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Sains Humanika

Gamification's Effect on Learning and Engagement in Programming Course among Non-Major Computer Science Students

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Abstract

In this quasi-experimental research design with non-equivalent groups, the gamification method was used in the teaching delivery of a computer programming course among non-major computer science students. The gamification technique incorporates all game elements, including points, leaderboards, obstacles, and badges. We contrasted the gamified course (Section 02) with its non-gamified equivalent to determine how gamification impacts learner engagement and performance (Section 01). The experiment was conducted among first-year students in one public university's Pre-Service Teacher programme during the second half of the first semester of the academic year 2019–2020. Although there was no discernible difference in academic achievement between the experimental and control groups, the engagement results were encouraging, and students gave them positive feedback.

Keywords: Gamification; learn programming; engagement.

Abstrak

Strategi gamifikasi telah digunakan dalam penyampaian pengajaran bagi kursus Pengaturcaraan Komputer dalam kalangan pelajar bukan major Sains Komputer menerusi kajian kuasi-eksperimen dua kumpulan bukan setara. Pemarkahan, papan pendahulu, cabaran dan lencana digital adalah elemen permainan yang disertakan dalam strategi gamifikasi ini. Untuk melihat adakah strategi gamifikasi mempengaruhi penglibatan dan prestasi pembelajaran, kami membandingkan dua kursus yang sama dimana satu kursus menggunakan strategi gamifikasi (Seksyen 02) sebagai kumpulan rawatan, manakala satu kursus lagi sebagai kumpulan kawalan yang tidak menggunakan strategi gamifikasi (Seksyen 01). Kajian eksperimen itu berlaku pada bahagian kedua semester pertama tahun akademik 2019-2020 dalam kalangan pelajar tahun satu dalam satu program Guru Pra-Perkhidmatan universiti awam. Walaupun tiada perbezaan ketara dalam pencapaian akademik antara kumpulan eksperimen dan kawalan, keputusan penglibatan adalah memberansangkan, dengan maklum balas yang menggalakkan daripada pelajar.

Kata kunci: Gamifikasi, belajar pengaturcaraan, penglibatan.

1.0 INTRODUCTION

Over the last few years, gamification, the use of game elements in a non-game sense (Deterding et al., 2011), has emerged as a popular trend over the few years as a promising method to motivate and engage learners in learning. These game elements refer to characteristics found in most games, such as awarding points, leader boards and badges. In higher education, gamification is primarily used to engage and motivate learners to actively participate in their learning (Siemon & Eckardt, 2017). Gamification is beneficial for learning because it has been proven that gamification could increase learners' motivation (Buckley and Doyle, 2017), engagement (Suh et al., 2018) or even memory retention (Groh, 2012). Almost all these studies on gamification applications portray positive outcomes. The positive results show that gamification could also bring benefits to learning.

In higher education, educators often lack motivation and engagement among their learners, especially when the non-major computer science students need to learn something new out of their scope of major, like Computer Programming language course. Even for students majoring in computer science or information technology, learning a programming language is seen as a difficult task to take on. Because they are difficult and complex, programming classes are one of the seven major difficulties in computing education (Mcgettrick, et al., 2005). As a result, learners develop the mentality of relying on their peers to finish a task, eventually becoming sedentary, lacking their passion for studying and relying on instructors for sympathy. The introductory programming course, often known as basic programming, is frequently

offered as a general education course across fields in higher education for students who are not majoring in computer science. (Ali & Smith, 2014).

Research by Permana and Kusumo, (2018) and Ibanez, Di-Serio & Delgado-Kloos, (2014) showed a positive outcome when gamification was applied in the Computer Science courses. This gamification teaching strategy looks very promising and hopefully will help to enhance students' performance and engagement among students whose field is not computer related, which adds more challenges due to their background.

2.0 LITERATURE REVIEW

A programming language is a type of computer language that has been around for more than a century. There are different types of programming languages that have even developed over the years, enabling programmers to create software applications, scripts, and other types of sets of instructions that computers can follow. Each language has its own syntax even though the majority of them have commonalities. Once a programmer is familiar with the language's syntax, structure, and rules, they write the source code and translate it into a form that the computer can understand by compiling it. One of the fundamental topics that computer science students in higher education study is a programming language. Over the years, introductory programming learning and teaching challenges have been a study concern (Gomes & Mendes, 2014).

In addition, an introductory or fundamental programming course is being offered more commonly in higher education as a cross-disciplinary subject (Ali & Smith, 2014). Non-computer science majors can take this course as an elective. Due to the difficulty of learning a programming language, both students (Ali & Shubra, 2010; Daly, 2011; Kaplan, 2010) and teachers encounter challenges while attempting to teach these courses to students with different majors or educational backgrounds. These challenges include figuring out the intricacy or difficulty of the course as well as inspiring and engaging pupils whose minds and attention are already occupied with something else (Pregitzer & Clements, 2013).

Gomes & Mendes (2014) contend that motivation and effort are necessary for programming learning. The study's authors also noted that inexperienced programmers lacked motivation, and that teaching strategies should be reviewed and changed to help these students stay motivated throughout the course. In terms of practising, finishing assignments, and participating in group projects, non-major learners and programming major learners have a significantly different level of commitment, according to a study done by Seo (2017). This is influenced by a variety of factors, including interest, learning motivation, a lack of understanding of programming ideas, and a lack of cooperative learning. Considering these facts, it's possible that the course design needs to be modified to address the issues raised.

Similar to this phenomenon, students in Malaysia also have trouble learning computer programming languages. According to research by Derus & Ali (2012), there are three interrelated types of difficulties students face when learning to program: the first is having trouble grasping the fundamental ideas of programming structure (mean 3.40); the second is having trouble understanding a programme that is intended to carry out a specific task (mean 3:36); and the third is having trouble learning the syntax of programming languages (mean 3:35). While Kadar et al. (2021) found an association between student motivation and grades in programming courses. Most students make little effort and are demotivated to study programming with an open mind because of their bad perceptions of programming.

Based on a review by Blohm & Leimeister (2013), gamification shows high potential for behavioural change and supports the learning process. The review also stated that an IT-based gamified system could arouse the user's intrinsic motivation, which is better than the traditional incentives mechanism that usually focuses on increasing extrinsic motivation only. Recently, there have been increasing studies on using gamification in various subjects, including mathematics education, language learning and programming courses (Seixas et al., 2016; Dias, 2017; Rosmansyah & Rosyid, 2017; Yildirim, 2017; Bachtiar et al., 2018). Almost all these studies on gamification application portray positive outcomes on participation, engagement, motivation, and performance. The positive results show that gamification could also bring benefits to learning. These provide an excellent opportunity to apply IT-based gamified in learning programming language subjects, which might increase performance and students' motivation, eventually enhancing student engagement. Therefore, this study tries to identify the following research objectives:

i. To identify the effect of gamification on students' engagement.
ii. To measure the effect of gamification on student academic performance.

3.0 METHODOLOGY

This study used a quasi-experimental pretest-postest non-equivalent control group design conducted among one non-major computer science program in one public university. A treatment group is given a pretest, a treatment, and a posttest as part of this pretest-posttest non-equivalent groups design. However, at the same time, a non-equivalent control group is given a pretest, does not receive the treatment, and then is given a posttest (Fife-Schaw, 2012).

50 first-year undergraduate students from one Pre-Service Teacher programme at one public institution participated in this study. These students enrolled in a two-section; concurrent basic computer programming course given by the same instructor. There are 29 pupils in Section 01 and 21 in Section 2, respectively. With section 01 serving as the control condition (N = 29) and section 02 serving as the gamified experimental condition (N = 22), a quasi-experimental design was created. All students gave their informed consent, and the study was given an approval by university administrators.

The intervention was set up during the second half of the first semester of the academic year 2019-2020. Both control (Section 01) and experimental group (Section 02) were exposed to the conventional teaching methods, which are face-to-face learning supported by online learning resources set up on the university e-learning platform. University e-learning is a learning management system where lectures upload

notes, videos, quizzes, and all other content on the course for learners to access and complete. The learning resources can enable learners to carry out their self-learning to complete the quiz in e-learning.

To respond the research objectives, the researcher selected 3 course units which are Introduction of Python (Part 1 and Part 2), Python Programming Structure (Part 1 and Part 2), and Python Functions (Part 1 and Part2). These three (3) courses unit was covered in six weeks for both the control and experimental group.

The learning resources and the three (3) Level quizzes for python programming in the e-learning system was set up based on gamification strategy. The learning resources and the three (3) Level quizzes for python programming in the e-learning system were set up based on gamification strategy. Learners will need to go through all the learning resources and complete all three Levels and quizzes for python programming in the e-learning to earn the respective badges. Learners will not be able to proceed to another topic or level unless they perform 80% on the respective quiz level.

The badges given to students who fulfil the gamification criterion are shown in Figure 1 below. Figure 2 depicts a display in e-learning that does not enable students access to quiz 2 until they score more than 80 percent on quiz 1.

Image	Name	Description	Criteria
	Python Warrior	You get this badge because you pass at least 80% in all 3 python beginner quiz. well done !!	Users are awarded this badge when they complete the following requirement: • **ALL** of the following activities are completed: ◦ **"Quiz - Quiz 1 (Conditional Statements)"** ◦ **"Quiz - Quiz 2 (Loop Statements)"** ◦ **"Quiz - Quiz 3 (Function)"**
	Python Rookie	You get this badge because you pass at least 80% in all the python quiz on Conditional statement. Keep up the good work!!	Users are awarded this badge when they complete the following requirement: • **ANY** of the following activities are completed: ◦ **"Quiz - Quiz 1 (Conditional Statements)"** ◦ **"Quiz - Quiz 2 (Loop Statements)"**

Figure 1 Python Game Badge in e-learning issuance

The ranking for the leader board was analysed by extracting the score of quizzes from the e-learning system and the result published in the e-learning course. Ranking placement is based on the number of attempts and the earliest submission criteria. Figure 3 shows the experimental group students ranking in the Leaderboard.

The control group (Section 01) was also set up to finish the three-course units in six weeks using the same university e-learning platform. Learners will need to go through all the learning resources and are encouraged (not compulsory) to attempt all three quizzes for python programming in the e-learning. However, they will not earn the respective badges or leader board.

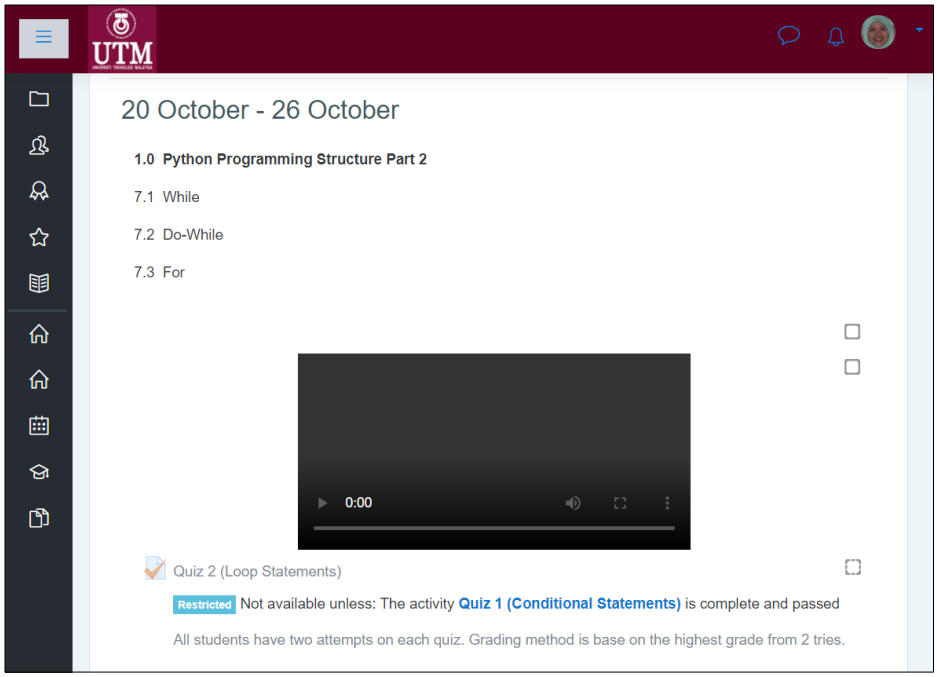

Figure 2 Course design on Python Programming Structure in e-learning with gamification rules applied

Figure 3 Leaderboard in e-learning

In this research, an instrument was used for collecting data, which consists of two sections to measure 'learners gamification experience in the online learning process. The first Section (Section A) consists of respondents' demographic details, and the second Section (Section B) is about gamification experience. The gamification experience among learners of Programming Language consists of five (5) Likert-scale questions. The Likert scale requires an individual to respond to a series of statements by indicating whether they strongly agree (SA), agrees (A), is undecided (U), disagrees (D), or strongly disagrees (SD). Students also need to answer a performance test prepared by the instructors to evaluate their understanding of the Python programming concept.

■4.0 RESULTS

In order to identify the effect of gamification on students' engagement, the survey instruments were given to the experimental group (21 students) and analysed using descriptive analysisThe . result was as shown in Table 1.

Table 1 Data analysis on 'Students Engagement in Gamification learning environment

	Gamification Items	Mean	SD
1	I found gamification activities at SPPP2102 e-learning module interesting.	4.62	0.51
2	I found gamification activities at SPPP2102 e-learning module exciting.	4.62	0.51
3	I found gamification activities at SPPP2102 e-learning module fun.	4.77	0.44
4	I found gamification activities at SPPP2102 e-learning module enjoyable.	4.69	0.48
5	Using gamification improves my learning performance in the SPPP2102 learning modules	4.69	0.63
6	Using gamification increases my productivity in the SPPP2102 learning modules	4.62	0.51
7	Using gamification enhances my effectiveness in the SPPP2102 learning modules	4.46	0.66
8	I paid more attention to the lecture slide due to gamification	4.69	0.48

	Gamification Items	Mean	SD
9	I paid more attention to the lecture video due to gamification	4.31	0.63
10	I try to explore more resources in Python programming due to gamification	4.54	0.66
	Overall mean	4.60	0.55

The overall mean among students in the experimental group on the gamification experience was encouraging, with a mean of4.60. Despite the difficulties in learning to program, data collected from this research shows that students found the gamification activities in the eLearning to be fun (mean = 4.77). However, they did not seem to refer tothe learning video due to gamification (mean 4.31) but more towards the lecture slide (mean 4.54) when they needed to clarify their understanding to ensure that they could perform the quiz and get the badges. Students even claim that the Gamification activities within the eLearning module areenjoyable (mean 4.69).

In order to identify the effect of gamification on students' performance, theoverall grade of the control and experimental students were collected from their quizzes attempts in the e-learning. Students could attempt twice for each quiz, and the highest marks were graded. Due to that, 7 out of 29 students from Section 1 were excluded from the performance analysis as they did not attempt all the three quizzes prepared in the e-learning.

Students' performance tests were also collected, which was done after the six weeks intervention, consisting of 4 subjective questions prepared by the instructors to evaluate their understanding of the Python programming concept. 'Students grades were analysed using descriptive analysis, and the result was shown as follows.

Table 2 Overall Grade of 'Students Performance in both Section

	Mean grade in eLearning (maximum 10 marks)	Mean grade in performance Test (Maximum 40 marks)
Section 01 (Control)	8.17	26
Section 02 (Experiment)	9.59	23

Based on Table 2, the grade for students in the experimental group had a slightly higher result compared to the control group. However, in the actual performance test, the Control group outperforms the experimental group. This means that the students in the experimental group did try their best in the gamification quiz due to the badges and ranking.

Table 3 Distribution of students scoring levels in both Section on performance Test

Scoring level	Section 01 (Control)	Section 02 (Experiment)
30 – 40 (Very Good)	4 (18.18%)	4 (19.05%)
20 – 29 (Good)	16 (72.73%)	11 (52.38%)
10 – 19 (Medium)	2 (9.09%)	6 (28.57%)
0 – 9 (Low)	0 (0.00%)	0 (0.00%)

Based on Table 3, 4 out of 21 students in the experimental group got more than 30 marks (19.05%), while four of 22 students in the control group got more than 30 marks (18.18%). Despite a bit higher mean in the eLearning gamification Quiz, more students in the experiment group fall under the Medium scoring level compared to the Control group. Since the eLearning quiz allows two attempts, the challenge might be under-challenged and need to be amended to equally shows students' actual performance. Groh (2012) claims that the difficulty inside the flow region must neither be under-challenged nor over-challenged; even failures are desired because it improves the experience of mastering the challenge after that.

At the end of the six (6) weeks of learning, students in the experimental group (Section 02) were requested to give comments on the gamification learning strategy applied in the course. The followings are some of the positive comments from the respondent,

S1 : create more activity that needs creativity
S4 : Interesting subject. I hope I can learn more about this subject in the future.
S10 : Im happy to learn this course because the course give me experience in knowledge about computers. I'm from zero to ten and know how to use the computer in programming language.
S12 : Interactive way to learn programming
S17 :This course is very interesting.
S15 : Everything is good. I am so grateful that my programming lecturer is XXXX cause she taught me and my classmates very diligent and effectives

Respondent were also asked whether he/she would recommend using gamification in another e-learning course. Students' answers were categorised into Agree, Disagree and Neutral. The descriptive data is shown in Table 4.

Table 4 Distribution of students' agreement towards using gamification strategy in other courses.

Agree	Disagree	Neutral
12 (57%)	1 (5%)	8 (38%)

The followings are some of the comments from the respondent,

S1: *Yes because its more interesting and enjoyable*

S2: *Yes. Because it can attract our interest and focus*

S7: *Yes, because it will help you in future*

S10: *Yes. Student can emphasise their capability of doing programming*

S11: *Yes. Because this strategy can improve your hard skill.*

S12: *Yes. Using gamification, student is more capable in learning process.*

S15: *Because it could increase our knowledge about python programming, which we didn't even know about computer at all. Even though we are not in school of computing, but with this course, we could learn the basic about programming language*

S20: *Yes. Because it can push us to explore more about computer language*

In a study by Suh, et al. (2018), lack of engagement in learning is mainly caused by a loss of interest. Comments above show that the strategy applied in this programming course was positively accepted and even recommended by the experimental group students to apply in another course.

■5.0 DISCUSSION AND RECOMMENDATION

Based on the data analysed, students' feedback shows a promising positive impact of gamification on students' engagement in learning Computer Programming subjects. This provides a great opportunity to explore further as if students arehighly engaged, they are more likely to perform better in their learning. However, Table 2 demonstrates that there is no appreciable distinction between the experimental and control groups' academic achievement. Only a slightly higher result among students in the experimental group compared to the control group in e-learning quiz while the Control group outperformed the experimental group in the performance test. Based on Bai, Hew, & Huang (2020), other research shows that some learners expressed their desire to convert badges into tangible marks that count toward actual course grades. The score in this e-learning quiz and badges does not contribute to any final overall grade of the students. This might be the reason why seven students in the Control group do not even bother to try out the quiz, while the experiment group attempt the quiz only to gain the badges and less concern about long-term memory retention, which affects their final performance test.

■6.0 CONCLUSION

In conclusion, the gamification strategy in the Computer Programming subject, which added a score, leader board, rules, and badges, did help to improve students' engagements during online learning. Students seem convinced and pay more attention to the learning resources in the e-learning to understand the course content while trying to score the quiz and get the badges. However, there is no significant difference in performance between the experiment and control group.

■7.0 LIMITATIONS AND FUTURE STUDIES

The gamification learning setting for this research only considers four (4) elements of gamification: scoring, leader boards, challenges, and badges. Thus, the effectiveness of the gamification element and the performance of the students learning Computer programming subjects might come up with different results. For future research and development, the researcher will also try to include other game elements proposed by (Simões, Redondo and Vilas, 2013) in the online learning setting.

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References

Ali, A., & Smith, D. (2014). Teaching An Introductory Programming Language In A General Education Course. *Journal of Information Technology Education: Innovations in Practice*, 13(6), 57-67.

Ali, A., & Shubra, C. (2010). Efforts To Reverse The Trend Of Enrollment Decline In Computer Science Programs. *Issues in Informing Science and Information Technology*, *7*, 209-224.

Bachtiar, F. A., Pradana, F., Priyambadha, B., & Bastari, D. I. (2018, July). CoMa: Development of Gamification-based E-learning. In *2018 10th International Conference on Information Technology and Electrical Engineering (ICITEE)* ,1-6. IEEE.

Bai, S., Hew, K. F., & Huang, B. (2020). Does Gamification Improve Student Learning Outcome? Evidence From A Meta-Analysis And Synthesis Of Qualitative Data In Educational Contexts. *Educational Research Review*, 30.

British Learning Association (2005). *Quality mark profiles.* Retrieved from http://www.british-learning.org.uk/qualitymark/pages/profiles.htm.

Blohm, I., & Leimeister, J. M. (2013). Gamification. *Business & information systems engineering*, *5*(4), 275-278.

Buckley, P., & Doyle, E. (2017). Individualising Gamification: An Investigation Of The Impact Of Learning Styles And Personality Traits On The Efficacy Of Gamification Using A Prediction Market. *Computers & Education*, *106*, 43-55.

Dias, J. (2017). Teaching Operations Research To Undergraduate Management Students: The Role of Gamification. *The International Journal of Management Education*, *15*(1), 98-111.

Daly, T. (2011). Minimising To Maximise: An Initial Attempt At Teaching Introductory Programming Using Alice. *Journal of Computing Sciences in Colleges*, *26*(5), 23-30.

Derus, S. R. M., & Ali, A. M. (2012). Difficulties In Learning Programming: Views of Students. *In 1st International Conference on Current Issues in Education* (ICCIE 2012), 74-79.

Deterding, S., Sicart, M., Nacke, L., O'Hara, K., & Dixon, D. (2011). *Gamification. Using Game-Design Elements In Non-Gaming Contexts*. In CHI'11 extended abstracts on human factors in computing systems, 2425-2428.

Fife-Schaw, C. (2012). *Quasi-Experimental Designs. Research Methods In Psychology*, 75-92.

Gomes, A., & Mendes, A. (2014, October). A teacher's view about introductory programming teaching and learning: Difficulties, strategies and motivations. In *2014 IEEE Frontiers in Education Conference (FIE) Proceedings*. 1-8. IEEE.

Groh, F. (2012). *Gamification: State of the Art Definition and Utilisation*. Proceedings of the 4th Seminar on Research Trends in Media Informatics, 39. Institute of Media Informatics Ulm University

Ibanez, M. B., Di-Serio, A., & Delgado-Kloos, C. (2014). Gamification For Engaging Computer Science Students In Learning Activities: A Case Study. *IEEE Transactions on learning technologies, 7*(3), 291-301.

Kadar, R., Wahab, N. A., Othman, J., Shamsuddin, M., & Mahlan, S. B. (2021). A Study Of Difficulties In Teaching And Learning Programming: A Systematic Literature Review. *International Journal of Academic Research in Progressive Education and Development, 10,* 591-605.

Kaplan, R. M. (2010, October). Choosing A First Programming Language. In *Proceedings of the 2010 ACM conference on Information technology education,* 163-164.

Mcgettrick, A., Boyle, R., Ibbett, R., Lloyd, J., Lovegrove, G., & Mander, K. (2005). Grand Challenges in Computing: Education—A Summary. *The Computer Journal*, *48*(1), 42-48.

Pregitzer, M., & Clements, S. N. (2013). Bored with the core: Stimulating student interest in online general education. *Educational Media International*, *50*(3), 162-176.

Permana, Y. A., Kusumo, D. S., & Nurjanah, D. (2018). Gamification for Learning Basic Algorithm. In *2018 6th International Conference on Information and Communication Technology* (ICoICT), 402-408. IEEE.

Rosmansyah, Y., & Rosyid, M. R. (2017). Mobile Learning with Gamification for Alquran Memorisation. In *2017 International Conference on Information Technology Systems and Innovation (ICITSI)*, 378-383. IEEE.

Siemon, D., & Eckardt, L. (2017). Gamification of Teaching In Higher Education. In *gamification*, 153-164. Springer, Cham.

Suh, A., Wagner, C., & Liu, L. (2018). Enhancing User Engagement Through Gamification. *Journal of Computer Information Systems*, *58*(3), 204-213.

Seixas d. R., L., Gomes, A. S., & de Melo Filho, I. J. (2016). Effectiveness of Gamification in The Engagement of Students. *Computers in Human Behavior*, *58*, 48-63.

Seo, J. (2017). A Case Study On Programming Learning Of Non-SW Majors For SW Convergence Education. *Journal of Digital Convergence*, *15*(7), 123-132.

Simões, J., R. D. Redondo, and A. F. Vilas, (2013). A Social Gamification Framework for A K-6 Learning Platform. *Computers in Human Behavior, 29*(2), 345-353.

Yeomans, L., Zschaler, S., & Coate, K. (2019). Transformative and Troublesome? Students' and Professional Programmers' Perspectives on Difficult Concepts in Programming. *ACM Transactions on Computing Education (TOCE)*, *19*(3), 1-27.

Yildirim, I. (2017). The Effects of Gamification-Based Teaching Practices on Student Achievement and Students' Attitudes Toward Lessons. *The Internet and Higher Education*, *33*, 86-92.