Tampere University

ANH CHU

GAMIFICATION IN SOFTWARE EDUCATION: A SYSTEMATIC LITERATURE REVIEW

Bachelor's Science and Engineering Thesis

Bachelor's thesis
Faculty of Information Technology and Communication Sciences
Supervisor: Prof. Juho Hamari
April 2023

ABSTRACT

Anh Chu: Gamification in Software Education: A Systematic Literature Review
Bachelor of Science and Engineering Thesis
Tampere University
International Bachelor Programme in Science and Engineering
April 2023

Context: Gamification is now used widely in education in order to improve students' engagement, performance, satisfaction, and motivation. There contains various types of research on how to apply gamification in software education and how it affects the student

Objective: This paper will carry out a systematic literature review method to give an overall picture of the current state of gamification in software education.

Method: We conduct the review by identifying the search string and screening out the irrelevant studies by 4 research questions: How do they define gamification, in which software education context, which game elements, and what are the effects?

Results: We found 28 primary studies between 2020 to 2023. Software engineer and computer science are the most popular field in software education. They also use multiple common game elements and have positive results for students.

Conclusions: The existing research in the field shows a highly positive result in student engagement and motivation. Future research could also focus more on the performance effect and focus on other software education domains.

Keywords: Gamification, software education, software engineer, motivation, systematic literature review

PREFACE

I would like to express my gratitude to Professor Juho Hamari for supervising me through the process and teaching me how to conduct literature review research.

Tampere, 11th April 2022

Anh Chu

CONTENT

LIST OF TABLES

1. INTRODUCTION

Motivation is an important aspect of human that affect engagement and performance in Software Engineering [1][2]. It is emphasized to have the biggest impact on the productivity of students. There are various methods and techniques have been studied and applied to enhance motivation in education. One of the strategies is known as gamification, which as the name suggests, uses a set of game techniques to make activities more interesting and appealing or turn activities into “game-like” [3].

In the early 2010s, the gamification concept became popular and has been applied in various domains. It has multiple definitions and is mainly defined by Deterding et al. [4] as “the use of game design elements in non-game contexts”, while Hamari and Sarsa [5] define it as “the concept of applying game-design thinking through the use of game mechanics to drive game-like player behavior to non-game applications”. Moreover, Werbach [3] understands gamification as close to a serious game and more of turning activities into a game. On a similar note, gamification can also be defined as “a process of enhancing a service with affordances for gameful experiences in order to support user’s overall value creation” by Huotari and Hamari [6].

Gamification has been applied in many different domains in the last years such as health and wellbeing [7], brand [8], management [9], transportation [10], and sustainability [11]. Gamification is also a crucial part of designing mobile apps for smartphones and tablets in order to achieve more user satisfaction. Some companies also try to improve the customer experience of their website through the use of gamification [12]. It has also been applied in some corporations to improve the results of employees’ performance of their daily tasks and work [13]. But the most potential domain is that gamification will be used in education and training where students can be more engaged and excited with the lessons [14][15].

This short paper will focus on how gamification has been clarified and used in software education, and what is its effect on the student. Its application deserves more attention and promises to help improve the daily engagement and motivation of software students in their courses. The method will be carried out as a systematic literature review. The following sections are structured as such: Section 2 presents the related work. Section 3 shows how systematic literature was planned. Section 4 we analyze the results we obtained during the search and answer the research questions. Section 5 will discuss the obtained result and shows the limitation of this method. And finally, conclusions of the papers and future research suggestions will be in section 6.

2. RELATED WORK

In recent years, there are many studies about gamification in software development using a systematic literature review. For instance, Barreto and França [16] pulled out systematic literature research combined with an Ad-hoc review and gained positive overall results. After reviewing 130 studies, the result describes that gamification is expected to produce both positive results and little negative impact in both behavioral and technical dimensions. The studies show the potential of gamification in software development and need more sophisticated views on this field. Other papers studied by Oscar [17] also support that there is a lack of studies about this research subject and the result is very preliminary or even immature. The lack of user profile analysis, appropriate design methods, and too simple gamification schemas make it below expectations. “More than 38% of the studies only consider the simplest gamification element, namely rewarding user’s behaviors with points, which could be called “pontification”, instead of gamification”, Oscar stated [17]. Furthermore, Xu [18] conducts literature research about how gamification is used in web applications. He concludes that the application still uses relatively superficial game mechanics such as points, levels, leaderboards, and badges. As a future direction for research, Oscar [17] and Xu [18] highlight it would be significant to use more different mechanics and tools to measure engagement metrics and behavior analytics.

From an education perspective, gamification is also implemented in Moodle platform which provides some story-based, narrative courses towards a fully gamified course or app such as Duolingo [19]. The experienced report also stated that there are difficulties in establishing game elements in university settings, besides some difficulties, they could implement good gamification in the lessons with the aim to motivate the students. In addition, Valéria conducted an experience report on gamification in remote teaching software engineering courses during the COVID-19 pandemic. The results show that students in both Software Engineering (SE) and Fundamentals of Programming (FP) engaged in the gamified teaching methodology since most of them like to play video games and RPGs. The advantage of gamified remote teaching is nowadays every student has access to the Internet which allowed them to follow gamification remotely. It also presented that some students are not interested in gamification activities or don’t know how to play games. Therefore, in this paper, we will conduct literature research on how education applies gamification and how do they affect the students.

3. PLANNING OF THE SYSTEMATIC LITERATURE

From the related papers, we need to do further research to characterize the state of gamification now in software education which forms a big question “What is the state of Gamification applied to Software Education now?”.

To execute the systematic literature, we followed “Guidance on Conducting a Systematic Literature Review” by Yu and Maria [21] and some recommendations in [22][25]. The steps for planning included: research questions, data sources and search strategies, and quality assessment.

3.1 Research methods and questions

The aim of the research questions are established is to provide a general insight into relevant factors of the existing studies in gamification applied to software education. These questions include how other proposals define the topic, which game mechanics they apply, and in which software context. We also want to analyze how they affect on students in general, positive or negative. The literature review questions are presented in Table 1.

Num.	Research question
RQ1	How do literature studies in Software Education define gamification?
RQ2	Which Software Education field is gamification being applied to?
RQ3	Which game elements or game mechanics are used in Software Education?
RQ4	What are the effects on students gamification achieved?

Table 1: Literature review research questions

3.2 Data sources and search strategy

The search string we built has 2 major focuses: “Gamification” and “Software Education”. The second major term will be refined into the string with multiple software development processes. We construct the search string by following the steps in [23][24]. The Boolean OR is used to represent alternative terms, synonyms, or related terms, Boolean And is inserted to link to two major terms, and Symbol * indicated all the relations to the major term. The search string in the Scopus database: TITLE-ABS-KEY (gamif*) AND (TITLE-ABS-KEY (software AND engineering) OR TITLE-ABS-KEY (software AND testing) OR TITLE-ABS-KEY (software AND design) OR TITLE-ABS-KEY (software AND process) OR TITLE-ABS-KEY (software AND

requirements) OR TITLE-ABS-KEY (software AND implementation) OR TITLE-ABS-KEY (software AND configuration) OR TITLE-ABS-KEY (software AND construction) OR TITLE-ABS-KEY (software AND integration) OR TITLE-ABS-KEY (software AND framework) OR TITLE-ABS-KEY (software AND maintenance) OR TITLE-ABS-KEY (software AND verification) OR TITLE-ABS-KEY (software AND validation) OR TITLE-ABS-KEY (project AND management) OR TITLE-ABS-KEY (project AND planning) OR TITLE-ABS-KEY (project AND assessment)). The search string can be simplified in table 2 below.

Major terms	**Alternative terms**
Gamification	gamif* AND
Software Education	((software engineering) OR (software testing) OR (software design) OR (software process) OR (software requirement) OR (software implementation) OR (software configuration) OR (software construction) OR (software integration) OR (software framework) OR (software maintenance) OR (software verification) OR (software validation) OR (project management) OR (project planning) OR (project assessment))

Table 2: Search string

The main academic database we use for searching is Scopus, and the search strategy is presented in Table 3.

Search Strategy	
Academic databases searched	- Scopus - Science@Direct (subject Computer Science) - IEEExplore - ACM Digital Library - Springer
Other data sources	- Google
Target items	- Journal papers - Workshop papers - Conference papers - Industry/Professional workshop contributions - Industry/Professional conference contributions - Non-academic online publication
Search applied to	- Title - Abstract - Keywords
Language	- Papers written in English
Publication period	- From 2020 to April 2023

Table 3: Search strategy

With the help of Scopus, we can directly check the publisher site such as Science@Direct, IEEExplore, and ACM Digital Library. We aim for professionals paper or forums such as conferences and workshops. The search string was also modified multiple times in the pre-search stage in order to give the most accurate results.

3.3 Quality assessment

The expected search results will be large, therefore, the inclusion and exclusion criteria are created to assess the quality of searched studies. The inclusion/exclusion criteria are presented in table 4 below:

Inclusion/Exclusion criteria	
Inclusion criteria	- Terms fulfill the search string - Academic journal, conference, and workshop papers - Contributions to industry/professional conferences, workshops, and online publications - Papers written in English - Publication date: From 2020 to 2023
Exclusion criteria for titles and abstract	- Papers which do not focus on either gamification and software education - Papers available only in the form of abstracts or PowerPoint presentations - Personal blogs or web pages - Product brochures
Exclusion criteria for full text	- Papers presenting a summary of a workshop

Table 4: Inclusion/Exclusion criteria

In this search stage, we first needed to record all the titles, abstracts, and keywords for the search using the inclusion criteria. After having a list of studies, exclusion criteria will first be applied for titles and abstracts to screen out most of the irrelevant research. Finally, after careful screening, reading the full text to analyze the data, and possibly some of them presented a summary of the workshop or inaccessible.

4. RESULTS

With all the planning for systematic literature research, this part will show the result of the search and how they reflect the research questions.

4.1 Results of the search

In the searching stage, we applied 7 steps which are presented in Table 5 below:

Step	Description	Deleted	Total
Step 0	Literature search	+818	818
Step 1	Duplicated manuscripts	-15	803
Step 2	Lack of relation to either gamification or software development	-266	537
Step 3	Only related to gamification and lack of software development	-272	265
Step 4	Only related to software development and lack of gamification	-160	105
Step 5	Related to gamification and software development but lack of education	-60	45
Step 6	Inaccessible	-17	28

Table 5: Literature search

The literature search found a total of 818 studies, which is a large number and will be screened step by step. Step 2 indicates the studies don't relate or lack relation to gamification or software development even though they fulfill the search string. Step 3 concerns the lack of software field in the studies, for example, "A framework of gamified learning design targeting behavior change and design of a gamificated time management training manual" by Chen [26], which relate to gamification but focus on time management. Lack of gamification is step 4 and it is easily misunderstood as a serious game or VR, AR, and AI will be gamification. As defined before in Section 1, Gamification is more of applying game elements to non-game applications, not actually creating a serious game [4]. For instance, "Lego Serious Pay in Software Engineering Education" by Daniel [27] which build an actual game to teach software engineering so the studies are not selected. For education, we searched for teaching or education keywords, and finally, there are few inaccessible resources due to paid studies or different languages.

4.2 Research questions

4.2.1 RQ1. How do literature studies in Software Education define Gamfication?

Most studies define gamification as the application of game elements, mechanics, or techniques (67%, 19/28 studies) in a non-game context, or environment (39%, 11/28 studies) [4]. A small

number of studies also define gamification as the use of game thinking or game fulfillness [5]. The purpose of gamification is also well defined as 11 studies stated that it provides more engagement and 9 studies show that it provides more motivation. 9 researchers don't provide the definition, which assume the readers already know about it and use it directly in context. The definition can be summarized in the table below.

Definition	**Studies**	**Total**
Game elements	[A1], [A2], [A3], [A5], [A6], [A7], [A9], [A11], [A12], [A13], [A14], [A15], [A16], [A18], [A21], [A23], [A24], [A25], [A27]	19
Non-game contexts	[A1], [A2], [A3], [A6], [A13], [A14], [A15], [A16], [A18], [A21], [A24]	11
Game-thinking	[A1], [A5], [A23], [A25], [A26]	5
Engagement	[A2], [A5], [A6], [A9], [A11], [A12], [A14], [A18], [A21], [A23], [A27]	11
Motivation	[A2], [A7], [A9], [A11], [A12], [A13], [A18], [A21], [A27]	9
Not defined	[A4], [A8], [A10], [A17], [A19], [A20], [A22], [A28]	8

Table 6: Gamification definition

4.2.2 RQ2. Which Software Education field is Gamification being applied?

There are various fields in that gamification is applied but most of them all is software testing (17.8%; 5/28 studies). Since some of the studies state that software testing isn't that appealing to students compare to software design or programming. Therefore, a large amount of experience and studies implement gamification in this field. Other popular is generally such as software development (32%, 9/28 studies) and computer science or programming (17.8%; 5/28 studies).

Field	**Studies**	**Total**
Software testing	[A1], [A16], [A23], [A24], [A28]	5
Software in general	[A2], [A11], [A13], [A18], [A20], [A21], [A22], [A25], [A26]	9
Computer Science or Programming	[A3], [A6], [A9], [A14], [A17]	5
Cyber Security	[A4], [A8]	2
Software Project Management	[A5]	1
Blockchain	[A7]	1

Software Process Improvement (SPI)	[A10], [A12]	2
Software Modeling Learning	[A15]	1
Software Quality Assurance	[A19]	1
Software Measurement Process	[A27]	1

Table 7: Software field is Gamification being applied

4.2.3 RQ3. Which game elements or game mechanics are use in Software Education?

As these studies define gamification as the implementation of game elements or game mechanics, we will have a look at which game elements are used the most. Hamari et al.[5] describes some of the most used mechanics: points, leaderboards, achievements/badges, levels, story/theme, clear goals, feedback, rewards, progress, and challenge. Among those mechanics, points are the most used with 60.7% in about 17/28 studies, and achievements/badges are second with 46.4% in around 13/28 studies. Surprisingly, clear goals mechanics have the least use which only has 10.7% around 3/28 studies.

Game elements/mechanics	**Studies**	**Total**
Points	[A1], [A2], [A3], [A6], [A7], [A11], [A13], [A14], [A15]. [A17], [A19], [A23], [A24], [A25], [A26], [A27], [A28]	17
Leaderboards	[A2], [A6], [A7], [A11], [A17], [A19], [A20], [A25], [A26], [A28]	10
Achievement/Badges	[A2], [A4], [A6], [A8], [A11], [A14], [A17], [A19], [A20], [A23], [A25], [A26], [A28]	13
Levels	[A6], [A8], [A11], [A13], [A20], [A23], [A24], [A25], [A26]	9
Story/Theme	[A1], [A9], [A10], [A12], [A16], [A26], [A27], [A28]	8
Clear Goals	[A2], [A8], [A25]	3
Feedback	[A1], [A2], [A3], [A11], [A15], [A20]	6
Rewards	[A2], [A5], [A10], [A12], [A17], [A28]	6
Progress	[A1], [A6], [A10], [A11], [A12], [A15], [A17], [A20], [A24], [A25], [A26]	11
Challenges	[A1], [A2], [A9], [A11], [A13], [A15], [A17], [A22], [A26]	9

Table 8: Common game elements/ mechanics are used

Besides these common mechanics, other mechanics also have been studied in some research. These elements need more attention on them and are listed in table below.

Game elements/mechanics	**Studies**	**Total**
Avatars	[A2], [A10], [A11], [A17]	4

Power-Up	[A3], [A4]	2
Competitive/Coop	[A1], [A5], [A7], [A17], [A24]	5
Social Interaction	[A1], [A4], [A9], [A14]	4
Experience Points(XPs)	[A2], [A8], [A25]	3
Time	[A6], [A23], [A27]	3
Building from Scratch	[A11], [A13]	2
Tutorial	[A11], [A13]	2
Rockstar Effect	[A11], [A13]	2
Elitism	[A11], [A13]	2
Brilliant Choice	[A11], [A13]	2
Symbols of Conquest	[A11], [A13]	2
Mysteries box	[A11], [A13]	2

Table 9: Uncommon game elements/mechanics are used

Software process improvement (SPI) researches used the same elements which are building from scratch, tutorial, Rockstar effect, and more. One of the studies doesn't offer any element or mechanics.

4.2.4 RQ4. What are the effect on student Gamfication achieved?

With the help of [A18], we evaluate the effect of Gamification on students into 4 main categories: engagement, performance, satisfaction, and motivation. Moreover, don't have an effect and negative feedback also be included.

Effect	Studies	Total
Engagement	[A1], [A3], [A4], [A6], [A9], [A10], [A16], [A17], [A18], [A21], [A22], [A23], [A24], [A26]	14
Performance	[A1], [A3], [A7], [A10], [A12], [A18], [A21], [A24], [A28]	9
Satisfaction	[A3], [A8], [A13], [A15], [A18], [A20], [A21], [A28]	8
Motivation	[A5], [A6], [A8], [A9], [A10], [A11], [A12], [A13], [A14], [A18], [A19], [A21], [A22], [A24], [A25]	15
No effect	[A9], [A27]	2
Negative effect	[A2]	1

Table 10: Effect on student Gamification achieved

Engagement (50%; 14/28) and satisfaction (53,57%; 15/28) have the highest rates, and no effect and negative effect have the lowest with only 1 study containing negative effect.

5. DISCUSSION AND LIMITATIONS

From the data analysis, most studies research carefully the definition of gamification, and have a clear vision of how to apply it to the software education field. After reviewing carefully 28 texts, gamification has a highly positive effect on software education and lots of papers recommend further research on this topic. Common game elements such as points, badges, and progress bars have been used the most and have been proven to be effective. By implementing these techniques in education, students are more encouraged and interested in the topic. As expected, the engagement and motivation results are high as it reflects some of the definition of the effect of gamification.

This research contains a small number of review studies that still have some limitations. Some of the studies couldn’t be accessed, and some of them don’t use experimental or empirical results. This paper's purpose is to provide a general state of gamification in software education which also needs to further research in more specific fields.

6. CONCLUSION AND FUTURE WORK

Overall, most studies show that they understand the theory of gamification and are able to conduct an experience on this topic. The results have some positive effects on students' engagement and motivation.

Even though this systematic literature review shows a highly positive result. There is still more potential in these Software Education fields. For instance, the gamification method only applies to software in general and computer science but does not focus on other main software process domains. In addition, there are multiple effective game mechanics that haven't been indicated much in Table 9 which have lots of potentials.

In future research, we suggest researching other software education domains or using other game mechanics. One more aspect which also needs attention is the performance of gamification effect on students is still low. We suggest conducting an experiment on the relation between game elements and students' performance in software education.

APPENDIX A

[A1] Raquel Blanco, Manuel Trinidad, María José Suárez-Cabal, Alejandro Calderón, Mercedes Ruiz, Javier Tuya, Can gamification help in software testing education? Findings from an empirical study, Journal of Systems and Software, Volume 200, 2023, 111647, ISSN 0164-1212, https://doi.org/10.1016/j.jss.2023.111647.

[A2] Cláuvin Almeida, Marcos Kalinowski, Anderson Uchôa, Bruno Feijó, Negative effects of gamification in education software: Systematic mapping and practitioner perceptions, Information and Software Technology, Volume 156, 2023, 107142, ISSN 0950-5849, https://doi.org/10.1016/j.infsof.2022.107142.

[A3] Grey, S.; Gordon, N.A. Motivating Students to Learn How to Write Code Using a Gamified Programming Tutor. Educ. Sci. 2023,13, 230. https://doi.org/10.3390/educsci13030230

[A4] Casimer DeCusatis, Erin Alvarico, and Omar Dirahoui. 2022. Gamification of cybersecurity training. In Proceedings of the 1st International Workshop on Gamification of Software Development, Verification, and Validation (Gamify 2022). Association for Computing Machinery, New York, NY, USA, 10–13. https://doi.org/10.1145/3548771.3561409

[A5] Dan Mircea Suciu. 2022. Implementing microlearning and gamification techniques in teaching software project management concepts. In Proceedings of the 4th International Workshop on Education through Advanced Software Engineering and Artificial Intelligence (EASEAI 2022). Association for Computing Machinery, New York, NY, USA, 37–44. https://doi.org/10.1145/3548660.3561335

[A6] William P. Rey, Elcid A. Serrano, Adrian B. Alfonso, John Ramil F. Funilas, and Kiel Cedrick T. Huplo. 2022. Gamification of Learning as a Supplementary Learning Support for Mapua IT Students. In Proceedings of the 8th International Conference on Education and Training Technologies (ICETT '22). Association for Computing Machinery, New York, NY, USA, 1–8. https://doi.org/10.1145/3535756.3535757

[A7] Davut Çulha. 2022. Gamification of Open Inquiry-based Learning of Blockchain Technologies. https://doi.org/10.24840/2183-6493_008.001_0003

[A8] C. J. Berisford et al., "Can gamification help to teach Cybersecurity?," 2022 20th International Conference on Information Technology Based Higher Education and Training (ITHET), Antalya, Turkey, 2022, pp. 1-9, doi: 10.1109/ITHET56107.2022.10031716.

[A9] E. Pradanika, Y. Widyani and Y. Rusmawati, "Designing Gamification for Programming Learning Applications," 2022 International Conference on Data and Software Engineering (ICoDSE), Denpasar, Indonesia, 2022, pp. 18-23, doi: 10.1109/ICoDSE56892.2022.9972176.

[A10] E. M. Soares and S. R. B. Oliveira, "An Evaluation of the Participants' Perception of a Gamification to solve Problems of Software Process Improvement in the Educational

Context," 2022 IEEE Frontiers in Education Conference (FIE), Uppsala, Sweden, 2022, pp. 1-8, doi: 10.1109/FIE56618.2022.9962464.
[A11] W. N. Hidayat, H. Elmunsyah, L. I. Bariroh and T. A. Sutikno, "Gamification-Based E-learning Design for Vocational Software Engineering Subjects," 2022 14th International Conference on Information Technology and Electrical Engineering (ICITEE), Yogyakarta, Indonesia, 2022, pp. 142-147, doi: 10.1109/ICITEE56407.2022.9954090.
[A12] Monteiro Soares, E., Bezerra Oliveira, S. R., Souza Elgrably, I., & Henrique Barbosa Monteiro, R. (2022). Application of a Gamified Approach to Learning in the Treatment of Problems in Software Process Improvement: Analysis and Discussion of Results. International Journal of Emerging Technologies in Learning (iJET), 17(11), pp. 242–296. https://doi.org/10.3991/ijet.v17i11.30671
[A13] I. John and T. Fertig, "Gamification for Software Engineering Students - an Experience Report," 2022 IEEE Global Engineering Education Conference (EDUCON), Tunis, Tunisia, 2022, pp. 1942-1947, doi: 10.1109/EDUCON52537.2022.9766825.
[A14] M. W. Call, E. Fox and G. Sprint, "Gamifying Software Engineering Tools to Motivate Computer Science Students to Start and Finish Programming Assignments Earlier," in IEEE Transactions on Education, vol. 64, no. 4, pp. 423-431, Nov. 2021, doi: 10.1109/TE.2021.3069945.
[A15] Ed Júnior and Kleinner Farias. 2021. ModelGame: A Quality Model for Gamified Software Modeling Learning. In 15th Brazilian Symposium on Software Components, Architectures, and Reuse (SBCARS '21). Association for Computing Machinery, New York, NY, USA, 100–109. https://doi.org/10.1145/3483899.3483910
[A16] Beáta Lőrincz, Bogdan Iudean, and Andreea Vescan. 2021. Experience report on teaching testing through gamification. In Proceedings of the 3rd International Workshop on Education through Advanced Software Engineering and Artificial Intelligence (EASEAI 2021). Association for Computing Machinery, New York, NY, USA, 15–22. *https://doi.org/10.1145/3472673.3473960*
[A17] Paiva, J., Queirós, R., Leal, J., Swacha, J., & Miernik, F. (2021). An Open-Source Gamified Programming Learning Environment. In Second International Computer Programming Education Conference (ICPEC 2021) (pp. 5:1–5:8). Schloss Dagstuhl – Leibniz-Zentrum fur Informatik.
[A18] R. H. Barbosa Monteiro, M. R. de Almeida Souza, S. R. Bezerra Oliveira, C. dos Santos Portela and C. E. de Cristo Lobato, "The Diversity of Gamification Evaluation in the Software Engineering Education and Industry: Trends, Comparisons and Gaps," 2021 IEEE/ACM 43rd International Conference on Software Engineering: Software Engineering Education and Training (ICSE-SEET), Madrid, ES, 2021, pp. 154-164, doi: 10.1109/ICSE-SEET52601.2021.00025.
[A19] G. Moser, R. Vallon, M. Bernhart and T. Grechenig, "Teaching Software Quality Assurance with Gamification and Continuous Feedback Techniques," 2021 IEEE Global Engineering Education Conference (EDUCON), Vienna, Austria, 2021, pp. 505-509, doi: 10.1109/EDUCON46332.2021.9453921.

[A20] D. Iquira, M. Galarza and O. Sharhorodska, "Enhancing software engineering courses with a mobile gamified platform: results of a mixed approach," 2021 XVI Latin American Conference on Learning Technologies (LACLO), Arequipa, Peru, 2021, pp. 534-537, doi: 10.1109/LACLO54177.2021.00097.
[A21] R. H. B. Monteiro, S. R. B. Oliveira and M. R. De Almeida Souza, "A standard framework for gamification evaluation in education and training of software engineering: an evaluation from a proof of concept," 2021 IEEE Frontiers in Education Conference (FIE), Lincoln, NE, USA, 2021, pp. 1-7, doi: 10.1109/FIE49875.2021.9637232.
[A22] R. Malhotra, M. Massoudi and R. Jindal, "An Innovative Approach: Coupling Project-Based Learning and Game-Based Learning Approach in Teaching Software Engineering Course," 2020 IEEE International Conference on Technology, Engineering, Management for Societal impact using Marketing, Entrepreneurship and Talent (TEMSMET), Bengaluru, India, 2020, pp. 1-5, doi: 10.1109/TEMSMET51618.2020.9557522.
[A23] Pedro Henrique Dias Valle, Ricardo Ferreira Vilela, and Elis C. Montoro Hernandes. 2021. Does Gamification Improve the Training of Software Testers? A Preliminary Study from the Industry Perspective✱ In Proceedings of the XIX Brazilian Symposium on Software Quality (SBQS '20). Association for Computing Machinery, New York, NY, USA, Article 43, 1–10. https://doi.org/10.1145/3439961.3440004
[A24] E. Sherif, A. Liu, B. Nguyen, S. Lerner and W. G. Griswold, "Gamification to Aid the Learning of Test Coverage Concepts," 2020 IEEE 32nd Conference on Software Engineering Education and Training (CSEE&T), Munich, Germany, 2020, pp. 1-5, doi: 10.1109/CSEET49119.2020.9206224.
[A25] Paiva JC, Leal JP, Queirós R. Fostering Programming Practice through Games. Information. 2020; 11(11):498. https://doi.org/10.3390/info11110498
[A26]Valéria Lelli, Rossana M. C. Andrade, Lavinia M. Freitas, Rubens A. S. Silva, Francisco Gutenberg S. Filho, Renata Faria Gomes, and Jan Sousa de Oliveira Severo. 2020. Gamification in Remote Teaching of SE Courses: Experience Report. In Proceedings of the XXXIV Brazilian Symposium on Software Engineering (SBES '20). Association for Computing Machinery, New York, NY, USA, 844–853. *https://doi.org/10.1145/3422392.3422497*
[A27] L. S. Furtado and S. Ronaldo Bezerra Oliveira, "A teaching proposal for the software measurement process using gamification: an experimental study," 2020 IEEE Frontiers in Education Conference (FIE), Uppsala, Sweden, 2020, pp. 1-8, doi: 10.1109/FIE44824.2020.9274194.
[A28] I. E. Ferreira Costa and S. R. B. Oliveira, "The use of gamification to support the teaching-learning of software exploratory testing: an experience report based on the application of a framework," 2020 IEEE Frontiers in Education Conference (FIE), Uppsala, Sweden, 2020, pp. 1-9, doi: 10.1109/FIE44824.2020.9273943.

REFERENCES

[1] C. Franca, F. Q. B. da Silva, and H. Sharp, “Motivation and Satisfaction of Software Engineers,” IEEE Transactions on Software Engineering, vol. 46, no. 2, Feb. 2020, doi: 10.1109/TSE.2018.2842201.

[2] T. Hall, N. Baddoo, S. Beecham, H. Robinson, and H. Sharp, “A systematic review of theory use in studies investigating the motivations of software engineers,” ACM Transactions on Software Engineering and Methodology, vol. 18, no. 3, May 2009, doi: 10.1145/1525880.1525883.

[3] K. Werbach, “(Re) Defining Gamification : A Process Approach Gamification as a Process,” pp. 266–272, 2014.

[4] S. Deterding, D. Dixon, R. Khaled, and L. Nacke, “From game design elements to gamefulness: Defining ‘gamification,’” in Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments, MindTrek 2011, 2011, pp. 9–15, doi: 10.1145/2181037.2181040.

[5] J. Hamari and H. Sarsa, “Does Gamification Work ? — A Literature Review of Empirical Studies on Gamification,” 2014.

[6] K. Huotari and J. Hamari, “Defining gamification,” 2012, doi: 10.1145/2393132.2393137.

[7] Koivisto, J., & Hamari, J. (2019). Gamification of physical activity: A systematic literature review of comparison studies. In 3rd International GamiFIN Conference, GamiFIN 2019. CEUR-WS.

[8] Xi, N., & Hamari, J. (2020). Does gamification affect brand engagement and equity? A study in online brand communities. Journal of Business Research, 109, 449- 460

[9] Xu, H., Wu, Y., & Hamari, J. (2022). What determines the successfulness of a crowdsourcing campaign: A study on the relationships between indicators of trustworthiness, popularity, and success. Journal of Business Research, 139, 484-495.

[10] Wallius, E., Klock, A. C. T., & Hamari, J. (2022). Playing it safe: A literature review and research agenda on motivational technologies in transportation safety. Reliability Engineering & System Safety, 108514.

[11] Guillen Mandujano. G., Quist, J., & Hamari, J. (2021). Gamification of backcasting for sustainability: The development of the gameful backcasting framework (GAMEBACK). Journal of Cleaner Production, 302, 126609.

[12] J. Currier, Gamification: Game Mechanics is the New Marketing, OogaLabs Blog, 2008.

[13] M. Hugos, Enterprise Games, O’Reilly, 2012

[14] K.M. Kapp, The Gamification of Learning and Instructio, Pfeiffer, 2012

[15] Legaki, N. Z., Karpouzis, K., Assimakopoulos, V., & Hamari, J. (2021). Gamification to avoid cognitive biases: An experiment of gamifying a forecasting course. Technological Forecasting and Social Change, 167, 120725.

[16] C. F. Barreto and C. França, "Gamification in Software Engineering: A literature Review," *2021 IEEE/ACM 13th International Workshop on Cooperative and Human Aspects of Software Engineering (CHASE)*, Madrid, Spain, 2021, pp. 105-108, doi: 10.1109/CHASE52884.2021.00020.

[17] Oscar Pedreira, Félix García, Nieves Brisaboa, Mario Piattini, Gamification in software engineering – A systematic mapping, Information and Software Technology, Volume 57, 2015, Pages 157-168, ISSN 0950-5849, https://doi.org/10.1016/j.infsof.2014.08.007.

[18] Y. Xu, Literature Review on Web Application Gamification and Analytics, Collaborative Software Development Lab (CSDL), Department of Information and Computer Sciences, University of Hawaii, 2012

[19] I. John and T. Fertig, "Gamification for Software Engineering Students - an Experience Report," 2022 IEEE Global Engineering Education Conference (EDUCON), Tunis, Tunisia, 2022, pp. 1942-1947, doi: 10.1109/EDUCON52537.2022.9766825.

[20] Valéria Lelli, Rossana M. C. Andrade, Lavinia M. Freitas, Rubens A. S. Silva, Francisco Gutenberg S. Filho, Renata Faria Gomes, and Jan Sousa de Oliveira Severo. 2020. Gamification in Remote Teaching of SE Courses: Experience Report. In Proceedings of the XXXIV Brazilian Symposium on Software Engineering (SBES '20). Association for Computing Machinery, New York, NY, USA, 844–853. https://doi.org/10.1145/3422392.3422497

[21] Yu Xiao, Maria Watston. 2017. Guidance on Conducting a Systematic literature Review. Journal of Planning Education and Research 39:1, 93-112

[22] B.A. Kitchenham, D. Budgen, O. Pearl Brereton, Using mapping studies as the basis for further research – a participant–observer case study, Inf. Softw. Technol. 53 (2011) 638–651 (06/01/2011).

[23] P. Brereton, B. Kitchenham, D. Budgen, M. Turner, M. Khalil, Lessons from applying the systematic literature review process within the software engineering domain, J. Syst. Softw. (2007) 571–583.

[24] Moodle internet learning environment, Thesis writing guidelines in technical field (pdf file)

Available at: https://moodle.tuni.fi > Bachelor's Thesis Seminar in Science and Engineering (Seminar) > Information searching and topic commenting > Thesis writing guidelines in technical fields (pdf file) [10/4/2023]

[25] OpenAI. (2023). [Online]. Available: https://chat.openai.com/chat

[26] Chen, B., Wang, W., Shui, L. (2021). A Framework of Gamified Learning Design Targeting Behavior Change and Design of a Gamificated Time Management Training Manual. In: Fang, X. (eds) HCI in Games: Serious and Immersive Games. HCII 2021. Lecture Notes in Computer Science(), vol 12790. Springer, Cham. https://doi.org/10.1007/978-3-030-77414-1_13

[27] D. López-fernández, A. Gordillo, F. Ortega, A. Yagüe and E. Tovar, "LEGO® Serious Play in Software Engineering Education," in IEEE Access, vol. 9, pp. 103120-103131, 2021, doi: 10.1109/ACCESS.2021.3095552.