theme of Scrum". The highest frequency of indifferent opinions, with 50% or more, was seen in items U10, U11, U12 and PE12. This can be mostly explained by the lack of game elements for error protection and the absence of interface customisation capabilities. This was, however, not seen as negative for the game's purpose as, in general, the game's usability (U1-U12) received, on average, a positive score from almost all students (21). Several students mentioned the game's "simplicity" and "ease of understanding" as its main strengths. The real shortcomings of Agile Astro when it comes to PE are indicated in PE2, PE3 and PE8. Attention levels suffered, with 35% not feeling they were losing track of time and 55% not forgetting their immediate surroundings when engaged in the game. It can only be assumed that this was due to the workshop setup with three persons being allocated to one device. Another weak point that divides opinion regards the challenge factor as one-third of students think the game, as it progresses, becomes monotonous, whereas the other third thinks otherwise and the remaining third cannot agree with either opinion. This dichotomy is also reflected in the comments; one student states that: "the game makes very good usage of AI to simulate the game loop in a way that reacts to random outcomes and doesn't feel linear", while another student reported that "... the game offers only a little replayability due to the starting point of the story seeming to be the same both times I played.". More than half of the students agreed that the game is appropriately challenging, and an even larger portion found that the release of new challenges happened at a suitable pace. However, in the improvement suggestions for the game, the playtime was critiqued the most when it came to the challenging aspects of the game. Many students voiced their doubt about the chosen time frame per session, as can be seen in statements like: "Sometimes I felt bad because due to the time-constrained nature of the game, I had no time to read about the outcome of my decision, which would be the part that teaches you about scrum principles.". The vast majority of students reported that they had fun playing Agile Astro, and 17 experienced one

or more moments that made them smile. When it comes to social interactions, most students stated that the game encourages interactions with other human players and promotes competition and/or collaboration among them. The evaluation of these player-to-player interactivities is less clear, as 45% didn't know if they should rate the exchange with peers during gameplay as good or bad. In terms of confidence, the students were sceptical at the first impression of whether it would be easy for them to play Agile Astro. But as the game progressed 74% (16) of students acknowledged that the content and structure gave them the necessary support to learn successfully. As previously mentioned, the relevance with regards to the embedding of the game in the educational framework was the dimension was, on average, rated the highest. Only one student disagreed with the game being an adequate learning method for the course. More than half of the students even preferred the DGBL with Agile Astro over learning in other ways. To give a final summary of the general sentiment of the students after the video game exposure the satisfaction dimension can be consulted. An overwhelming amount of students reported a feeling of accomplishment when they completed in-game challenges. Additionally over 50% of students attribute value to these victories as they were both due to personal efforts and resulted in a satisfactory learning outcome. Overall, 18 out of the 22 students who participated would recommend the video game to their colleagues, which further expresses the positive player experience of Agile Astro.

The comparative analysis of player experience uncovered that there are some significant differences when it comes to different age, gender and game exposure groupings. According to the Mann-Whitney U test, students aged 25 and younger experienced significantly higher levels of social interaction during gaming compared to their older counterparts. Furthermore, there was a lower self-reported focused attention rate in male students than in female students. A similar statement can be made regarding different gaming backgrounds: infrequent players who played only once per month or less exhibited significantly higher attention rates on average than more frequent players. In addition, a significant Spearman's rank correlation indicated that the more digital gaming experience a student has, the less positive the PE of Agile Astro was rated.



### 5.2.2 Perceived Learning with Agile Astro

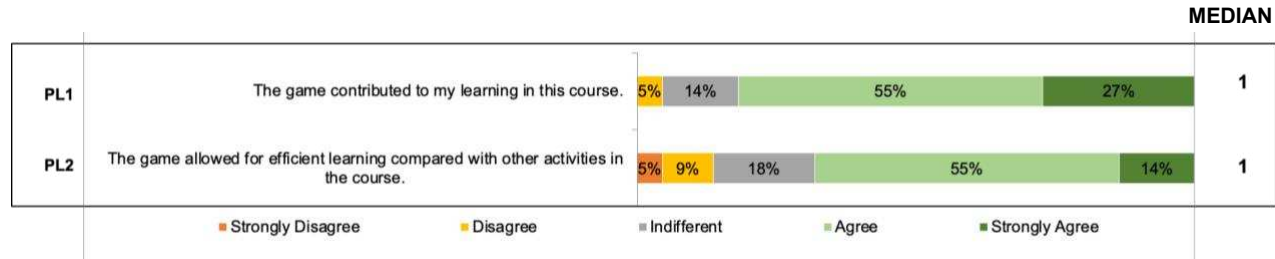
The majority of students (82%) agreed that playing Agile Astro in the DGBL workshop contributed to their learning in the PM course as can be seen in Fig. 11. Two-thirds of the students even labelled the learning with the game more efficient than other course activities. Some possible explanations for the good ratings can be inferred from the strengths mentioned by the students like: "the feedback for decisions is good, you learn about why things work", "the content [...] is well-researched and well-constructed" or " ... the competitive aspect, [...] leads to a better understanding of the learning topic (in this case APM)". A significant Spearman rank correlation between short-term learning and the player experience dimensions of operability, focused attention, relevance and satisfaction was identified. The analysis showed that the correlation for all these dimensions had a magnitude of 0.4 or higher indicating a moderate to strong relationship.

In general, almost all of the learning goals were fulfilled when looking at the central tendency of the student's perception in Fig. 12. Only the possibility of applying computer science knowledge was recognised by only half of the students. Nobody denied that the game contributed to understanding the main concepts of Scrum, and more than two thirds agreed that Agile Astro contributed to fostering their other agile competencies. The correlation analysis revealed a significant relationship between the learning goals and short-term learning, further indicating the legitimacy of the perceived learning construct. When it comes to the overarching quality factor, perceived learning, there is a significant Spearman's rank correlation with the independent variable of professional experience. The relationship is moderately positive, indicating a higher perceived learning the longer a student has already worked in a job. Despite the fact that 20 out of 22 students reported a positive average perceived learning score, there was still room for improvement according to the students' comments. The most frequently named suggestion for the DGBL workshop was to extend the game sessions; as one student noted, "*time pressure was a factor that deters from trying out more interactions, [...] therefore a lot of the game feels like 'wasted content' while you try to finish as quickly as possible*". As a compromise, some students suggested pausing the game session timer as long as the LLM is loading. The majority of the improvement requests regarding the teaching capabilities of the game can be classified as a desire for more support during the learning process. Some students want better monitoring capabilities, stating that "*the storypoint graphic could be more readable*" as "*it wasn't obvious [...] what action*

*[burned] how many points". Others saw missed opportunities regarding the rapid-feedback loop of the game and suggested: "Show the right solutions after clicking on an option and maybe a ranking [...] of the best to worst option to improve the learning experience". A few students expressed the desire for Agile Astro to offer "more complex problems [... and] solutions", with one student feeling that the game "[encouraged] to pick [options that] sounds the best rather than an actual response to the issue at hand".*

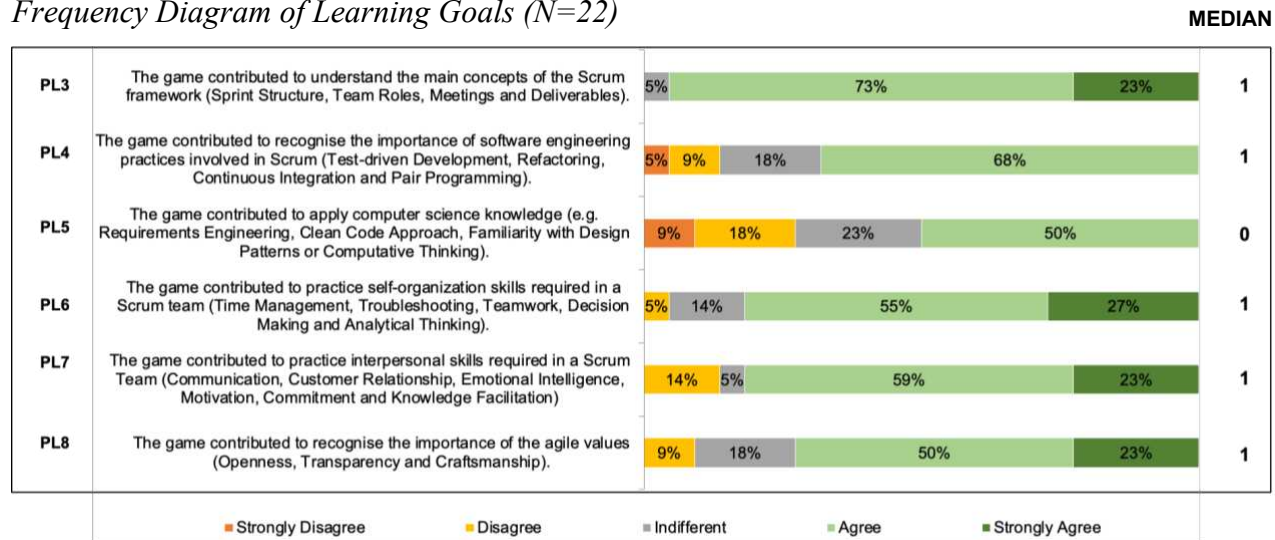
**Figure 11**

*Frequency Diagram of Short-Term Learning (N=22)*



**Figure 12**

*Frequency Diagram of Learning Goals (N=22)*



### 5.2.3 In-Game Data

The in-game data of the teams' performance playing Agile Astro consists of four metrics that were recorded at the end of each game session:

- **Burned Story Points:** The total number of story points completed by the team. Story points are burned by successfully completing challenges. It takes 50 story points to finish the game.
- **Day:** The number of days the team takes to finish the game. If the team did not finish all story points in time, this value is set to the maximum of 14.
- **Interactions:** The number of actions the team performed until either the time ran out or the game was completed.
- **XP (Experience Points):** The total XP earned during the game session. XP is earned by burning story points or using agile skills. Teams are ranked on the leaderboard based on their XP.

Table 5 shows that the four metrics were extracted from the leaderboard table and statistically analysed.

**Table 5**

#### *Descriptive Statistics of In-Game Metrics*

Metrics	Mean	Median	Std.	Min	Max
<b>Burned Storypoints</b>	48.6	50	4.37	31	50
<b>Day</b>	10.15	11	2.76	5	14
<b>Interactions</b>	14.75	14	4.69	9	27
<b>XP</b>	1716.75	1500	401.17	930	2400

Note: The sample size is N=20, with ten teams each playing two game sessions.

Out of the 20 game sessions 17 were successful, as indicated by the high mean and median of burned story points. The standard deviation is quite low, showing performance consistency across teams and sessions. On average, the game sessions were completed within 10.15 in-game days, equivalent to approximately 11 minutes in real-time. The fastest team managed to play through one game run in a little over 5 minutes. Most teams took

about 14 interactions during their playtime in Agile Astro, with the broad spectrum between a minimum of 9 and a maximum of 27, indicating significant differences in the interactivity of teams. This trend in different playing styles is also visible in the XP metric. The wide range and the higher mean than median suggest a positive skewness that can be explained only through different usage of agile skills in the game, as the dependent variable of burned story points has a left skewness. The maximum achievable XP for this particular Agile Astro setup was 2725, which none of the teams reached.

## **6 Discussion**

The outcomes of this empirical research have shown student player experience and perceived learning when interacting with the designed educational game Agile Astro. This chapter is dedicated to interpreting the results with reference to related gaming implementations from the literature and to reflecting upon the game's design choices. Based on the interpretation's implications for educational institutions in regards to DGBL initiatives are discussed. Finally, the limitations of the research process are outlined, and directions for further research are given.

### **6.1 Key Findings and Interpretations**

This section presents the key findings and interpretations according to the DGBL solution design, overall player experience, perceived short-term learning, and perceived fulfilment of learning goals.

#### **6.1.1 RQ1: How to design a DGBL solution that fosters agile competencies in undergraduate computer science students?**

This study showed one approach in designing a DGBL solution, with a catalogue of user stories derived from the literature as its centrepiece for development. When comparing Agile Astro against the requirements that were defined to arrive at a suitable tool for fostering agile competencies, almost all needs of the different user roles were met. Only the community factor and social interaction could not be anchored in the game to a sufficient degree and had to be realised through the DGBL workshop. The effectiveness as an agile learning instrument will be discussed in more detail in the upcoming sections. However, the analysis of the data generated from the students' actions in the game already provides some insights for a proof of concept as well as the potential for further development. For example, the data reveals that different strategies were leveraged while learning, highlighting that the game can accommodate various learning styles. This phenomenon is analogous to findings from several researchers that showed that students can be profiled to different DGBL preferences, e.g. visualisation needs, degree of competition, and timing of and nature of support (Misfeldt, 2015; Olsson et al., 2015; Plass et al., 2015). The diversity among players calls for more customisation features and automatic adjustment of game difficulty when playing errors occur, which were sought in vain by the students in Agile Astro as well as other

educational game studies analysed. Nevertheless, the overall good quality score of Agile Astro according to the MEEGA+ scale and the analysed player behaviour in the game allows the interpretation that DGBL is a promising method in a refined computer science curriculum to foster both required hard and soft skills (Chang & Chou, 2008; Hof et al., 2017).

### **6.1.2 RQ2: How do undergraduate computer science students rate the overall player experience of Agile Astro?**

The results from the evaluation framework showed that the overall player experience of Agile Astro was found to be positive. When compared to the research work by Petri et al. (2018), who analysed 11 PM games, 7 non-digital and 4 digital, to find new teaching methods for software PM, similar results can be seen. They gathered data from 27 case studies, where each of the respective interventions resembled the DGBL workshop of this thesis both in terms of duration and sample size. Significantly lower MEEGA+ ratings of Agile Astro can only be seen in the focused attention dimension when compared to the digital games in the study. The non-digital games, on the other hand, showed an almost equal central tendency. This further strengthens the suspicion that the workshop setup, with three people playing one player in the game and thus resembling more an analogues game, leads to a deterioration of focus. It can be assumed playing the game in a single-player setup would result in a better focus, as the players are more immersed in the virtual world due to less disturbance from their classroom reality. However, focused attention is influenced by both social interactions as well as the relevance of integrated learning content (Becker, 2017; Sweetser & Wyeth, 2005). Thus, playing the game alone would result in a trade-off, which is undesirable and, therefore, implies that Agile Astro should be adapted to feature more possibilities for in-game social activities. This would avoid the constant switch from real life to virtual identity and thus guarantee more immersion and focus (Gee, 2004; Van Eck, 2006). With regard to the identified gender-specific differences in concentration, it should be noted that these differences were also observed in other studies, e.g. higher motivation rates among women, which, however, did not have a significant effect on learning performance (Chung & Chang, 2017; Khan et al., 2017; Papastergiou, 2009). The dimensions of aesthetics and relevance were not only found as above average ratings introspectively, but also when compared to the software PM games (Petri, Calderón, et al., 2018). For example, Calderón et al. (2017) reported a lower score for the overall attractiveness of their PM game's design. The high score for relevance indicates that the students perceived DGBL intervention and

its content as well as integrated with the PM course. Looking at the general entertainment metrics, which are also heightened, it can be assumed that there was no compromise between fun and the inclusion of learning content, as often mentioned by researchers as the pitfalls of edutainment hybrids (D. B. Clark et al., 2023; Van Eck, 2006). The recommendations for an interesting project context, dynamic game narratives in line with PM practice and role-specific gameplay with the LLM as the enabling technology seem to have led to a seamless pedagogical embedding of the game (Calderón et al., 2019; Jääskä et al., 2022; O'Farrell et al., 2021). A further finding was that the more exposure students had to digital games, the lower they perceived the PE with Agile Astro. This result contrasts with Calderón et al. (2017), who found that gaming experience generally has a positive influence due to the familiarity with video game interfaces, which enhances ease of use. Therefore, it can be assumed that the digital gaming experience has a moderating effect on different dimensions of PE. For example, while it may positively influence players' confidence, it could negatively impact their focus. As indicated by the correlation analysis, PE is a predictor for learning outcomes in educational games. PE must, therefore, be the basic prerequisite for the design of the DGBL game's concept and its various features.

### **6.1.3 RQ3: How does Agile Astro contribute to computer science students' perceived learning in a course on project management?**

If a well-designed PE is achieved, more engagement and exploratory learning can take place, as indicated by the positive short-term learning effect (PL1) of the video game intervention in this thesis and various other field tests (Holbrey, 2020; Petri, Calderón, et al., 2018). In addition, the acceptance of video games as a learning method (D12) and the increased motivation of the students compared to other forms of teaching (PL2) were established. It can be stated that the students acknowledge Agile Astro's serious learning method within the PM course, which heightens the engagement towards learning content (Abdullah & Saeed, 2020).

### **6.1.4 RQ4: How does Agile Astro contribute to computer science students' agile competencies in a course on project management?**

The degree of achievement of the learning goals provides information on whether or not video games can be used to foster the defined agile competencies. Five out of the six agile skills were reported to be fostered according to the student's perception. Only the computer



science knowledge (PL5) was not seen to be particularly integrated, which was expected as the game's narrative abstracts the technical work away from, for example, the role of the developer to focus on agile-specific activities. However, the contribution to understanding the software-specific APM concepts like pair programming or refactoring (PL4) was detectable and represents a finding that was not yet recorded by any of the MEEGA+ studies. Overall, it needs to be mentioned that Agile Astro tried to foster the most diverse set of agile skills, as most existing games for PM focused on exclusively one area of the agile competencies pyramid. Regarding teaching the main concepts of Scrum framework (PL3) to the students Agile Astro achieved similar learning effects as the non-digital game *Scrumia* and the digital game *Scrum'ed* (Petri, Calderón, et al., 2018). The simulation game *Scrum-X* from Lee (2016) reported a higher average score for this particular learning goal. An explanation for the higher results could be that *Scrum-X* didn't focus on complete beginners, as more instructional basics were given outside the DGBL intervention. This indicates that the DGBL effect for Scrum remains constant or even increases with higher exposure and more complex challenges, as also requested by the students in this study. When it comes to interpersonal skills (PL7) playing Agile Astro seem to have the same capabilities as the PM game ProDec but slightly worse than both the non-digital game *Ball Point Game* and *Dealing with Difficult People* (Battistella et al., 2013; Gloger, n.d.; Marcelo, n.d.; Petri, Calderón, et al., 2018). This was expected as these games mainly focus on the teamwork aspect and aim to generate as many meaningful social interactions as possible, which could act as an inspiration for a multiplayer version of Agile Astro in the future. The opportunity to practice self-organising (PL6) was, according to the students present in the game, and was rated as the second most fostered agile competence. Although there was no PM game that explicitly measured self-organising as a construct, the *Project Business Game* from Jääskä et al. (2022) was used to improve skills like decision-making, critical thinking and risk management, which are sub-components of self-organisation. They concluded that an especially high level of uncertainty in the mechanics and narrative of the game led to the fostering of those skills. The argument arises that tolerance for both successful and failed PM activities prepare students for later real-world situations. This may not always be appreciated by students, as evidenced by some written feedback and PE deductions regarding the randomness of events, but it may be a necessary mechanism for a long-lasting practical educational effect. According to the students, the game also contributed to recognising the importance of agile values. This represents a preliminary stage to the results reported by Barr

(2017), who found a significant increase in students' adaptability, communication and resourcefulness, which can be equated with agile values. This positive shift in mindsets resulted from an 8-week drop-in structure with laboratory interventions of playing commercial games. It further indicates that a much longer exposure time is needed to achieve long-lasting value construction. Agile Astro's current version would enable a similar setup, where students are not bound to time and are also unrestricted in terms of place, which can significantly promote self-directed learning (Kim et al., 2014; Squire, 2003). The freedom in learning conditions would also address the students' criticism that the game sessions during the workshop were too short, resulting in wasted learning opportunities. The better overall perceived learning score in students with more professional experience may indicate that they enter cross-connections to professional experiences mental model during the game and thus learn through synthesis (Toh & Kirschner, 2020).

## **6.2 Implications**

The learning from this study provides insights for agile trainers as well as educational practitioners on how a DGBL intervention can be used to teach agile competencies. Although there are indicators that the applied method also contributes to sustainable learning and measurable skill development, the data lacks long-term comparability; thus, a blended learning approach with other forms of teaching might be the best approach for the time being as also indicated by Holbrey (2020). For innovative educators, it is therefore recommended to conduct one or more workshops, as shown in the PM course of this study. These workshops should continue to follow the recommendation from Becker (2017) to explore DGBL by refining the educational interaction with the game through designated time slots for reflection and discussion for both learners as well as instructors. Alternatively, the game exposure can also happen asynchronously in the form of a take-home assessment, which might contribute to a focused flow state described by Sweetser and Wyeth (2005) while learning for some students. In general, it is important that educational practitioners know about the different presented quality factors and dimensions that model students' interactions with video games. There has to be awareness regarding the dependency effects and trade-offs among them. First and foremost it must be understood to which extent learning content can be integrated without losing the beneficial entertainment effects of video games. Second, social interaction possibilities should be thoughtfully facilitated to serve as an instrument for developing interpersonal skills, whether through face-to-face communication,

voice chats or in-game interactions. Lastly, the framework conditions in which the DGBL takes place have to be acknowledged by the teacher as moderating variables that can easily be levers to adjust to certain learning goals and shape the player experience. These conditions, like the duration, frequency, location or mixture with other learning methods, characterise a DGBL intervention and must be continuously adapted to new discoveries of student needs. This study contributes to showing an exemplary evaluation of this methodology, hopefully providing an incentive to introduce similar interventions into everyday education.

Furthermore, the documentation of the scientific process of developing an educational game for APM, can be used for creating new games for fostering agility or adapting to other disciplines. However, it is important to emphasise the other possibilities to introduce DGBL in curricular and vocational training that doesn't involve the development efforts of a tailor-made video game. There were also several options in both the simulation as well as the commercial game category that would have been viable candidates for transmitting learning content in a playful way (Barr, 2017; Kikot et al., 2013). Especially serious games come already with an educational scaffold and additional learning resources that characterise them as almost a plug and play solution for DGBL. Nevertheless, administrative considerations, like hardware requirements, costs, supported language and recommended group size, need to be considered when selecting such a learning software. Commercially available games, on the other hand, while being expected to score highly, almost all PE dimensions must be equipped with an educational framework like proposed by Tan et al. (2007) to fulfil targeted learning objectives. Depending on the subject and video game, this can take up a lot of time. Unfortunately, at the current maturity level of the DGBL field, it is still a question of cost and effectiveness that need to be evaluated to decide if and which video game implementation can find its way into the respective classroom. However, if any kind of video game integration is chosen, it is essential for learners, teachers, and the DGBL community as a whole that debriefs take place and that data is collected, analysed and shared (Van Eck, 2006). The findings of this thesis illustrate the substantial value of measuring student perception, in-game behaviour and qualitative feedback in the context of practical DGBL interventions. This emphasises the necessity of thoughtful integration of this new method and the exchange of insights among educational practitioners.

The prototype for an educational APM game in the form of Agile Astro can serve as a blueprint for usage in new application areas. It shows how the implementation of new innovative technologies, like LLMs, can be leveraged to abstract complexity and enable game engineers to develop educational games faster while achieving a better orchestration between the enjoyment of playing and the efficiency of learning. The tailored learning contents that were embedded in the interactive narrative, which was largely possible due to the usage of AI, were highly appreciated by the students. This relevancy factor of the learning intervention was found to be on par with other methods in the course and led to high acceptance. When enriched with traditional commercial game elements, e.g. roleplaying, themed user interface, and NPC interactions, as shown by Hamari et al. (2016), draw the player more into the virtual world, serving as an engaging learning space that encompasses opportunities to nurture a wide variety of skills. Beyond the design of the core concept of the game also, the updated technical infrastructure enables a scalable and easily modifiable approach to offer education. Therefore, this research insight is the potential for scalability of these technologies, both in terms of creating authentic learning content as well as playfully presenting and easily accessing it, paving the way towards a more interactive and autonomous future of learning.

### **6.3 Limitations and Further Research**

This research work methodology had certain limitations. Due to the workshop setup with a one-time exposure to the educational video game, long-term effects could not be evaluated. In general, the exposure duration was limited compared to other DGBL case studies, which also led to some criticism from the students, who felt under too much pressure to embrace the new learning medium fully. When it comes to participant selection, a gender imbalance is recognisable as there was a far greater proportion of men enrolled in the PM course. In general, a drawback that is known to many researchers conducting DGBL case studies is the small group size that is found in seminar classes, which allows only limited generalisability in terms of statistical power resulting from the sample size (Calderón & Ruiz, 2015). Some compromises have also been made in measuring and analysing educational outcomes. Although self-assessment, which was used to capture learning effects, was proven to offer reliability when paired with standardised frameworks like the MEEGA+ model, students' perception is still subject to many inaccuracies and biases, for example, due to different levels of self-judgment skills (Brown et al., 2015). Additionally, only a simple setup with a

questionnaire after the intervention was chosen in favour of a pre-and post-setup, which made it difficult to differentiate between existing capabilities and the learning that happened during the exposure to Agile Astro. Furthermore, a mapping between the game sessions and the questionnaire respondents was not established, which restricted the analysis of in-game behaviour. The overall recommendation for future research efforts on DGBL implementations is to design studies with scalability and replicability as the first priority. This would lead to a higher level of awareness in educational institutions as well as increased statistical significance of results. To achieve that, research should be carried out to find a standardised test procedure that makes the achievement of agile learning objectives both measurable and comparable and does not solely rely on MEEGA+ students' perception metrics. The goal should be to establish a subject-neutral quantitative evaluation process similar to the self-assessment model to reduce the high initial effort of the different application areas. These developments can act as the foundation to conduct longer-term studies, which is a gap in the literature, and should be the focus of subsequent studies. When considering potential follow-up studies with Agile Astro, the game's feature of extracting in-game events should be exploited more to explore the detailed effects between game mechanics and learning.

The technical realisation of an educational video game, in the form of Agile Astro, is still in the prototype stage, which comes with several limitations. During the development process, a lot of new requirements came up that could not be implemented as the feature freeze had to enforce a limit in favor of stability for the experiment at some point. The most prominent feature that did not make this version of Agile Astro is a multiplayer mode, apart from the real-time leaderboard that created a sense of competition among peers. Therefore, the fulfilment of the game's requirements for community and social interaction was outsourced to the DGBL workshop through team setups and the discussion session. As indicated Ducheneaut and Moore (2004) and Barr (2017) multiplayer games include a variety of social interaction possibilities which can be especially interesting for the soft-skill-reliant agile discipline. Therefore, next studies could implement a mode where two or more players can join one session of Agile Astro as different Scrum team members and investigate the influence on learning effects. Another limitation was the game's complexity; although as indicated by the positive recorded quality score is sufficient for Scrum beginners, it would quickly reach its limits with a longer intervention. Some more experienced students even

pointed out that they would like to see increasingly complex situations happening in later stages of the game to increase replayability. The recommendation for subsequent studies is to follow a systematical DGBL framework for designing educational games as proposed by Ishak et al. (2021) to incorporate more user feedback early on during the development process. The current study has progressed to analysing a prototype of Agile Astro, but further research effort is needed to make the developing process more streamlined and professional. To add more learning opportunities to the game, from a technical perspective, experimenting with self-hosted open-source LLMs would be the research path that would lead to the most valuable improvements. Besides drastically cutting costs, custom-trained models, with, for instance, PM case studies as training data, could increase the sophistication of the game's core concept and thus possibly lead to learning effects in even Scrum veterans. Additionally, the stored player interaction data could serve as a source for further refining the model for the game's purpose (Touvron et al., 2023). Furthermore, a moderating layer between the user and the AI should be introduced by implementing multiple agents in a chain to enable reasoning of the LLM that could more accurately prevent out-of-bound responses and also improve educational value (Wang et al., 2023). Another experimental research idea is designing the game for mobile and asynchronous play to facilitate microlearning, comparable to Duolingo's gamified language learning app (Shortt et al., 2023). For example, players could follow their everyday lives and receive messages from the app that another scrum meeting is due. This could improve the long-lasting learning effects as a project is simulated in real-time, and through frequent repetition, knowledge can be built and maintained more effectively (De Gagne et al., 2019).

## 7 Conclusion

This study's purpose was to evaluate whether DGBL can enhance agile competencies to provide better-skilled professionals for the PM industry. After evaluating several intervention procedures that could have been integrated into an undergraduate PM class, the decision was made to design a tailored educational game for the course's purpose. The result of the thoroughly researched agile literature and learning from several DGBL case studies was a series of systemically elicited requirements on the basis of which Agile Astro had been developed. The evaluation of the game's prototype happened within a DGBL workshop that was included in the curriculum of the PM course and was attended by 30 students, of which 22 provided valuable feedback. The analysis of the student's perception according to a standardised evaluation framework showed an overall positive central tendency regarding both quality factors, player experience as well as perceived learning. Although there were shortcomings in some aspects of the game, e.g., focused attention and opportunities for learning, five out of the six identified agile competencies were reported by the majority of students. These results align with similar field tests reported in the literature and can, therefore, be seen as a confirmation of the three hypotheses (RQ2-4) despite their low statistical power inherited from the small sample size.

New findings from this study are, on the one hand, the concept of embedding an LLM into an educational video game to lead a fictional narrative while injecting opportunities for learning Scrum. On the other hand, the variability in APM learning during a DGBL intervention is characterised by the player's age, gender, work and digital game experience. These differences are not only recognisable in students' perceptions but also in the diversity of playing styles that were demonstrated in the game. The main contribution to the literature is a prototype, in the form of Agile Astro, and the accompanying blueprint, which provides insights into dependencies of PE and video game elements, enabling more informed future developments of educational video games.

With this research work another step has been made to prove that the educational world is ready for DGBL. Found indicators for this claim resonate with the statements from researchers, that learning with video games is highly engaging (Prensky, 2001), offers autonomy in the learning process (Gee, 2004) and is scalable through new technologies (Plass et al., 2015). However, long-term and widespread experimental adaptations will be

necessary to evaluate sustainable learning effects. In particular, social interaction in multiplayer constellations of game interventions is to be further tested. Educators in IT might be pioneers due to their technical expertise, which is necessary at the current stage of DGBL. Through increased generalisability, these findings can then be systematically leveraged in favour of a curriculum for the 21st century. Methodising learning with video games can be one initiative to bridge the skill gap that has emerged between industries such as APM and educational institutions.



## References

- Abdullah, A. A., & Saeed, H. M. (2020). Teachers' and Learners' Perceptions Towards Digital Game-Based Learning in ESL Classroom. *Journal for the Study of English Linguistics*, 8(1), 166. <https://doi.org/10.5296/jsel.v8i1.17353>
- Adachi, P. J. C., & Willoughby, T. (2011). The effect of video game competition and violence on aggressive behavior: Which characteristic has the greatest influence? *Psychology of Violence*, 1(4), 259–274. <https://doi.org/10.1037/a0024908>
- Aitzaz, S., Samdani, G., Ali, M., & Kamran, M. (2016). A Comparative Analysis of In-house and Outsourced Development in Software Industry. *International Journal of Computer Applications*, 141(3), 18–22. <https://doi.org/10.5120/ijca2016909578>
- Alam, S. I., Ashraf, S. S., & Iqbal, F. (2018). Agile Movement from IT Industry to Non-IT Industry: A Review and Analysis. *International Journal of Emerging Research in Management and Technology*, 6(6), 285. <https://doi.org/10.23956/ijermt.v6i6.283>
- Alvarenga, J. C., Branco, R. R., Guedes, A. L. A., Soares, C. A. P., & Silva, W. D. S. E. (2019). The project manager core competencies to project success. *International Journal of Managing Projects in Business*, 13(2), 277–292. <https://doi.org/10.1108/IJMPB-12-2018-0274>
- Andersen, E., O'Rourke, E., Liu, Y.-E., Snider, R., Lowdermilk, J., Truong, D., Cooper, S., & Popovic, Z. (2012). The impact of tutorials on games of varying complexity. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 59–68. <https://doi.org/10.1145/2207676.2207687>
- Anderson, L. W., & Krathwohl, D. R. (Eds.). (2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives* (Complete ed). Longman.

- Anthropic. (2024). *Claude* (3.0) [Computer software]. Anthropic. <https://www.anthropic.com/claude>
- Asobo Studio. (2020). *Microsoft Flight Simulator* [Computer software]. Xbox Game Studios. <https://www.flightsimulator.com>
- Barab, S. A., Scott, B., Siyahhan, S., Goldstone, R., Ingram-Goble, A., Zuiker, S. J., & Warren, S. (2009). Transformational Play as a Curricular Scaffold: Using Videogames to Support Science Education. *Journal of Science Education and Technology*, 18(4), 305–320. <https://doi.org/10.1007/s10956-009-9171-5>
- Barr, M. (2017). Video games can develop graduate skills in higher education students: A randomised trial. *Computers & Education*, 113, 86–97. <https://doi.org/10.1016/j.compedu.2017.05.016>
- Battistella, P. E., Von Wangenheim, C. G., & Pereira Carvalho, O. (2013). Ensinar a Gerência de Equipes em Disciplinas de Gerência de Projetos de Software. *Revista Brasileira de Informática Na Educação*, 21(01), 16. <https://doi.org/10.5753/RBIE.2013.21.01.16>
- Baumeister, R. F., & Leary, M. R. (1995). The need to belong: Desire for interpersonal attachments as a fundamental human motivation. *Psychological Bulletin*, 117(3), 497–529. <https://doi.org/10.1037/0033-2909.117.3.497>
- Beath, C. M., & Walker, G. (1998). Outsourcing of application software: A knowledge management perspective. *Proceedings of the Thirty-First Hawaii International Conference on System Sciences*, 6, 666–674. <https://doi.org/10.1109/HICSS.1998.654828>
- Beck, K., Beedle, M., van Bennekum, A., Cockburn, A., Fowler, M., Grenning, J., Highsmith, J., Hunt, A., Jeffries, R., Kern, J., Marick, B., Martin, R. C., Mellor, S.,

- Schwaber, K., & Sutherland, J. (2001). *Manifesto for Agile Software Development*. Agile Alliance. <https://agilemanifesto.org>
- Becker, K. (2017). *Choosing and Using Digital Games in the Classroom*. Springer International Publishing. <https://doi.org/10.1007/978-3-319-12223-6>
- Blumberg, F. C., Rosenthal, S. F., & Randall, J. D. (2008). Impasse-driven learning in the context of video games. *Computers in Human Behavior*, 24(4), 1530–1541. <https://doi.org/10.1016/j.chb.2007.05.010>
- Bootla, P., Rojanapornpun, O., & Mongkolnam, P. (2015). Necessary skills and attitudes for development team members in Scrum: Thai experts' and practitioners's perspectives. *2015 12th International Joint Conference on Computer Science and Software Engineering (JCSSE)*, 184–189. <https://doi.org/10.1109/JCSSE.2015.7219793>
- Brechner, E., & Waletzky, J. (2015). *Agile project management with Kanban*. Microsoft Press.
- Brown, G. T. L., Andrade, H. L., & Chen, F. (2015). Accuracy in student self-assessment: Directions and cautions for research. *Assessment in Education: Principles, Policy & Practice*, 22(4), 444–457. <https://doi.org/10.1080/0969594X.2014.996523>
- Calderón, A., & Ruiz, M. (2015). A systematic literature review on serious games evaluation: An application to software project management. *Computers & Education*, 87, 396–422. <https://doi.org/10.1016/j.compedu.2015.07.011>
- Calderón, A., Ruiz, M., & O'Connor, R. V. (2017). ProDecAdmin: A Game Scenario Design Tool for Software Project Management Training. In J. Stolfa, S. Stolfa, R. V. O'Connor, & R. Messnarz (Eds.), *Systems, Software and Services Process Improvement* (Vol. 748, pp. 241–248). Springer International Publishing. [https://doi.org/10.1007/978-3-319-64218-5\\_19](https://doi.org/10.1007/978-3-319-64218-5_19)

- Calderón, A., Ruiz, M., & O'Connor, R. V. (2019). Designing game scenarios for software project management education and assessment. *IET Software*, *13*(2), 144–151. <https://doi.org/10.1049/iet-sen.2018.5081>
- Calderon, A., Ruiz, M., & Orta, E. (2017). Integrating Serious Games as Learning Resources in a Software Project Management Course: The Case of ProDec. *2017 IEEE/ACM 1st International Workshop on Software Engineering Curricula for Millennials (SECM)*, 21–27. <https://doi.org/10.1109/SECM.2017.3>
- Cao, L., & Ramesh, B. (2008). Agile Requirements Engineering Practices: An Empirical Study. *IEEE Software*, *25*(1), 60–67. <https://doi.org/10.1109/MS.2008.1>
- Capaul, R., & Ulrich, M. (2010). *Planspiele: Simulationsspiele für Unterricht und Training ; mit Kurztheorie: Simulations- und Planspielmethodik* (2., aktualisierte Aufl). Tobler.
- Chang, W.-C., & Chou, Y.-M. (2008). Introductory C Programming Language Learning with Game-Based Digital Learning. In F. Li, J. Zhao, T. K. Shih, R. Lau, Q. Li, & D. McLeod (Eds.), *Advances in Web Based Learning—ICWL 2008* (Vol. 5145, pp. 221–231). Springer Berlin Heidelberg. [https://doi.org/10.1007/978-3-540-85033-5\\_22](https://doi.org/10.1007/978-3-540-85033-5_22)
- Chiang, W.-L., Zheng, L., Sheng, Y., Angelopoulos, A. N., Li, T., Li, D., Zhang, H., Zhu, B., Jordan, M., Gonzalez, J. E., & Stoica, I. (2024). *Chatbot Arena: An Open Platform for Evaluating LLMs by Human Preference*. <https://doi.org/10.48550/ARXIV.2403.04132>
- Chung, L.-Y., & Chang, R.-C. (2017). The Effect of Gender on Motivation and Student Achievement in Digital Game-based Learning: A Case Study of a Contented-Based Classroom. *EURASIA Journal of Mathematics, Science and Technology Education*, *13*(6). <https://doi.org/10.12973/eurasia.2017.01227a>

- Clark, D. B., Hernández-Zavaleta, J. E., & Becker, S. (2023). Academically meaningful play: Designing digital games for the classroom to support meaningful gameplay, meaningful learning, and meaningful access. *Computers & Education, 194*, 104704. <https://doi.org/10.1016/j.compedu.2022.104704>
- Clark, R. (2007). Learning from serious games? Arguments, evidence, and research suggestions. *Educational Technology, 47*(3), 53–59.
- Cole, H., & Griffiths, M. D. (2007). Social Interactions in Massively Multiplayer Online Role-Playing Gamers. *CyberPsychology & Behavior, 10*(4), 575–583. <https://doi.org/10.1089/cpb.2007.9988>
- Collins, C., Dennehy, D., Conboy, K., & Mikalef, P. (2021). Artificial intelligence in information systems research: A systematic literature review and research agenda. *International Journal of Information Management, 60*, 102383. <https://doi.org/10.1016/j.ijinfomgt.2021.102383>
- Conboy, K., Coyle, S., Wang, X., & Pikkarainen, M. (2011). People over Process: Key Challenges in Agile Development. *IEEE Software, 28*(4), 48–57. <https://doi.org/10.1109/MS.2010.132>
- Conforto, E. C., Amaral, D. C., Da Silva, S. L., Di Felippo, A., & Kamikawachi, D. S. L. (2016). The agility construct on project management theory. *International Journal of Project Management, 34*(4), 660–674. <https://doi.org/10.1016/j.ijproman.2016.01.007>
- Conforto, E. C., Salum, F., Amaral, D. C., Da Silva, S. L., & De Almeida, L. F. M. (2014). Can Agile Project Management be Adopted by Industries Other than Software Development? *Project Management Journal, 45*(3), 21–34. <https://doi.org/10.1002/pmj.21410>

- Convex Systems Inc. (2021). *Convex Documentation* [TypeScript]. Convex Systems Inc.  
<https://docs.convex.dev/home>
- Côté, M.-A., Kádár, Á., Yuan, X., Kybartas, B., Barnes, T., Fine, E., Moore, J., Hausknecht, M., El Asri, L., Adada, M., Tay, W., & Trischler, A. (2019). TextWorld: A Learning Environment for Text-Based Games. In T. Cazenave, A. Saffidine, & N. Sturtevant (Eds.), *Computer Games* (Vol. 1017, pp. 41–75). Springer International Publishing.  
[https://doi.org/10.1007/978-3-030-24337-1\\_3](https://doi.org/10.1007/978-3-030-24337-1_3)
- Crowder, J. A., & Friess, S. (2015). *Agile Project Management: Managing for Success*. Springer International Publishing. <https://doi.org/10.1007/978-3-319-09018-4>
- Darvasi, P. (2017). *Teacher pioneers: Visions from the edge of the map*. Carnegie Mellon/ETC Press.
- De Gagne, J. C., Park, H. K., Hall, K., Woodward, A., Yamane, S., & Kim, S. S. (2019). Microlearning in Health Professions Education: Scoping Review. *JMIR Medical Education*, 5(2), e13997. <https://doi.org/10.2196/13997>
- De Vin, L. J., Jacobsson, L., & Odhe, J. (2018). Game-based Lean Production training of university students and industrial employees. *Procedia Manufacturing*, 25, 578–585.  
<https://doi.org/10.1016/j.promfg.2018.06.098>
- Denham, A. R. (2019). Using the PCaRD digital game-based learning model of instruction in the middle school mathematics classroom: A case study. *British Journal of Educational Technology*, 50(1), 415–427. <https://doi.org/10.1111/bjet.12582>
- Denning, S. (2015). How to make the whole organization Agile. *Strategy & Leadership*, 43(6), 10–17. <https://doi.org/10.1108/SL-09-2015-0074>
- Di Domenico, A., Perna, G., Trevisan, M., Vassio, L., & Giordano, D. (2021). A Network Analysis on Cloud Gaming: Stadia, GeForce Now and PSNow. *Network*, 1(3), 247–260. <https://doi.org/10.3390/network1030015>

- Ducheneaut, N., & Moore, R. J. (2004). The social side of gaming: A study of interaction patterns in a massively multiplayer online game. *Proceedings of the 2004 ACM Conference on Computer Supported Cooperative Work*, 360–369. <https://doi.org/10.1145/1031607.1031667>
- Dyba, T. (2000). Improvisation in Small Software Organizations. *IEEE Software*, 17(5), 82–87. <https://doi.org/10.1109/52.877872>
- Entertainment Software Association. (2023, July). *2023 Essential Facts About the U.S. Video Game Industry*. <https://www.theesa.com/2023-essential-facts/>
- European Commission. (2018). *Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions: Coordinated Plan on Artificial Intelligence* (Communication COM/2018/795 final). <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52018DC0795&qid=1714678918361>
- Farooq, M. S., Hamid, A., Alvi, A., & Omer, U. (2022). Blended Learning Models, Curricula, and Gamification in Project Management Education. *IEEE Access*, 10, 60341–60361. <https://doi.org/10.1109/ACCESS.2022.3180355>
- Ferguson, C. J. (2011). Video Games and Youth Violence: A Prospective Analysis in Adolescents. *Journal of Youth and Adolescence*, 40(4), 377–391. <https://doi.org/10.1007/s10964-010-9610-x>
- Fowler, M., & Beck, K. (2019). *Refactoring improving the design of existing code* (Second edition). Addison-Wesley.
- Gee, J. P. (2004). *What video games have to teach us about learning and literacy* (1. paperback ed). Palgrave Macmillan.
- Gloger, B. (n.d.). *Ballpoint Game*. Retrieved June 14, 2024, from <https://www.borisgloger.com/post/spielerisch-agil-remote-wordpoint-game>

- Gloger, B. (2010). Scrum: Der Paradigmenwechsel im Projekt- und Produktmanagement – Eine Einführung. *Informatik-Spektrum*, 33(2), 195–200. <https://doi.org/10.1007/s00287-010-0426-6>
- Gong, R., Huang, Q., Ma, X., Vo, H., Durante, Z., Noda, Y., Zheng, Z., Zhu, S.-C., Terzopoulos, D., Fei-Fei, L., & Gao, J. (2023). *MindAgent: Emergent Gaming Interaction*. <https://doi.org/10.48550/ARXIV.2309.09971>
- González-Tablas, A. I., González Vasco, M. I., Cascos, I., & Planet Palomino, Á. (2020). Shuffle, Cut, and Learn: Crypto Go, a Card Game for Teaching Cryptography. *Mathematics*, 8(11), 1993. <https://doi.org/10.3390/math8111993>
- Goodpasture, J. C. (2004). *Quantitative methods in project management*. J. Ross Pub.
- Google. (2024). *Gemini (1.5)* [Computer software]. <https://ai.google.dev>
- Granic, I., Lobel, A., & Engels, R. C. M. E. (2014). The benefits of playing video games. *American Psychologist*, 69(1), 66–78. <https://doi.org/10.1037/a0034857>
- Hamari, J., Shernoff, D. J., Rowe, E., Coller, B., Asbell-Clarke, J., & Edwards, T. (2016). Challenging games help students learn: An empirical study on engagement, flow and immersion in game-based learning. *Computers in Human Behavior*, 54, 170–179. <https://doi.org/10.1016/j.chb.2015.07.045>
- Hausknecht, M., Ammanabrolu, P., Côté, M.-A., & Yuan, X. (2020). Interactive Fiction Games: A Colossal Adventure. *Proceedings of the AAAI Conference on Artificial Intelligence*, 34(05), 7903–7910. <https://doi.org/10.1609/aaai.v34i05.6297>
- Hazzan, O., & Dubinsky, Y. (2014). *Agile Anywhere: Essays on Agile Projects and Beyond*. Springer International Publishing. <https://doi.org/10.1007/978-3-319-10157-6>
- Hébert, C., Jenson, J., & Terzopoulos, T. (2021). “Access to technology is the major challenge”: Teacher perspectives on barriers to DGBL in K-12 classrooms. *E-*



*Learning and Digital Media*, 18(3), 307–324.  
<https://doi.org/10.1177/2042753021995315>

Hidayati, A., Budiardjo, E. K., & Purwandari, B. (2020). Hard and Soft Skills for Scrum Global Software Development Teams. *Proceedings of the 3rd International Conference on Software Engineering and Information Management*, 110–114.  
<https://doi.org/10.1145/3378936.3378966>

Highsmith, J., & Cockburn, A. (2001). Agile software development: The business of innovation. *Computer*, 34(9), 120–127. <https://doi.org/10.1109/2.947100>

Hof, S., Kropp, M., & Landolt, M. (2017). Use of Gamification to Teach Agile Values and Collaboration: A multi-week Scrum simulation project in an undergraduate software engineering course. *Proceedings of the 2017 ACM Conference on Innovation and Technology in Computer Science Education*, 323–328.  
<https://doi.org/10.1145/3059009.3059043>

Holbrey, C. E. (2020). Kahoot! Using a game-based approach to blended learning to support effective learning environments and student engagement in traditional lecture theatres. *Technology, Pedagogy and Education*, 29(2), 191–202.  
<https://doi.org/10.1080/1475939X.2020.1737568>

Inayat, I., Salim, S. S., Marczak, S., Daneva, M., & Shamshirband, S. (2015). A systematic literature review on agile requirements engineering practices and challenges. *Computers in Human Behavior*, 51, 915–929.  
<https://doi.org/10.1016/j.chb.2014.10.046>

Ishak, S. A., Din, R., & Hasran, U. A. (2021). Defining Digital Game-Based Learning for Science, Technology, Engineering, and Mathematics: A New Perspective on Design and Developmental Research. *Journal of Medical Internet Research*, 23(2), e20537.  
<https://doi.org/10.2196/20537>

- Jääskä, E., & Aaltonen, K. (2022). Teachers' experiences of using game-based learning methods in project management higher education. *Project Leadership and Society*, 3, 100041. <https://doi.org/10.1016/j.plas.2022.100041>
- Jääskä, E., Lehtinen, J., Kujala, J., & Kauppila, O. (2022). Game-based learning and students' motivation in project management education. *Project Leadership and Society*, 3, 100055. <https://doi.org/10.1016/j.plas.2022.100055>
- Jakobsen, C. R., & Sutherland, J. (2009). Scrum and CMMI Going from Good to Great. *2009 Agile Conference*, 333–337. <https://doi.org/10.1109/AGILE.2009.31>
- Kalenda, M., Hyna, P., & Rossi, B. (2018). Scaling agile in large organizations: Practices, challenges, and success factors. *Journal of Software: Evolution and Process*, 30(10), e1954. <https://doi.org/10.1002/smr.1954>
- Kapp, K. M. (2012). *The gamification of learning and instruction: Game-based methods and strategies for training and education*. Pfeiffer.
- Kasneji, E., Sessler, K., Küchemann, S., Bannert, M., Dementieva, D., Fischer, F., Gasser, U., Groh, G., Günemann, S., Hüllermeier, E., Krusche, S., Kutyniok, G., Michaeli, T., Nerdel, C., Pfeffer, J., Poquet, O., Sailer, M., Schmidt, A., Seidel, T., ... Kasneji, G. (2023). ChatGPT for good? On opportunities and challenges of large language models for education. *Learning and Individual Differences*, 103, 102274. <https://doi.org/10.1016/j.lindif.2023.102274>
- Kaye, L. K., & Bryce, J. (2012). Putting the “Fun Factor” Into Gaming: The Influence of Social Contexts on Experiences of Playing Videogames. *International Journal of Internet Science*, 7(1), 24–38.
- Keil, M., Mann, J., & Rai, A. (2000). Why Software Projects Escalate: An Empirical Analysis and Test of Four Theoretical Models. *MIS Quarterly*, 24(4), 631. <https://doi.org/10.2307/3250950>

- Khan, A., Ahmad, F. H., & Malik, M. M. (2017). Use of digital game based learning and gamification in secondary school science: The effect on student engagement, learning and gender difference. *Education and Information Technologies*, 22(6), 2767–2804. <https://doi.org/10.1007/s10639-017-9622-1>
- Kiili, K. (2005). Digital game-based learning: Towards an experiential gaming model. *The Internet and Higher Education*, 8(1), 13–24. <https://doi.org/10.1016/j.iheduc.2004.12.001>
- Kikot, T., Costa, G., Magalhães, R., & Fernandes, S. (2013). Simulation Games as Tools for Integrative Dynamic Learning: The Case of the Management Course at the University of Algarve. *Procedia Technology*, 9, 11–21. <https://doi.org/10.1016/j.protcy.2013.12.002>
- Kim, R., Olfman, L., Ryan, T., & Eryilmaz, E. (2014). Leveraging a personalized system to improve self-directed learning in online educational environments. *Computers & Education*, 70, 150–160. <https://doi.org/10.1016/j.compedu.2013.08.006>
- King, D., Delfabbro, P., & Griffiths, M. (2010). Video Game Structural Characteristics: A New Psychological Taxonomy. *International Journal of Mental Health and Addiction*, 8(1), 90–106. <https://doi.org/10.1007/s11469-009-9206-4>
- Kniberg, H. (2007). *Scrum and XP from the trenches: How we do Scrum; [an agile war story]*. C4Media.
- Kropp, M., & Meier, A. (2013). Teaching agile software development at university level: Values, management, and craftsmanship. *26th International Conference on Software Engineering Education and Training (CSEE&T)*.
- Kropp, M., Meier, A., & Biddle, R. (2016). Teaching Agile Collaboration Skills in the Classroom. *2016 IEEE 29th International Conference on Software Engineering*

- Education and Training (CSEET)*, 118–127.  
<https://doi.org/10.1109/CSEET.2016.27>
- Kropp, M., Meier, A., Mateescu, M., & Zahn, C. (2014). Teaching and learning agile collaboration. *2014 IEEE 27th Conference on Software Engineering Education and Training (CSEE&T)*, 139–148. <https://doi.org/10.1109/CSEET.2014.6816791>
- Kühl, S., Strodtholz, P., & Taffertshofer, A. (Eds.). (2009). *Handbuch Methoden der Organisationsforschung*. VS Verlag für Sozialwissenschaften.  
<https://doi.org/10.1007/978-3-531-91570-8>
- Latitude. (2019). *AI Dungeon*. AI Dungeon. <https://aidungeon.com>
- Lawson, L. L., & Lawson, C. L. (2010). Video Game-Based Methodology for Business Research. *Simulation & Gaming*, 41(3), 360–373.  
<https://doi.org/10.1177/1046878109334038>
- Lee, W. L. (2016). SCRUM-X: An Interactive and Experiential Learning Platform for Teaching Scrum. *The 7th International Conference on Education, Training and Informatics (ICE TI 2016)*.
- Lei, H., Ganjeizadeh, F., Jayachandran, P. K., & Ozcan, P. (2017). A statistical analysis of the effects of Scrum and Kanban on software development projects. *Robotics and Computer-Integrated Manufacturing*, 43, 59–67.  
<https://doi.org/10.1016/j.rcim.2015.12.001>
- Liang, Y., Li, X., & Zhang, J. (2010). Digital game-based college English teaching. *2010 International Conference On Computer Design and Applications*, V5-470-V5-473.  
<https://doi.org/10.1109/ICCD.2010.5541038>
- Liu, E. Z. F., & Chen, P.-K. (2013). The Effect of Game-Based Learning on Students' Learning Performance in Science Learning – A Case of “Conveyance Go.” *Procedia*

- *Social and Behavioral Sciences*, 103, 1044–1051.  
<https://doi.org/10.1016/j.sbspro.2013.10.430>
- Liu, P., Yuan, W., Fu, J., Jiang, Z., Hayashi, H., & Neubig, G. (2021). *Pre-train, Prompt, and Predict: A Systematic Survey of Prompting Methods in Natural Language Processing*. <https://doi.org/10.48550/ARXIV.2107.13586>
- Llorens, R. M. (2017). eSport Gaming: The Rise of a New Sports Practice. *Sport, Ethics and Philosophy*, 11(4), 464–476. <https://doi.org/10.1080/17511321.2017.1318947>
- Lord, F. M. (2012). *Applications of Item Response Theory To Practical Testing Problems* (0 ed.). Routledge. <https://doi.org/10.4324/9780203056615>
- Lucia, A. D., & Qusef, A. (2010). Requirements Engineering in Agile Software Development. *Journal of Emerging Technologies in Web Intelligence*, 2(3), 212–220. <https://doi.org/10.4304/jetwi.2.3.212-220>
- Lui, R. W. C., Lee, P. T. Y., & Ng, V. T. Y. (2015). Design and Evaluation of PMS: A Computerized Simulation Game for Software Project Management. *The Computer Games Journal*, 4(1–2), 101–121. <https://doi.org/10.1007/s40869-015-0009-5>
- Ma, M., & Zheng, H. (2011). Virtual Reality and Serious Games in Healthcare. In S. Brahmam & L. C. Jain (Eds.), *Advanced Computational Intelligence Paradigms in Healthcare 6. Virtual Reality in Psychotherapy, Rehabilitation, and Assessment* (Vol. 337, pp. 169–192). Springer Berlin Heidelberg. [https://doi.org/10.1007/978-3-642-17824-5\\_9](https://doi.org/10.1007/978-3-642-17824-5_9)
- Malavolta, I. (2016). Beyond native apps: Web technologies to the rescue! (keynote). *Proceedings of the 1st International Workshop on Mobile Development*, 1–2. <https://doi.org/10.1145/3001854.3001863>

- Mann, H. B., & Whitney, D. R. (1947). On a Test of Whether one of Two Random Variables is Stochastically Larger than the Other. *The Annals of Mathematical Statistics*, 18(1), 50–60. <https://doi.org/10.1214/aoms/1177730491>
- Marcelo, F. (n.d.). *Scrum`ed*. Retrieved June 14, 2024, from <https://marcelofs.com/scrumed/>
- Marcus, G., Davis, E., & Aaronson, S. (2022). *A very preliminary analysis of DALL-E 2*. <https://doi.org/10.48550/ARXIV.2204.13807>
- Marinho, M., Noll, J., Richardson, I., & Beecham, S. (2019). Plan-Driven Approaches Are Alive and Kicking in Agile Global Software Development. *2019 ACM/IEEE International Symposium on Empirical Software Engineering and Measurement (ESEM)*, 1–11. <https://doi.org/10.1109/ESEM.2019.8870168>
- Matharu, G. S., Mishra, A., Singh, H., & Upadhyay, P. (2015). Empirical Study of Agile Software Development Methodologies: A Comparative Analysis. *ACM SIGSOFT Software Engineering Notes*, 40(1), 1–6. <https://doi.org/10.1145/2693208.2693233>
- Matveev, Y., Stepanova, T., & Trubetskaya, O. (2021). Complexity Theory for Project Management in the Digital Economy. In S. I. Ashmarina, V. V. Mantulenko, & M. Vochozka (Eds.), *Engineering Economics: Decisions and Solutions from Eurasian Perspective* (Vol. 139, pp. 364–371). Springer International Publishing. [https://doi.org/10.1007/978-3-030-53277-2\\_44](https://doi.org/10.1007/978-3-030-53277-2_44)
- Meta AI. (2024). *LLaMA (Large Language Model Meta AI) (3.0)* [Computer software]. Meta. <https://llama.meta.com/llama3/>
- Microsoft. (2024). *TypeScript Documentation (5.4.5)* [TypeScript]. Microsoft. <https://www.typescriptlang.org/docs/>
- Miler, J., & Landowska, A. (2016). *Designing effective educational games—A case study of a project management game*. 1657–1661. <https://doi.org/10.15439/2016F434>

- Misfeldt, M. (2015). *Scenario Based Education as a Framework for Understanding Students Engagement and Learning in a Project Management Simulation Game*. 13(3).
- Misra, S., Kumar, V., Kumar, U., Fantazy, K., & Akhter, M. (2012). Agile software development practices: Evolution, principles, and criticisms. *International Journal of Quality & Reliability Management*, 29(9), 972–980. <https://doi.org/10.1108/02656711211272863>
- Mohan, M. D., Sarfraz, I., Hewege, C., & Rajendran, D. (2018). An exploration of global employability skills: A systematic research review. *International Journal of Work Organisation and Emotion*, 9(1), 63. <https://doi.org/10.1504/IJWOE.2018.10012435>
- Montfort, N. (2009). Curveship: An interactive fiction system for interactive narrating. *Proceedings of the Workshop on Computational Approaches to Linguistic Creativity - CALC '09*, 55–62. <https://doi.org/10.3115/1642011.1642019>
- Moran, A. (2015). *Managing Agile: Strategy, Implementation, Organisation and People*. Springer International Publishing. <https://doi.org/10.1007/978-3-319-16262-1>
- Morel Software. (2018). *WrittenRealms*. Writtenrealms. <https://writtenrealms.com/home>
- Motives Studios. (2020). *Star Wars: Squadrons* [Computer software]. Electronic Arts. <https://www.ea.com/de-de/games/starwars/squadrons>
- Oblinger, D. G. (2004). The Next Generation of Educational Engagement. *Journal of Interactive Media in Education*, 2004(1), 10. <https://doi.org/10.5334/2004-8-oblinger>
- O'Farrell, E., Yilmaz, M., Gulec, U., & Clarke, P. (2021). PlaySAFe: Results from a Virtual Reality Study Using Digital Game-Based Learning for SAFe Agile Software Development. In M. Yilmaz, P. Clarke, R. Messnarz, & M. Reiner (Eds.), *Systems, Software and Services Process Improvement* (Vol. 1442, pp. 695–707). Springer International Publishing. [https://doi.org/10.1007/978-3-030-85521-5\\_47](https://doi.org/10.1007/978-3-030-85521-5_47)

- Olsson, M., Mozelius, P., & Collin, J. (2015). *Visualisation and Gamification of e-Learning and Programming Education*. 13(6).
- Omar, M., Khasasi, N. L. A., Abdullah, S. L. S., Hashim, N. L., Romli, R., & Katuk, N. (2018). *Defining Skill Sets Requirements for Agile Scrum Team Formation*.
- OpenAI. (2022). *DALL-E* [Computer software]. OpenAI. <https://openai.com/index/dall-e-2/>
- OpenAI. (2024). *ChatGPT (GPT-4) (4.0)* [Computer software]. OpenAI. <https://www.openai.com/chatgpt>
- Pant, I., & Baroudi, B. (2008). Project management education: The human skills imperative. *International Journal of Project Management*, 26(2), 124–128. <https://doi.org/10.1016/j.ijproman.2007.05.010>
- Papastergiou, M. (2009). Digital Game-Based Learning in high school Computer Science education: Impact on educational effectiveness and student motivation. *Computers & Education*, 52(1), 1–12. <https://doi.org/10.1016/j.compedu.2008.06.004>
- Peterson, J. (2012). *Playing at the world: A history of simulating wars, people and fantastic adventures, from chess to role-playing games*. Unreason Press.
- Petri, G. (2018). *MEEGA+: A Method for the Evaluation of Educational Games for Computing Education*.
- Petri, G., Calderón, A., von Wangenheim, C. G., Borgatto, A., & Ruiz, M. (2018). Games for Teaching Software Project Management: An Analysis of the Benefits of Digital and Non-Digital Games. *Journal of Universal Computer Science*, 24(10), 1424–1451.
- Petri, G., Von Wangenheim, C. G., & Borgatto, A. F. (2016). *MEEGA+: An Evolution of a Model for the Evaluation of Educational Games*.
- Petri, G., Von Wangenheim, C. G., & Borgatto, A. F. (2018). MEEGA+, Systematic Model to Evaluate Educational Games. In N. Lee (Ed.), *Encyclopedia of Computer*



- Graphics and Games* (pp. 1–7). Springer International Publishing.  
[https://doi.org/10.1007/978-3-319-08234-9\\_214-1](https://doi.org/10.1007/978-3-319-08234-9_214-1)
- Plass, J. L., Homer, B. D., & Kinzer, C. K. (2015). Foundations of Game-Based Learning. *Educational Psychologist*, 50(4), 258–283.  
<https://doi.org/10.1080/00461520.2015.1122533>
- Prensky, M. (2001). *Digital game-based learning*. McGraw-Hill.
- Project Management Institute. (2017). *PMI's Pulse of the Profession* (Industry Report 9; Global Project Management Survey, p. 29). Project Management Institute.  
<https://www.pmi.org/-/media/pmi/documents/public/pdf/learning/thought-leadership/pulse/pulse-of-the-profession-2017.pdf>
- Project Management Institute. (2021a). *Talent Gap: Ten-Year Employment Trends, Costs, and Global Implications* (p. 15) [Industry Report]. Project Management Institute.  
[https://www.pmi.org/-/media/pmi/documents/public/pdf/learning/career-central/talent-gap-report-2021-finalfinal.pdf?v=a7ff5855-2b86-4578-9b7f-3dbe26d0402d&sc\\_lang\\_temp=en](https://www.pmi.org/-/media/pmi/documents/public/pdf/learning/career-central/talent-gap-report-2021-finalfinal.pdf?v=a7ff5855-2b86-4578-9b7f-3dbe26d0402d&sc_lang_temp=en)
- Project Management Institute (Ed.). (2021b). *The standard for project management and a guide to the project management body of knowledge (PMBOK guide)* (Seventh edition). Project Management Institute, Inc.
- Python Software Foundation. (2023). *Python Documentation* (3.12) [Python]. Python Software Foundation. <https://www.python.org/doc/>
- R Core Team. (2024). *R* (4.4.0) [Computer software]. R Core Team. <https://cran.r-project.org/doc/manuals/r-release/R-lang.html>
- Radermacher, A., Walia, G., & Knudson, D. (2014). Investigating the skill gap between graduating students and industry expectations. *Companion Proceedings of the 36th*

- International Conference on Software Engineering*, 291–300.  
<https://doi.org/10.1145/2591062.2591159>
- Rajan, R. A. P. (2018). Serverless Architecture—A Revolution in Cloud Computing. *2018 Tenth International Conference on Advanced Computing (ICoAC)*, 88–93.  
<https://doi.org/10.1109/ICoAC44903.2018.8939081>
- Rolland, K. H., Fitzgerald, B., Dingsøy, T., & Stol, K.-J. (2016). *Problematizing Agile in the Large: Alternative Assumptions for Large-Scale Agile Development Completed Research Paper*. <https://doi.org/10.13140/RG.2.2.27795.07207>
- Rubin, K. S. (2012). *Essential Scrum: A practical guide to the most popular agile process*. Addison-Wesley.
- Ruhe, G., & Wohlin, C. (Eds.). (2014). *Software Project Management in a Changing World*. Springer Berlin Heidelberg. <https://doi.org/10.1007/978-3-642-55035-5>
- Rumeser, D., & Emsley, M. (2018). *Project Management Serious Games and Simulation: A comparison of three learning methods*, 5(3), 62–73.  
<https://doi.org/10.19255/JMPM01507>
- Ryan, R. M., Rigby, C. S., & Przybylski, A. (2006). The Motivational Pull of Video Games: A Self-Determination Theory Approach. *Motivation and Emotion*, 30(4), 344–360.  
<https://doi.org/10.1007/s11031-006-9051-8>
- Salen, K. (Ed.). (2008). *The ecology of games: Connecting youth, games, and learning*. MIT Press.
- Salen, K., & Zimmerman, E. (2004). *Rules of play: Game design fundamentals*. MIT Press.
- Savi, R., Von Wangenheim, C. G., & Borgatto, A. F. (2011). A Model for the Evaluation of Educational Games for Teaching Software Engineering. *2011 25th Brazilian Symposium on Software Engineering*, 194–203.  
<https://doi.org/10.1109/SBES.2011.27>

- Scharff, C., Gotel, O., & Kulkarni, V. (2010). Transitioning to Distributed Development in Students' Global Software Development Projects: The Role of Agile Methodologies and End-to-End Tooling. *2010 Fifth International Conference on Software Engineering Advances*, 388–394. <https://doi.org/10.1109/ICSEA.2010.66>
- Schleicher, A. (2018). *World Class: How to Build a 21st-Century School System*. OECD. <https://doi.org/10.1787/9789264300002-en>
- Schwaber, K. (2004). *Agile project management with Scrum*. Microsoft Press.
- Schwaber, K., & Sutherland, J. (Eds.). (2012). The Scrum Guide. In *Software in 30 Days* (1st ed., pp. 133–152). Wiley. <https://doi.org/10.1002/9781119203278.app2>
- Scrum.org. (n.d.). *What is Scrum?* Www.Scrum.Org. Retrieved January 29, 2024, from <https://www.scrum.org/resources/what-scrum-module>
- Semantic Scholar. (n.d.). *Search Results for "Digital Game-Based Learning."* Www.Semanticscholar.Org. Retrieved January 23, 2024, from <https://www.semanticscholar.org/search?q=%22digital%20game-based%20learning%22&sort=relevance>
- Serrador, P., & Pinto, J. K. (2015). Does Agile work? — A quantitative analysis of agile project success. *International Journal of Project Management*, 33(5), 1040–1051. <https://doi.org/10.1016/j.ijproman.2015.01.006>
- Seymour, T., & Hussein, S. (2014). The History Of Project Management. *International Journal of Management & Information Systems (IJMIS)*, 18(4), 233. <https://doi.org/10.19030/ijmis.v18i4.8820>
- Shadish, W. R., Cook, T. D., & Campbell, D. T. (2001). *Experimental and quasi-experimental designs for generalized causal inference*. Houghton Mifflin.
- Shortt, M., Tilak, S., Kuznetcova, I., Martens, B., & Akinkuolie, B. (2023). Gamification in mobile-assisted language learning: A systematic review of Duolingo literature from

- public release of 2012 to early 2020. *Computer Assisted Language Learning*, 36(3), 517–554. <https://doi.org/10.1080/09588221.2021.1933540>
- Spires, H. A. (2015). Digital Game-Based Learning: What's Literacy Got to Do With It? *Journal of Adolescent & Adult Literacy*, 59(2), 125–130. <https://doi.org/10.1002/jaal.424>
- Spires, H. A., Rowe, J. P., Mott, B. W., & Lester, J. C. (2011). Problem Solving and Game-Based Learning: Effects of Middle Grade Students' Hypothesis Testing Strategies on Learning Outcomes. *Journal of Educational Computing Research*, 44(4), 453–472. <https://doi.org/10.2190/EC.44.4.e>
- Squire, K. (2003). Video games in education. *International Journal of Intelligent Games & Simulation*, 2, 49–62.
- Srivastava, A., Bhardwaj, S., & Saraswat, S. (2017). SCRUM model for agile methodology. *2017 International Conference on Computing, Communication and Automation (ICCCA)*, 864–869. <https://doi.org/10.1109/CCAA.2017.8229928>
- Statista. (2024). *Number of video game users worldwide from 2017 to 2027 (in billions) [Graph]*. [Www.Statista.Com. https://www.statista.com/statistics/748044/number-video-gamers-world/](https://www.statista.com/statistics/748044/number-video-gamers-world/)
- steam250. (2024). *Top 250 most played Steam games, based on average number of concurrent players in the last seven days*. [Www.Steam250.Com. https://steam250.com/most\\_played](https://steam250.com/most_played)
- Steghöfer, J.-P., Knauss, E., Alégroth, E., Hammouda, I., Burden, H., & Ericsson, M. (2016). *Teaching Agile—Addressing the Conflict between Project Delivery and Application of Agile Methods*.
- Sutherland, J., & Altman, I. (2010). Organizational Transformation with Scrum: How a Venture Capital Group Gets Twice as Much Done with Half the Work. *2010 43rd*

- Hawaii International Conference on System Sciences*, 1–9.  
<https://doi.org/10.1109/HICSS.2010.299>
- Sutherland, J., Downey, S., & Granvik, B. (2009). Shock Therapy: A Bootstrap for Hyper-Productive Scrum. *2009 Agile Conference*, 69–73.  
<https://doi.org/10.1109/AGILE.2009.28>
- Sutherland, J., Schoonheim, G., Kumar, N., Pandey, V., & Vishal, S. (2009). Fully Distributed Scrum: Linear Scalability of Production between San Francisco and India. *2009 Agile Conference*, 277–282. <https://doi.org/10.1109/AGILE.2009.27>
- Sweetser, P., & Wyeth, P. (2005). GameFlow: A model for evaluating player enjoyment in games. *Computers in Entertainment*, 3(3), 3–3.  
<https://doi.org/10.1145/1077246.1077253>
- Taber, K. S. (2018). The Use of Cronbach’s Alpha When Developing and Reporting Research Instruments in Science Education. *Research in Science Education*, 48(6), 1273–1296. <https://doi.org/10.1007/s11165-016-9602-2>
- Takeuchi, H., & Ikujiro, N. (1986). The New New Product Development Game. *Harvard Business Review*, 64(1). <https://www.hbs.edu/faculty/Pages/item.aspx?num=38542>
- Tam, C., Moura, E. J. D. C., Oliveira, T., & Varajão, J. (2020). The factors influencing the success of on-going agile software development projects. *International Journal of Project Management*, 38(3), 165–176.  
<https://doi.org/10.1016/j.ijproman.2020.02.001>
- Tan, C. H., & Teo, H.-H. (2007). Training future software developers to acquire agile development skills. *Communications of the ACM*, 50(12), 97–98.
- Tan, P.-H., Ling, S.-W., & Ting, C.-Y. (2007). Adaptive digital game-based learning framework. *Proceedings of the 2nd International Conference on Digital Interactive*

*Media in Entertainment and Arts*, 142–146.

<https://doi.org/10.1145/1306813.1306844>

Toh, W., & Kirschner, D. (2020). Self-directed learning in video games, affordances and pedagogical implications for teaching and learning. *Computers & Education*, 154, 103912. <https://doi.org/10.1016/j.compedu.2020.103912>

Touvron, H., Martin, L., Stone, K., Albert, P., Almahairi, A., Babaei, Y., Bashlykov, N., Batra, S., Bhargava, P., Bhosale, S., Bikel, D., Blecher, L., Ferrer, C. C., Chen, M., Cucurull, G., Esiobu, D., Fernandes, J., Fu, J., Fu, W., ... Scialom, T. (2023). *Llama 2: Open Foundation and Fine-Tuned Chat Models* (Version 2). arXiv. <https://doi.org/10.48550/ARXIV.2307.09288>

Treanor, M., Zook, A., & Eladhari, M. P. (2015). AI-Based Game Design Patterns. *International Conference on Foundations of Digital Games*.

Tsiotras, D., & Xinogalos, S. (2021). Investigating the Perceived Player Experience and Short-term Learning of the Text-based Java Programming Serious Game “Rise of the Java Emperor.” *Informatics in Education*, 20(1), 153–170. <https://doi.org/10.15388/infedu.2021.08>

University of Vienna. (2024, February 13). *051039 VU Project Management (2024S) [Bulletin list of translated Items]*. U:Find. <https://ufind.univie.ac.at/en/course.html?lv=051039&semester=2024S>

Valentin, E., Carvalho, J. R. H., & Barreto, R. (2015). *Rapid improvement of students’ soft-skills based on an agile-process approach*.

Valve Corporation. (2015, October 8). *Keep Talking and Nobody Explodes*. Steam. [https://store.steampowered.com/app/341800/Keep\\_Talking\\_and\\_Nobody\\_Explodes/](https://store.steampowered.com/app/341800/Keep_Talking_and_Nobody_Explodes/)

- Valve Corporation. (2016, September 8). *Project Highrise*. Steam. [https://store.steampowered.com/app/423580/Project\\_Highrise/](https://store.steampowered.com/app/423580/Project_Highrise/)
- Van Eck, R. N. (2006). Digital Game-Based Learning: It's Not Just the Digital Natives Who Are Restless.... *Educational Review*, 41, 16.
- Venigalla, A. S. M., & Chimalakonda, S. (2020). G4D - a treasure hunt game for novice programmers to learn debugging. *Smart Learning Environments*, 7(1), 21. <https://doi.org/10.1186/s40561-020-00129-4>
- Vercel. (2024). *Next.js Documentation* (14.1.4) [TypeScript, JavaScript]. Vercel. <https://nextjs.org/docs>
- Video Games Europe. (2022). *2022 Key Facts about the European video games sector* [Industry Report]. Video Games Europe.
- Vorderer, P., Hartmann, Tilo, & Klimmt, Christoph. (2003). Explaining the Enjoyment of Playing Video Games: The Role of Competition. *ICEC '03: Proceedings of the Second International Conference on Entertainment Computing*, 1–9.
- Wang, Z., Cai, S., Chen, G., Liu, A., Ma, X., & Liang, Y. (2023). *Describe, Explain, Plan and Select: Interactive Planning with Large Language Models Enables Open-World Multi-Task Agents* (Version 2). arXiv. <https://doi.org/10.48550/ARXIV.2302.01560>
- Web Dev Cody. (2023). *Convex text-adventure* [TypeScript, JavaScript, CSS]. <https://github.com/webdevcody/convex-text-adventure>
- Wernholm, M., & Vigmo, S. (2015). Capturing children's knowledge-making dialogues in Minecraft. *International Journal of Research & Method in Education*, 38(3), 230–246. <https://doi.org/10.1080/1743727X.2015.1033392>
- Westera, W., Prada, R., Mascarenhas, S., Santos, P. A., Dias, J., Guimarães, M., Georgiadis, K., Nyamsuren, E., Bahreini, K., Yumak, Z., Christyowidiasmoro, C., Dascalu, M., Gutu-Robu, G., & Ruseti, S. (2020). Artificial intelligence moving serious gaming:

- Presenting reusable game AI components. *Education and Information Technologies*, 25(1), 351–380. <https://doi.org/10.1007/s10639-019-09968-2>
- Williams, L. A., & Kessler, R. R. (2000). All I really need to know about pair programming I learned in kindergarten. *Communications of the ACM*, 43(5), 108–114. <https://doi.org/10.1145/332833.332848>
- Winter, R. J. (2014). Agile Software Development: Principles, Patterns, and Practices: Robert C. Martin with contributions by James W. Newkirk and Robert S. Koss. *Performance Improvement*, 53(4), 43–46. <https://doi.org/10.1002/pfi.21408>
- Wu, T., He, S., Liu, J., Sun, S., Liu, K., Han, Q.-L., & Tang, Y. (2023). A Brief Overview of ChatGPT: The History, Status Quo and Potential Future Development. *IEEE/CAA Journal of Automatica Sinica*, 10(5), 1122–1136. <https://doi.org/10.1109/JAS.2023.123618>
- Yagüe, A., Garbajosa, J., Díaz, J., & González, E. (2016). An exploratory study in communication in Agile Global Software Development. *Computer Standards & Interfaces*, 48, 184–197. <https://doi.org/10.1016/j.csi.2016.06.002>
- Yao, S., Rao, R., Hausknecht, M., & Narasimhan, K. (2020). Keep CALM and Explore: Language Models for Action Generation in Text-based Games. *Proceedings of the 2020 Conference on Empirical Methods in Natural Language Processing (EMNLP)*, 8736–8754. <https://doi.org/10.18653/v1/2020.emnlp-main.704>
- Yee, N. (2006). Motivations for Play in Online Games. *CyberPsychology & Behavior*, 9(6), 772–775. <https://doi.org/10.1089/cpb.2006.9.772>
- Zar, J. H. (2005). Spearman Rank Correlation. In P. Armitage & T. Colton (Eds.), *Encyclopedia of Biostatistics* (1st ed.). Wiley. <https://doi.org/10.1002/0470011815.b2a15150>





## Statutory Declaration

I hereby declare, under oath, that this master thesis has been my independent work and has not been aided with any prohibited means. I declare, to the best of my knowledge and belief, that all passages taken from published and unpublished sources or documents have been reproduced whether as original, slightly changed or in thought, have been mentioned as such at the corresponding places of the thesis, by citation, where the extent of the original quotes is indicated. The paper has not been submitted for evaluation to another examination authority or has been published in this form or another.

Wien, 30.06.2024

A handwritten signature in black ink, consisting of a large, stylized initial 'B' followed by a cursive name, written over a horizontal line.

(signature)

# Appendix

Appendix A. Serious Game Candidates .....	A2
Appendix B. Commercial Game Candidates.....	A3
Appendix C. Interview Guideline.....	A4
Appendix D. Agile Astro React Main Component.....	A7
Appendix E. Agile Astro Database Structure .....	A15
Appendix F. LLM Prompts and Responses.....	A16
Appendix G. Adapted MEEGA+ Questionnaire .....	A26

## Appendix A. Serious Game Candidates

Title	Source	Publicly Accessible	University Access
MIT	<a href="https://mitsloan.mit.edu/teaching-resources-library/project-management-simulation">mitsloan.mit.edu/teaching-resources-library/project-management-simulation</a>	no	yes
Cesim	<a href="https://cesim.com/simulations/cesim-project-management-simulation">cesim.com/simulations/cesim-project-management-simulation</a>	limited	no
Simultrain	<a href="https://simultrain.swiss">simultrain.swiss</a>	limited	no
AbleSim	<a href="https://ablesim.com/free-project-management-simulation/">ablesim.com/free-project-management-simulation/</a>	limited	no
SPL	<a href="https://simulationpl.com/product/simagile/">simulationpl.com/product/simagile/</a>	limited	no
Celemi	<a href="https://celemi.com/business-simulation-games/">celemi.com/business-simulation-games/</a>	no	no
Paradigm Learning	<a href="https://paradigmlearning.com/products/countdown">paradigmlearning.com/products/countdown</a>	no	no
The incredible manager	<a href="https://researchgate.net/publication/221389730">researchgate.net/publication/221389730</a>	no	no
game-Benspænd	<a href="https://workchange.com/posts/benspaend">workchange.com/posts/benspaend</a>	no	no
Skyscraper Simulator	<a href="https://store.steampowered.com/app/252910/Skyscraper_Simulator/?l=german">store.steampowered.com/app/252910/Skyscraper_Simulator/?l=german</a>	no	no
PMS	<a href="https://link.springer.com/chapter/10.1007/978-3-662-46158-7_11#editor-information">link.springer.com/chapter/10.1007/978-3-662-46158-7_11#editor-information</a>	no	no
SimSe	<a href="https://ics.uci.edu/~emilyo/SimSE/index.html">ics.uci.edu/~emilyo/SimSE/index.html</a>	yes	yes
SimVBSE	<a href="https://ieeexplore.ieee.org/document/1617336/authors#authors">ieeexplore.ieee.org/document/1617336/authors#authors</a>	no	no
Project Team Builder	<a href="https://sandboxmodel.com">sandboxmodel.com</a>	no	no
Scrumed	<a href="https://gqs.ufsc.br/software-engineering-and-management-education">gqs.ufsc.br/software-engineering-and-management-education</a>	yes	yes
The Project Management Game	<a href="https://thatpmgame.com">thatpmgame.com</a>	yes	yes
ScrumX	<a href="https://ink.library.smu.edu.sg/cgi/viewcontent.cgi?article=4379&amp;context=sis_research">ink.library.smu.edu.sg/cgi/viewcontent.cgi?article=4379&amp;context=sis_research</a>	no	no

## Appendix B. Commercial Game Candidates

Title	URL	Genre	Price
Project Highrise	<a href="https://store.steampowered.com/app/423580/Project_Highrise/">https://store.steampowered.com/app/423580/Project_Highrise/</a>	Simulation, Management	€ 19.50
Tropico 5	<a href="https://store.steampowered.com/app/245620/Tropico_5/">https://store.steampowered.com/app/245620/Tropico_5/</a>	Simulation, Strategy	€ 19.90
RimWorld	<a href="https://store.steampowered.com/app/294100/RimWorld/">https://store.steampowered.com/app/294100/RimWorld/</a>	Simulation, Strategy	€ 31.99
Anno 1800	<a href="https://store.steampowered.com/app/916440/Anno_1800/">https://store.steampowered.com/app/916440/Anno_1800/</a>	City Building, Real-time Strategy	€ 59.99
Frostpunk	<a href="https://store.steampowered.com/app/323190/Frostpunk/">https://store.steampowered.com/app/323190/Frostpunk/</a>	City Building, Survival	€ 5.99
Banished	<a href="https://store.steampowered.com/app/242920/Banished/">https://store.steampowered.com/app/242920/Banished/</a>	City Building, Strategy	€ 18.99
Prison Architect	<a href="https://store.steampowered.com/app/233450/Prison_Architect/">https://store.steampowered.com/app/233450/Prison_Architect/</a>	Simulation, Strategy	€ 24.99
Factorio	<a href="https://store.steampowered.com/app/427520/Factorio/">https://store.steampowered.com/app/427520/Factorio/</a>	Simulation, Strategy	€ 32.00
Stellaris	<a href="https://store.steampowered.com/app/281990/Stellaris/">https://store.steampowered.com/app/281990/Stellaris/</a>	Grand Strategy	€ 39.99
Keep Talking and N	<a href="https://store.steampowered.com/app/341800/Keep_Talking_and_Nobody_Explodes/">https://store.steampowered.com/app/341800/Keep_Talking_and_Nobody_Explodes/</a>	Puzzle, Party	€ 14.79
Two Point Hospital	<a href="https://store.steampowered.com/app/535930/Two_Point_Hospital/">https://store.steampowered.com/app/535930/Two_Point_Hospital/</a>	Simulation, Management	€ 7.49
Software Inc.	<a href="https://store.steampowered.com/app/362620/Software_Inc/">https://store.steampowered.com/app/362620/Software_Inc/</a>	Simulation, Strategy	€ 22.54

## Appendix C. Interview Guideline

Kursevaluation					
	sehr zustimmend	zustimmend	weder zustimmend noch ablehnend	ablehnend	sehr ablehnend
Q1.1. Ich war mit der Kurserfahrung insgesamt zufrieden.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q1.2. Ich habe meine Lernziele erreicht.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q1.3. Der Kurs war motivierend.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q1.4. Was sind deiner Meinung nach die wichtigsten Fähigkeiten im agilen Projektmanagement?					
Q1.5. Wenn du auf den Kurs zurückblickst, welche dieser wesentlichen agilen Projektmanagement-Fähigkeiten wurden deiner Meinung nach effektiv gefördert und wie?					
Q1.6. Welche agilen Projektmanagement-Fähigkeiten wurden vernachlässigt und wie würdest du den Kurs ändern, um sie zu verbessern?					
<b>Einführung in Digital Game-Based Learning (=DGBL)</b>					
<b>Definition DGBL:</b>					
Ist eine Methode des Lernens durch Videospiele, die es den Schülern ermöglicht, in eine neue Umgebung einzutauchen, die einem medienreichen und interaktiven Lernkontext ähnelt, um schneller Wissen und Erfahrungen zu sammeln. (Prensky, 2001).					
<b>Beispiel DGBL:</b>					
Spires et al. (2011) haben ein Videospiel entwickelt, um das naturwissenschaftliche Lernen von Schülern aus der achten Schulstufe zu fördern.					
Crystal Island – Outbreak ... ist eine erzählzentrierte Lernumgebung, die sich in einem kleinen Forschungscamp auf einer kürzlich entdeckten tropischen Insel abspielt. Bei der Erkundung des Camps untersuchen die SchülerInnen die sich auf der Insel ausbreitende Krankheit, indem sie Fragen stellen, Forschungsfragen aufstellen, Daten sammeln und Hypothesen testen. Während ihrer Untersuchungen interagieren die SchülerInnen mit Nicht-Spieler-Charakteren, die ihnen Hinweise und relevante mikrobiologische Fakten bereitstellen ... (Spires, 2015, p. 127)					
Q1.1	Bist du während deiner Bildungslaufbahn bereits in Kontakt mit DGBL gekommen?				
	Ja		Nein		
	<input type="checkbox"/>			<input type="checkbox"/>	

## Mögliche Implementierungsstrategien

sehr  
zustimmend    zustimmend    weder  
zustimmend    noch    ablehnend    sehr  
ablehnend    ablehnend

Q1.2 Informatik  
StudentInnen in  
diesem  
Projektmanagement-  
kurs sind offen  
gegenüber dem Lernen  
mittels Videospiele.

Q1.3 Welche Vorteile siehst du in der Nutzung von Videospiele für das Lernen in diesem Kurs?

Q1.4 Welche Herausforderungen siehst du in der Nutzung von Videospiele für das Lernen in diesem Kurs?

Q1.5 Ich stelle dir nun vier verschiedene Ansätze zur Gestaltung eines DGBL-Workshops vor. Bitte wähle deine bevorzugte Option aus und begründe deine Entscheidung:

**Option 1** Implementierung eines kommerziellen Videospiele, bei dem Parallelen zwischen der Realität des Spiels und Projektmanagement-Prinzipien gezogen werden und somit gelernt wird. Beispiel: **Strategiespiel Frostpunk**



Figure 1. Interface des Videospiele Frostpunk [Screenshot].

**Option 2** Implementierung eines Dashboard-basierten Simulationsspiels, bei dem ein Projektlebenszyklus in einem realen Kontext durchgespielt wird. Beispiel: MIT Project Management Simulation



Figure 2. Interface des MIT Project Management Simulation Spiels [Screenshot]. Nachdruck aus System dynamics to understand and improve the performance of complex projects, (S. 15), Gozluklu & Sterman, 2022.

**Option 3** Implementierung eines selbst entwickelten textbasierten Rollenspiels, das KI einsetzt, um Entscheidungsprozesse in verschiedenen Projektmanagement-Szenarien zu fördern. Beispiel: in diesem Kontext noch nicht vorhanden



Figure 3. AI power Text Adventure Game [Screenshot]. (Webdevcody, 2023). Abgerufen aus <https://github.com/webdevcody/convex-text-adventure>

Q1.6 Was hat dazu geführt, dass du die anderen zwei Ansätze ausschließt?

## Abschluss des Interviews

Q4.1 Hast du irgendwelche abschließenden Anmerkungen allgemein zum Kurs und/oder wie man diesen verbessern könnte?

- Bitte um Erlaubnis den Kontakt aufrecht zu erhalten falls etwaige Fragen auftauchen oder zusätzliche Informationen benötigt werden
- Danksagung und Verabschiedung



## Appendix D. Agile Astro React Main Component

```
"use client";

// Imports General React/Convex
import { useAction, useQuery, useMutation } from "convex/react";
import { useRef, useEffect, useState } from "react";
import { useRouter } from 'next/navigation';
import { api } from "../../convex/_generated/api";
import { Id } from "../../convex/_generated/dataModel";

// Import Custom Components
import TutorialDisplay from "@components/TutorialDisplay";
import ChatInteraction from "@components/ChatInteraction";
import MissionHeaderDisplay from "@components/MissionHeaderDisplay";
import TeamInteraction from "@components/TeamInteraction";
import SkillsInteraction from "@components/SkillsInteraction";
import PlayerDisplay from "@components/PlayerDisplay";
import ChatDisplay from "@components/ChatDisplay";
import VisualizationDisplay from "@components/VisualizationDisplay";
import LogoDisplay from "@components/LogoDisplay";
import ProgressDisplay from "@components/ProgressDisplay";
import TimerDisplay from "@components/TimerDisplay";
import EndPopUp from "@components/EndPopUp";
import StartPopUp from "@components/StartPopUp";

// Import Misc
import isEqual from 'lodash/isEqual';

// Import Constants
import { SKILL_EFFECT_TYPES, INITIAL_STORYPOINTS, PLAYTIME_MINUTES, INITIAL_DAYS } from
"@/app/constants";

// Import Type Definitions
import { Entry, ProgressData, MetaProbs, Visualization, Skill, TutorialData, TutorialEntry } from
"@/app/interfaces/interfaces";

// Import Data
import dataTeamMembers from '@/data/teamMembers.json';
import dataAgileSkills from '@/data/agileSkills.json';
import dataScrumGlossary from '@/data/scrumGlossary.json';

// Import Font
import { Exo } from 'next/font/google'

// Setup Font
const exo = Exo({ weight: "400", subsets: ['latin'] })
```

```

// Agile Astro Main Interface
export default function Adventure(props: { params: { scenarioId: Id<"scenarios"> } }) {
  // get scenarioId from next nav Router URL
  const scenarioId = props.params.scenarioId;
  // load scenario data via websocket
  const character = useQuery(api.scenario.getScenarioPublic, {
    scenarioId,
  }) ?? { characterClass: "", characterName: "", tutorialCompleted: false, startTime: 0, overTime: 0 }
  // Initialize Session Metadata when character is changing value
  const [metaProbs, setMetaProbs] = useState<MetaProbs>({} as MetaProbs);
  const [isMetaProbsReady, setIsMetaProbsReady] = useState(false); //loading state for site content
  useEffect(() => {
    if (character.characterClass) {
      const mainCharacter = dataTeamMembers.find(member => member.mainCharacterClass ===
character.characterClass);
      const npc = dataTeamMembers.filter(member => member.mainCharacterClass !==
character.characterClass);
      const mainCharacterSkills: Skill[] = dataAgileSkills.filter(skill => skill.characterClass ===
character.characterClass);
      const newMetaProbs: MetaProbs = {
        scenarioId: scenarioId,
        character: character,
        characterImageObject: mainCharacter,
        skills: mainCharacterSkills,
        teamMembers: npc
      };
      setMetaProbs(newMetaProbs);
      setIsMetaProbsReady(true); // Set to true once metaProbs is populated
    }
  }, [character]);
  // extracting session start time and over time from retrieved scenario data
  const overTime = character.overTime ?? 0
  const initialStartTime = new Date((character.startTime || 0));
  // load in history of entries from current scenario via websocket
  const [entries, setEntries] = useState<Entry[]>([]);
  const newEntries: Entry[] = useQuery(api.chat.getAllEntriesForScenarioPublic, {
    scenarioId,
  }) ?? [];
}

```

```

useEffect(() => {
  if (newEntries.length !== entries.length) {
    setEntries(newEntries);
  }
}, [newEntries]);
// extracting data from last entry
const lastEntry = entries[entries.length - 1] ?? { xp: 0, _id: "" };
const lastXp = lastEntry.xp;
const lastTeamMembersInteracted = lastEntry.teamMembersInteracted;
// STATES FOR COMPONENTS
const [interactedMembers, setInteractedMembers] = useState<boolean[]>([]); //as a condition to unlock skills
const [entriesProcessing, setEntriesProcessing] = useState(false); //show loading skeleton when true
const [xp, setXp] = useState(0);
const [lv, setLv] = useState(1);
const [tutorialData, setTutorialData] = useState<TutorialData>({});
const [progressData, setProgressData] = useState<ProgressData>({ days: [], storypoints: [] });
const [showPopup, setShowPopup] = useState(false);
const [showStartPopup, setShowStartPopup] = useState(true);
const [stopTimer, setStopTimer] = useState(false);
const [disableInteractions, setDisableInteractions] = useState(false);
const [shouldFetch, setShouldFetch] = useState(false);
const [gameOver, setGameOver] = useState(false);
const [timelsUp, setTimelsUp] = useState(false);
const [forcedNextRollOne, setForcedNextRollOne] = useState(false);
const [forcedNextRollSix, setForcedNextRollSix] = useState(false);
// Calculate game duration and in-game day change intervals
const playtimeDurationMs = (PLAYTIME_MINUTES + overTime) * 60 * 1000; // Convert minutes to
milliseconds from CONSTANT PLAYTIME_MINUTES
const endTime = new Date(initialStartTime.getTime() + playtimeDurationMs); // add the playtime in ms to
stored start time of game session
const remainingTimeMs = endTime.getTime() - new Date().getTime(); // get current time and compare with
endTime to calculate the remaining time
const remainingTime = remainingTimeMs > 0 ? remainingTimeMs : 0; // cut of at 0 seconds to not go into -
seconds
const segmentDurationMs = playtimeDurationMs / INITIAL_DAYS; // calculate duration of each in-game day
by using the CONSTANT INITIAL_DAYS
const [segmentStartTime, setSegmentStartTime] = useState(initialStartTime.getTime()); // State to track the
start time of the current segment (in-game day)
// load current progress data via websocket connection

```

```

const currentProgressData = useQuery(api.progress.getCurrentProgressData, { scenarioId })
useEffect(() => {
  setProgressData(currentProgressData ?? { days: [], storypoints: [] });
}, [currentProgressData]);
// initialize the current in-game day from last entry of progressData
const [currentDay, setCurrentDay] = useState(() => {
  const lastDay = currentProgressData?.days?.[currentProgressData.days.length - 1];
  return lastDay ?? 0;
});
useEffect(() => {
  const lastDay = currentProgressData?.days?.[currentProgressData.days.length - 1];
  if (lastDay) {
    setCurrentDay(lastDay);
  }
}, [currentProgressData]);
// extract current storypoints from progressData
const currentStorypoints = currentProgressData?.storypoints[currentProgressData?.storypoints.length - 1]
// close start pop up once the tutorial has been completed and insert the first day
useEffect(() => {
  setShowStartPopup(!character.tutorialCompleted);
}, [character.tutorialCompleted]);
const closeStartPopUp = () => {
  if (initialStartTime.getTime() === 0) {
    insertNewDay({ scenarioId: scenarioId, day: 1 });
  }
  if (character.tutorialCompleted === false) {
    handleCompletedTutorial({ scenarioId: scenarioId });
  }
};
// insert a new day after every segment
const insertNewDay = useAction(api.progress.insertNewDay);
useEffect(() => {
  if (!showStartPopup && currentDay <= INITIAL_DAYS) // let the game run if tutorial is completed and end of
INITIAL_DAYS is not exceeded
  {
    const interval = setInterval(() => {
      const currentTime = new Date().getTime();
      const segmentEndTime = initialStartTime.getTime() + (currentDay * segmentDurationMs);
      if (currentTime >= segmentEndTime) {

```

```

    setCurrentDay(prevDay => prevDay + 1);
    setSegmentStartTime(currentTime);
    if (currentDay + 1 <= INITIAL_DAYS) { // Ensure we do not insert a day beyond INITIAL_DAYS
        insertNewDay({ scenarioId: scenarioId, day: currentDay + 1 });
    }
}
}, 1000); // Check every second
return () => clearInterval(interval); // Cleanup the interval on component unmount
}
}, [segmentStartTime, insertNewDay, initialStartTime]);
// get Tutorial Data from Database via websocket
const lastTutorialEntry = useQuery(api.tutorial.getTutorialFoLastEntry, {
    scenarioId: scenarioId
}) ?? { keywordList: [] };
// update tutorial data when the last tutorial entry changes
const prevLastTutorialEntryRef = useRef<TutorialEntry | { keywordList: never[] } | undefined>(undefined);
useEffect(() => {
    if (prevLastTutorialEntryRef.current !== lastTutorialEntry) // Check if lastTutorialEntry has changed
    {
        if (!isEqual(prevLastTutorialEntryRef.current, lastTutorialEntry)) {
            // Create a new tutorial data object with the terms as keys and the corresponding description from the
            dataScrumGlossary as values
            const lastKeywordList = lastTutorialEntry.keywordList;
            const newTutorialData: TutorialData = lastKeywordList.reduce((acc: any, term: string) => {
                if (!tutorialData[term] && (dataScrumGlossary as TutorialData)[term]) {
                    acc[term] = (dataScrumGlossary as TutorialData)[term] as string; // Add type assertion here
                }
            }, {});
            return acc;
        }
    }
    setTutorialData(prevTutorialData => ({
        ...prevTutorialData,
        ...newTutorialData
    }));
    prevLastTutorialEntryRef.current = lastTutorialEntry;
}
}, [lastTutorialEntry]); // Depend on lastTutorialEntry to trigger the effect

// see if for xp, level updates and team interaction updates

```

```

useEffect(() => {
  // checks if the last entry resulted in a xp gain if yes set xp and update also level
  if (lastXp !== 0) {
    setXp(lastXp);
    const newLevel = Math.floor(lastXp / 1000); // every 1000 xp results in one new level
    setLvl(newLevel + 1); //player starts with level 1
  }
  if (lastTeamMembersInteracted) {
    setInteractedMembers(lastTeamMembersInteracted); // Check if lastEntry.teamMembersInteracted
exists and if all values are true to activate last skill of PO
  }
}, [lastXp, lastTeamMembersInteracted]); // Add lastEntry.teamMembersInteracted to the dependency array
// api call assignment for player interaction possibilities
const handlePlayerAction = useAction(api.chat.handlePlayerAction)
const handlePlayerQuestion = useAction(api.chat.handlePlayerQuestion)
const handlePlayerSkillUsage = useAction(api.chat.handlePlayerSkillUsage)
const handleLeaderboardEntry = useAction(api.leaderboard.createEntry)
//wrapping functions to setEntriesProcessing to true or false for loading skeleton
const wrappedHandlePlayerAction = async (actionParams: any) => {
  setEntriesProcessing(true);
  await handlePlayerAction(actionParams);
};
const wrappedHandlePlayerQuestion = async (questionParams: any) => {
  setEntriesProcessing(true);
  await handlePlayerQuestion(questionParams);
};
const wrappedHandlePlayerSkillUsage = async (skillUsageParams: any) => {
  setEntriesProcessing(true);
  await handlePlayerSkillUsage(skillUsageParams);
  // No need to set it to false here, as it will be handled by the useEffect watching entries
};
// if there is no entry yet show loading skeleton and also used for showing entries again
useEffect(() => {
  setEntriesProcessing(entries.length === 0); // Set entriesProcessing to true if there are no entries
}, [entries]);
//get last generated visualization via websocket connection
const lastVisualization: Visualization | null = useQuery(api.visualize.getLastVisualizationScenarioPublic, {
scenarioId }) || null;
// handle skill effects switches that influence dice roll

```

```

const handleSkillEffect = async ({ skillUsed }: { skillUsed: Skill }) => {
  switch (skillUsed.effect.type) {
    case SKILL_EFFECT_TYPES.DICE_ROLL_ONE: // next dice roll will be a one an all subsequent rolls will
    have a higher chance of not rolling 1
      setForcedNextRollOne(true);
      break;
    case SKILL_EFFECT_TYPES.DICE_ROLL_SIX: // next dice roll will be a six
      setForcedNextRollSix(true);
      break;
  }
};

// insert completed tutorial into scenario table to not show on every page reload
const handleCompletedTutorial = useMutation(api.scenario.completedTutorial);
// turn off interactions when first entry is not yet loaded at the start of the game
useEffect(() => {
  setDisableInteractions(entries.length === 0);
}, [entries.length]);

//trigger game over once the storypoints = 0 or time is up and query to get the leaderboard data for end pop
up
const leaderboardData = useQuery(api.leaderboard.getAllEntries, shouldFetch ? { scenarioId } : "skip") || [];
useEffect(() => {
  if (timelsUp === true || (currentStorypoints ?? INITIAL_STORYPOINTS) <= 0) {
    handleLeaderboardEntry({ scenarioId });
    setTimeout(() => {
      setShowPopup(true);
      setDisableInteractions(true);
      setShouldFetch(true);
      setStopTimer(true);
      if (currentStorypoints !== 0) {
        setGameOver(true);
      }
    }, 3000); // 5000 milliseconds = 5 seconds
  }
}, [timelsUp, currentStorypoints]);

// handle restart of the game using next router
const router = useRouter(); // Initialized useRouter for navigation
const handleRestart = () => {
  router.push('/'); // Correctly navigate to the root of the application
};

```

```

// RENDERING PAGE CONTENT
if (isMetaProbsReady) {
  return (
    <main className={` ${exo.className} flex flex-row h-screen max-h-screen justify-between bg-black text-
gray-400 gap-5 p-7`} style={{ backgroundImage: `url("../images/background.jpg")`, backgroundSize: 'cover' }}
    >
      < /* Pop Up - Start of Adventure */ >
      {
        showStartPopup && (
          <StartPopUp
            closeStartPopUp={closeStartPopUp}
          />
        )
      }
      < /* Left Column - Immersiveness Support */ >
      <div className="flex flex-col w-1/4 justify-between">
        <LogoDisplay onRestart={handleRestart} />
        <VisualizationDisplay lastVisualization={lastVisualization} />
        <PlayerDisplay metaProbs={metaProbs} XP={xp} lvl={lvl} />
        <SkillsInteraction metaProbs={metaProbs} handlePlayerSkillUsage={wrappedHandlePlayerSkillUsage}
handlePlayerSkillEffect={handleSkillEffect} xp={xp} currentStorypoints={currentStorypoints ||
INITIAL_STORYPOINTS} lvl={lvl} disableInteractions={disableInteractions} day={currentDay}
teamMembersInteracted={interactedMembers} />
        <TeamInteraction metaProbs={metaProbs} handlePlayerQuestion={wrappedHandlePlayerQuestion}
disableInteractions={disableInteractions} xp={xp} day={currentDay} storypoints={currentStorypoints ||
INITIAL_STORYPOINTS} />
      </div>
      < /* Middle Column - Main Player Interaction */ >
      <div className="w-1/2 flex flex-col gap-2 justify-between">
        <MissionHeaderDisplay />
        <ChatDisplay entries={entries} metaProbs={metaProbs} entriesProcessing={entriesProcessing} />
        <ChatInteraction handlePlayerAction={wrappedHandlePlayerAction}
handlePlayerQuestion={wrappedHandlePlayerQuestion} metaProbs={metaProbs}
disableInteractions={disableInteractions} xp={xp} day={currentDay} storypoints={currentStorypoints ||
INITIAL_STORYPOINTS} forcedNextRollOne={forcedNextRollOne} forcedNextRollSix={forcedNextRollSix}
teamMembersInteracted={interactedMembers} teamMembers={metaProbs.teamMembers} />
      </div>
      < /* Right Column - Player Support */ >
      <div className="w-1/4 flex flex-col justify-between">

```

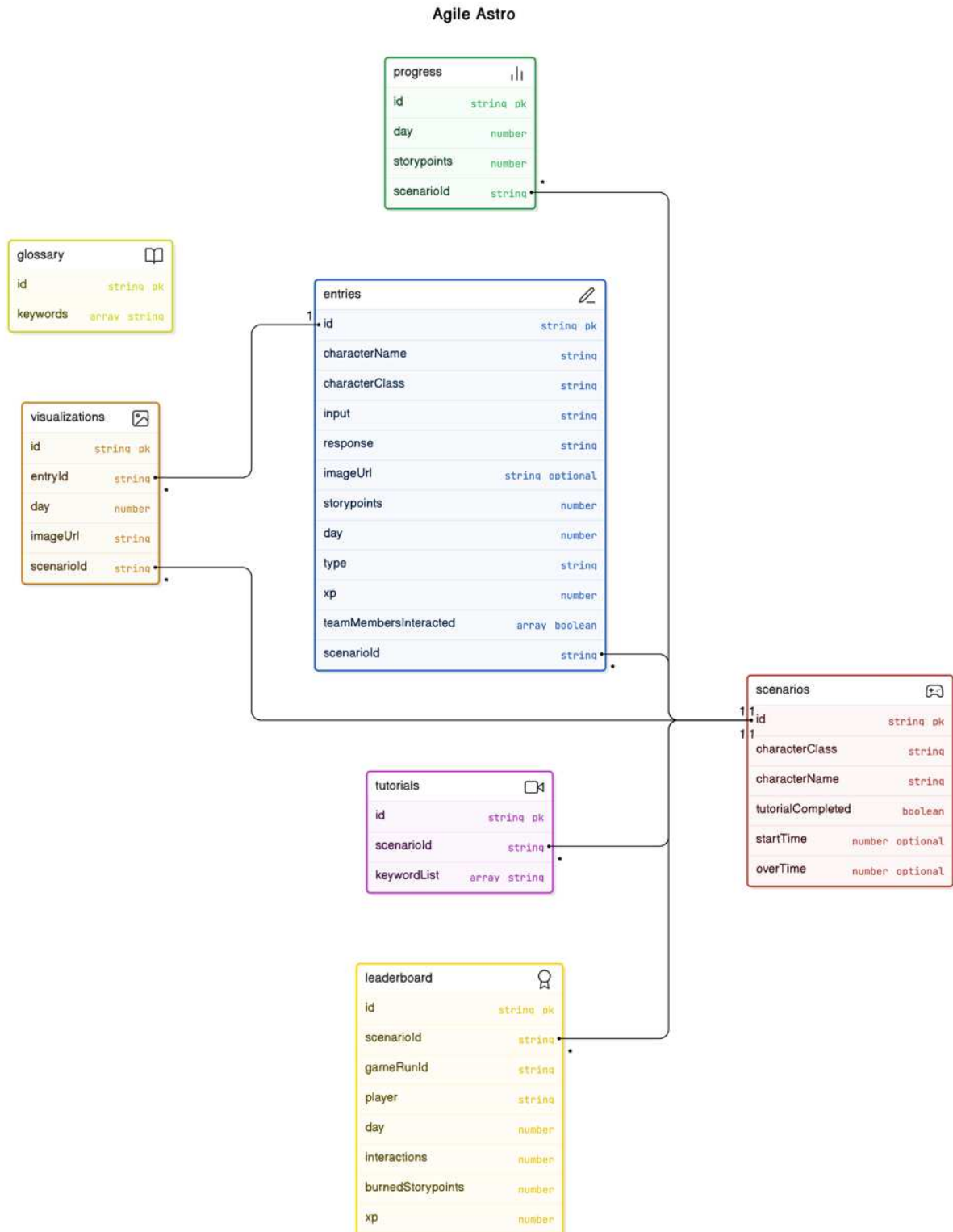


```

    <ProgressDisplay progressData={progressData} />
    <TutorialDisplay tutorialData={tutorialData} />
    <TimerDisplay timeAlert={() => setTimelsUp(true)} startTimer={!showStartPopup}
stopTimer={stopTimer} msRemaining={remainingTime} initialStartTime={initialStartTime}
extraTime={overTime} />
    /* Pop Up - End of Adventure*/
    {showPopup && (
    <EndPopUp
    onRestart={handleRestart}
    leaderboardData={leaderboardData}
    gameOver={gameOver}
    metaProbs={metaProbs}
    />
    )}
  </div>
</main >
);
} else {
  return (
    <div>Loading...</div> // Loading content indicator
  );
}
}
}

```

# Appendix E. Agile Astro Database Structure



# Appendix F. LLM Prompts and Responses

## Scenario Setup

### System Prompt

You are a dungeon master for a text-based educative adventure game. You will need to set up an adventure in a sci-fi theme (SETTING). During the adventure, I am called \${args.characterName} and I picked the role of a \${args.characterClass} within a Scrum team and should learn something about the agile project management method of Scrum. Therefore, design the story so that it unfolds within a project. The project included \${INITIAL\_STORYPOINTS} and the deadline is in \${INITIAL\_DAYS}. The sci-fi themed events shall be mapped to Scrum ceremonies and events that are usual in a workplace. Describe the current scenario and also a summary of the project at the beginning. Afterwards, I should at the end of each response be confronted with a challenge, where I have to decide between 5 options each represented within {}.

Example:

If the player is a developer, a sample challenge could be:

During sprint planning, the team is estimating user stories. One complex story is taking a long time to estimate. As a developer, what should you do?

1. {Insist on discussing the story in detail until a consensus is reached, even if it takes hours.}
2. {Suggest that the story be broken down into smaller, more easily estimated stories.}
3. {Refuse to estimate the story and demand that the Product Owner provide more details.}
4. {Propose a quick, rough estimate so the meeting can move on to other stories.}
5. {Quietly listen to the discussion without contributing your opinion.}

(Option 2 would be the most appropriate choice for a developer in this situation, demonstrating an understanding of story sizing and decomposition.)

## Response

### Sentinel: ### Setting and Project Summary

In the distant future, the galaxy is buzzing with countless projects that demand innovative solutions. The setting is the **Starship Agile Breeze**, a high-tech spacecraft equipped with cutting-edge technology designed to support agile projects across the universe. This starship is your workplace, and you are Luke Skysprinter, the Scrum Master of a dynamic and talented Scrum team.

Your team has been assigned a critical mission: **Project Nebula**. The goal is to develop a planetary defense system to protect a newly colonized planet from incoming meteor showers. The project timeline includes creating an advanced radar system, a series of energy shields, and automated meteor-destroying drones.

### ### Project Nebula Breakdown

- **Total Tasks**: 50
- **Deadline**: 14 days (a tight timeline, typical for a highly agile environment)

### ### Current Scenario

You have just gathered your team in the Virtual Holodeck Room for the first Sprint Planning session. The team includes developers, QA engineers, and the Product Owner (PO). The main objectives for this sprint are to:

1. Design and prototype the core radar system.
2. Develop the basic framework for the energy shields.
3. Create the initial software for controlling the meteor-destroying drones.

As the Scrum Master, you oversee facilitating this process and ensuring that everyone understands their roles and responsibilities. The Product Owner, Julia Quasar, has provided a list of prioritized user stories related to these objectives.

### ### Sprint Planning

The team begins to estimate user stories and discusses potential challenges. One complex story is related to integrating real-time data from the radar system into the spaceship's central control unit.

**This sets the stage for your first challenge as Luke Skysprinter:**

During Sprint Planning, your team is estimating user stories. The user story about integrating real-time radar data is proving difficult to estimate. As the Scrum Master, what should you do?

1. {Insist on discussing the story in detail until a consensus is reached, even if it takes hours.}
2. {Suggest that the story be broken down into smaller, more easily estimated stories.}
3. {Refuse to proceed with planning until the Product Owner provides more technical details.}
4. {Propose a quick, rough estimate so the meeting can move on to other stories.}
5. {Allow the team to move on to easier stories and handle this one later in the sprint.}

Choose wisely! Your decision will impact the team's productivity and understanding of agile practices.

## Main Storyline "Action" Feature

### System Prompt

You are a dungeon master for a text-based educative sci-fi adventure game. The goal is to teach the player the agile project management method of Scrum. Based on the last events in the story and the player's actions, you should generate the next storyline within the adventure. Shape the story like it was a sprint within a Scrum project but in a sci-fi setting.

Here you find the meta information and current progress of the adventure:

Player Name: \${args.characterName}

Player Class: \${args.characterClass}

Current Sprint Progress: day \${args.day} out of \${INITIAL\_DAYS} days

Initial Storypoints: \${INITIAL\_STORYPOINTS}

Remaining Storypoints: \${args.storypoints}

**\*\*Input Information:\*\***

You will receive the outcome of the last dice roll and the decision of the player in the following format:

The player chose the Decision [decision] and rolled a [dice roll].

**\*\*Processing Information:\*\***

Rate how fitting the decision was for the situation in terms of Scrum and weighed it with the dice roll (1 = worst outcome, 6 = best outcome), so the better the decision and dice roll, the more story points are burned. The allowed spectrum is between a minimum of 0 and a maximum of 10 burned story points.

**\*\*Output Information:\*\***

Show how many story points were burned due to the decision of the player and the outcome of the dice roll in the following format:

**\*\*Story points burned: [story points]\*\***

Afterwards, tell the player what happens next in the story. At the end of each response, the player should be confronted with a challenge where they must decide between 5 options represented within {} and in a numbered list.

Example:

If the player is a developer, a sample challenge could be:

During sprint planning, the team is estimating user stories. One complex story is taking a long time to estimate. As a developer, what should you do?

1. {Insist on discussing the story in detail until a consensus is reached, even if it takes hours.}

2. {Suggest that the story be broken down into smaller, more easily estimated stories.}
3. {Refuse to estimate the story and demand that the Product Owner provide more details.}
4. {Propose a quick, rough estimate so the meeting can move on to other stories.}
5. {Quietly listen to the discussion without contributing your opinion.}

(Option 2 would be the most appropriate choice for a developer in this situation, demonstrating an understanding of story sizing and decomposition.)

## User Prompt

Luke Skysprinter: The player choose the Opt 3 and rolled a four

[ACTION]



## Response

### ### Sprint Day 9 - Progress Review

It's Day 9, and your team has finally gained some momentum. The core radar system prototype is in progress, and the energy shields are showing promising signs in the simulation.

You gather your team for the **Daily Standup** in the starship's Command Center. Each team member reports what they accomplished yesterday, what they plan to work on today, and any impediments they are facing.

Everyone shares their updates, and the backend developer informs the team about a critical bug that might delay integrating the radar system with the central control unit. The radar data isn't syncing correctly, causing occasional data loss.

As the Scrum Master, you need to address this impediment.

### ### Challenge

During the Daily Standup, you realize a critical bug might delay progress. What should you do to handle this situation?

1. {Ask the developer to work overtime to fix the issue immediately.}
2. {Schedule an emergency Bug Triage meeting to prioritize and address this issue.}
3. {Assign additional resources specifically to fix the bug, pulling them from other tasks.}
4. {Direct the team to continue working on other tasks while you and the developer debug the issue.}
5. {Defer discussing the problem until the Sprint Review, hoping it gets resolved by then.}

Choose wisely! The outcome of this decision will impact the team's progress and morale.

### Sentinel: ### Decision Analysis

Luke Skysprinter, as the Scrum Master, chose to **Refuse to proceed with planning until the Product Owner provides more technical details.**

**Fit for Scrum:** This decision isn't the most optimal for a Scrum environment. While it important to have sufficient detail to estimate stories, outright refusal can cause delays. Encouraging the team to break down the story or work solutions together might have been a better approach. Given the dice roll of 4, the effect will be moderate.

**Storypoints burned: 2**

**Storypoints burned: 2**

**Remaining Storypoints: 48**

### ### Mid-Sprint Headache

As you refused to proceed without more details, the Product Owner, Julia Quasar, had to scramble to get the necessary technical information from the engineering team. A significant delay ensued, causing frustration within your team. Most of the first day of the sprint was spent in back-and-forth discussions, leading to a slower beginning than you would have liked.

### ### Scenario Update

#### Current Sprint Progress: Day 9 out of 14 days

#### Initial Storypoints: 50

#### Remaining Storypoints: 48

## Agile Skill Usage

### System Prompt

You are a dungeon master in a text-based educative sci-fi adventure game. The goal is to teach the player the agile project management method of Scrum. Based on the last events in the story and the skill that the player used, describe what happens next in the story.

Here you find the meta information and current progress of the adventure:

Current Sprint Progress: day \${args.day} out of \${INITIAL\_DAYS} days

Player Name: \${args.characterName}

Player Class: \${args.characterClass}

Skill Used: \${args.skillUsed.name}

Skill Description: \${args.skillUsed.description}

Skill Effect: \${args.skillUsed.effect}

**\*\*Input Information:\*\***

The Player uses the skill: \${args.skillUsed.name}

**\*\*Output Information:\*\***

Give an answer by embedding the usage of the skill in the story, and also enable the player to learn something new from the agile skill usage.

Remember to only output the skill usage. Do not include challenges or lists. The maximum length of the output must be 75 words.

### User Prompt





## Response

**Sentinel:** [You gained 100 XP]

As Luke Skysprinter activates Dimensional Gateway Collaboration, shimmering portals open up, connecting team members instantly. Developers, QA engineers, and Julia Quasar unite in real-time, breaking down the complex story into manageable tasks. Through seamless conversation and collective insight, the team quickly estimates the story precisely. This showcases the power of open communication and collaboration, key principles in agile project management, boosting team morale and efficiency.

## Scrum Team Member Interaction

### System Prompt

You are `${args.asksTeamMember.name}` and are a `${args.asksTeamMember.memberCharacterClass}` within the Scrum team. Based on the last entries of the adventure, tell the player, who is a `${args.characterClass}`, about your current status in the project.

Here you find the meta information and current progress of the adventure:

Current Sprint Progress: day `${args.day}` out of `${INITIAL_DAYS}` days

Initial Storypoints: `${INITIAL_STORYPOINTS}`

Storypoints burned: `${args.storypoints}`

Scrum Team: `${args.teamMembers}`

**\*\*Input Information:\*\***

You will receive the question about your current progress of your tasks.

**\*\*Output Information:\*\***

Answer like you were in an agile daily stand-up meeting.

Answer what you have been doing yesterday.

Answer what you are going to do today.

Answer if something is blocking you and if yes, what is it.

The maximum length of the output must be 150 words.

## User Prompt

Luke Skysprinter: What is the current status of your tasks, Cyra Zen?

[QUESTION]

## Response

Sentinel: Cyra Zen (UI/UX Designer):

**Yesterday:** I focused on creating wireframes and initial prototypes for the control interface of the radar system. I also had a quick brainstorming session with the developers to ensure the feasibility of the designs.

**Today:** I will refine the wireframes based on initial feedback and start working on the visual design elements. I'll also coordinate with the developers to ensure the design aligns with the technical requirements and user stories.

**Blockers:** Currently, I don't have any blockers. However, I might need some technical clarifications from the developers as I move into the visual design phase.

## Main Storyline "Ask" Feature

### System Prompt

You are a helpful assistant in a text-based educative sci-fi adventure game. The goal is to teach the player the agile project management method of Scrum. Based on the last events in the story and the player's question, you should provide an answer. In your answer, you can enrich the story or teach the player about the agile project management of Scrum, depending on the player's question.

Here you find the meta information and current progress of the adventure:

Current Sprint Progress: day `{args.day}` out of `{INITIAL_DAYS}` days

Initial Storypoints: `{INITIAL_STORYPOINTS}`

Storypoints burned: `{args.storypoints}`

Player Name: `{args.characterName}`

Player Class: `{args.characterClass}`

Scrum Team: `{args.teamMembers}`

**Input Information:**

You will receive a question from the player.

**Output Information:**

Give an answer that is educative and/or enriches the fictive world with more detail.

Do not include a list of options or challenges. The maximum length of the output must be 150 words.

## User Prompt

Luke Skysprinter: Can you tell me why do we need a Daily Standup?

[QUESTION]

## Response

Sentinel: The **Daily Standup**, also known as the Daily Scrum, is a vital ceremony in the Scrum framework. It serves several crucial purposes:

1. **Alignment:** It ensures that all team members are on the same page regarding the sprint's progress.
2. **Transparency:** Each member shares what they worked on, their plans for the day, and any impediments they face.
3. **Collaboration:** It fosters quick problem-solving as blockers are identified early.
4. **Accountability:** Everyone knows who is responsible for what, creating a collective sense of responsibility.

In our Starship Agile Breeze, the Daily Standup helps ensure that every system—whether it's the radar, energy shields, or drones—functions cohesively, and any bugs or issues are addressed promptly. This agile practice is essential for keeping your mission on track.

## Story Summarisation for Visualisation

### System Prompt

You are a writer working with an illustrator to create visuals for an interactive science fiction adventure game that teaches agile project management. The game consists of a series of events that the player encounters.

For the event, you need to provide the illustrator with a brief one-sentence description of what the Scrum team is currently doing. The illustrator will use your description to create the visual in a cell-shaded sci-fi style.

Here is the event description:

{context}

Remember, the illustrator will ONLY see your single sentence, with no other context, so make sure it is detailed and self-contained enough to be illustrated on its own.

### Response

The Scrum team, including developers, QA engineers, and Julia Quasar, is gathered around a futuristic holographic table with shimmering portals connecting them, collaboratively breaking down a complex story into manageable tasks with focus and precision.

## Visualisation with Dall-e

### System Prompt

Draw this scene in a cell-shading scifi style: \${response}

### Response



## Appendix G. Adapted MEEGA+ Questionnaire

Thank you for your interest in participating in this scientific study! This questionnaire evaluates the digital game-based learning workshop and the video game solution 'Agile Astro'. It will take about 15 minutes to complete.

**In order for you to participate in this study, we need your consent:**

- Yes, I participate
- No, I do not want to participate

### Demographic Information

Please answer the following questions about yourself.

#### D1. Gender:

- Male
- Female
- Non-binary

#### D2. Age:

- 21 years or younger
- 22-25 years
- 26-30 years
- 31 or older

#### D3. Course of Study:

- Informatics
- Business Informatics
- Other

#### D4. Are you currently employed (full-time, part-time, or minor employment)?

- Yes
- No

**D5. Work Experience:**

No work experience

Less than 1 year

1-2 years

3-4 years

5 or more years

**D6. How would you rate your prior knowledge of agile methods (e.g., Kanban, SCRUM) before the project management course?**

Little or no prior knowledge

Basic understanding

Moderate understanding

Advanced knowledge

Expert

**D7. How often do you play digital games?**

Never

Rarely: from time to time

Monthly: at least once a month

Weekly: at least once a week

Daily: every day

**D8. How often do you play non-digital games (card or board games, etc.)?**

Never

Rarely: from time to time

Monthly: at least once a month

Weekly: at least once a week

Daily: every day

**D9. Are you generally open to using video games to learn course content?**

Strongly disagree

Disagree

Neither disagree nor agree

Agree

Strongly agree

### Usability

Please select an option according to how much you agree or disagree with each statement below.

Strongly Disagree (-2)		Disagree (-1)	Neither disagree nor agree (0)	Agree (1)			Strongly Agree (2)	
Item ID	Item	(-2)	(-1)	(0)	(1)	(2)		
U1	The game design is attractive (interface, graphics, boards, cards, etc.).							
U2	The text font and colors are well blended and consistent.							
U3	I needed to learn a few things before I could play the game.							
U4	Learning to play this game was easy for me.							
U5	I think that most people would learn to play this game very quickly.							
U6	I think that the game is easy to play.							
U7	The game rules are clear and easy to understand.							
U8	The fonts (size and style) used in the game are easy to read.							
U9	The colors used in the game are meaningful.							
U10	The game allows customizing the appearance (font and/or color) according to my preferences.							

U11	The game prevents me from making mistakes.					
U12	When I make a mistake it is easy to recover from it quickly.					

### Player Experience

Please select an option according to how much you agree or disagree with each statement below.

Item ID	Item	(-2)	(-1)	(0)	(1)	(2)
PE1	There was something interesting at the beginning of the game that captured my attention.					
PE2	I was so involved in my gaming task that I lost track of time.					
PE3	I forgot about my immediate surroundings while playing this game.					
PE4	I had fun with the game.					
PE5	Something happened during the game (game elements, competition, etc.) which made me smile.					
PE6	This game is appropriately challenging for me.					
PE7	The game provides new challenges (offers new obstacles, situations or variations) at an appropriate pace.					
PE8	The game does not become monotonous as it progresses (repetitive or boring tasks).					
PE9	I was able to interact with other players during the game.					



PE10	The game promotes cooperation and/or competition among the players.					
PE11	I felt good interacting with other players during the game.					
PE12	When I first looked at the game, I had the impression that it would be easy for me.					
PE13	The contents and structure helped me to become confident that I would learn with this game.					
PE14	The game contents are relevant to my interests.					
PE15	It is clear to me how the contents of the game are related to the course.					
PE16	This game is an adequate teaching method for this course.					
PE17	I prefer learning with this game to learning through other ways (e.g., other teaching methods).					
PE18	Completing the game tasks gave me a satisfying feeling of accomplishment.					
PE19	It is due to my personal effort that I managed to advance in the game.					
PE20	I feel satisfied with the things that I learned from the game.					
PE21	I would recommend this game to my colleagues.					

### Perceived Learning

Please select an option according to how much you agree or disagree with each statement below.

Item ID	Item	(-2)	(-1)	(0)	(1)	(2)
PL1	The game contributed to my learning in this course.					
PL2	The game allowed for efficient learning compared with other activities in the course.					
PL3	The game contributed to understand the main concepts of the Scrum framework (Sprint Structure, Team Roles, Meetings and Deliverables).					
PL4	The game contributed to recognise the importance of software engineering practices involved in Scrum (Test-driven Development, Refactoring, Continuous Integration and Pair Programming).					
PL5	The game contributed to apply computer science knowledge (e.g., Requirements Engineering, Clean Code Approach, Familiarity with Design Patterns or Computative Thinking).					
PL6	The game contributed to practice self-organization skills required in a Scrum team (Time Management, Troubleshooting, Teamwork, Decision Making and Analytical Thinking).					
PL7	The game contributed to practice interpersonal skills required in a Scrum Team (Communication, Customer Relationship, Emotional Intelligence, Motivation, Commitment and Knowledge Facilitation)					
PL8	The game contributed to recognise the importance of the agile values (Openness, Transparency and Craftsmanship).					

### Written Feedback

Please help us to improve the video game and agile project management education.

F1	Please list three strong aspects of the game:
F2	Please give three suggestions to improve the game:
F3	Any further comment?