

Gamification Strategy to Support Self-Directed Learning in an Online Learning Environment

<https://doi.org/10.3991/ijet.v17i03.27489>

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Abstract—This research measures the effect of gamification on learners' academic performance, investigate their self-directed learning level within an online gamification learning environment and identify the relationship between learners self-directed learning level and their gamification learning experience. Pre-experimental research (single group) was carried out for a duration of 5 weeks among a group of 29 undergraduate year 2 learners from a non-major computer science course undertaking basic programming language subject. The learners SDL and knowledge on the subject was measured with a questionnaire and assessment test before and after the gamification learning intervention. A gamification experience questionnaire was used to evaluate their gamification learning experience after the intervention. The learning environment was infused with gamification in the form of competition to earn points, leaderboard ranks and python programmer badge. The learner's academic performance has significantly improved ($p=0.000 < 0.05$) after the gamification injection. Learners self-directed learning level also increased and there is a significant difference before ($M=3.59$) and after ($M=4.22$) the gamification strategy ($p=0.000 < 0.05$) imposed. Self-management, motivation and self-monitoring were all at high level with significance before and after ($p=0.000 < 0.05$) the gamified learning activities. Overall, the gamification strategy used in the online learning environment shows a positive influence to support learner's self-directed learning.

Keywords—gamification, self-directed learning, programming language, non-major computer science learners

1 Introduction

The growth of online learning via the expansion of information and communication technology (ICT) provides the flexibility and self-directed learning among learners suiting their learning methods, which not only cater the face-to-face learning but integrates online lessons and game-based elements in teaching and learning. Educational technology carries out an important role in the growth of worldwide education. With the advert technological learning tools availability, learners can directly engage in gaining knowledge themselves rather than attending face-to-face classes alone. Higher education is leaning more towards learner-centered approach as a response to our changing

society, where the ability to think critically, adapt and perform continuous learning through life is required [5]. Online Learning enables learners with flexibility and interactive learning environment without bounding them to time and location. In an online learning environment, self-directed learning (SDL) is essential for learners to independently guide themselves in obtaining knowledge as well enable them to develop their understanding to unravel problems in their learning. These learners usually participate actively in learning resources, learning activities, and setting goals in their learning process. Nevertheless, the learners find difficulties in retaining their self-directedness throughout the learning process in an online learning environment.

1.1 Self-directed learning

SDL is an approach in the field of education where learners take charge and be responsible for their self-learning and known as self-directed learners [1]. In an online learning environment, SDL is essential for learners to independently guide themselves in obtaining knowledge as well enable them to develop their understanding to unravel problems in their learning. These learners usually participate actively in learning resources, learning activities, and setting goals in their learning process. Course materials, information sharing, and assessment can be done online anytime and anywhere with online learning environment with the support of technology compared to traditional classroom method. Learners who show more self-directed behavior and prone to technological tools tends to have a better grasp on online learning setting to achieve the set learning objectives [22]. When it comes to teaching and learning process, a mix of both online learning and traditional learning methods were looked like the best approach for learner [11] [15]. However, it is important to understand how to promote motivation component in the SDL dimension in full online learning environment or even as a support in a blended learning environment [10].

1.2 Gamification

There is a significant potential found in game-based learning mainly in higher education as mentioned by [26]. [32] made a discovery that an effective approach where interactive games can improve academic achievement and plays an important role in cognitive development. According to [17] and [24] by engaging in video-based games, it directly shows a positive impact on individuals thinking abilities, motivational aspects and development of their emotions. Based on their findings, as the advancement of the technological tools, it is wise to fully utilize them into gamifying lessons in the learning process of the education field. On the other hand, there are other factors to be considered such as the cost that will incur, duration taken to develop the games before implementation of game-based learning. But it is not easy to implement game-based learning into the teaching and learning environment due to its shortcomings such as the cost of development and timeframe taken in creating the suitable games. Thus, the suitable and more feasible approach known as gamification learning environment with the infusion of game elements like points, scores, ranks, leaderboard etc. seems more practical rather than creating a whole new game from scratch for the education sector [4][9].

This research will try to explore online learning environment with gamification strategy towards learners' SDL and improvement in academic performance among learners in Malaysian education system. According to Garrison [12], Self-Directed Model (SDL) is accomplished by three dimensions interacting with each other: self-management, self-monitoring, and motivation. The focus of Garrison's model is on resource use, learning strategies use, and motivation to learn [1]. Garrison explained that self-management involved learners taking control of the learning context to reach their learning objectives. The motivation component in this model was added with the gamification strategy because research shows that gamification could increase learners' motivation [6], engagement [30], or even memory retention [14]. Furthermore, the game elements' nature and capabilities able to attract current generation of young and technology savvy learners [19].

1.3 Challenges in learning programming

Programming courses are one of the computer languages courses that has existed for more than 100 years. There are various types of programming languages which even has evolved in time that allows programmers to use them in developing programs for application or software, scripting, as well any other types of computer instructions that can be executed. Even though, most of the programming languages has similarities in them but each one of them has their own programming syntax and environment [20]. When a programmer grasps the underlying rules and conditions of the languages, it's structure as well its syntax, they are ready to develop the source code and compile the code into a machine language that is understood by the computer. Programming language is one of the core subjects that is learnt by computer science learners in higher education. It is also a multi-disciplinary course that is learnt as elective in the engineering and other non-computer science fields.

Learning programming language is deemed as a difficult subject to tackle even for information technology or computer science major learners. Programming courses are deemed as one of the difficult, complicated, and labelled as one of the seven grand challenges in the world of computing education [23]. This leads to learners to develop a dependent behaviour on other peers to carry out the given task and eventually can lead to inactive or withdrawal from the course. On top of that, as learners become idle and get disengaged from the course, they will remain without progress and will be expecting sympathy marks from their educators. According to [33], most students are scared of learning a programming language because they already believe that programming is difficult and demands a lot of cognitive effort.

At the same time, the introductory programming course or basic programming is often offered as a general education subject across disciplines in higher education [3] which is available as an elective subject for non-major computer science learners. By having learners from non-majors or different education background in these courses, challenges are faced by learners who find learning programming language is difficult [2] [7] [20] and educators during their teaching process. These challenges include in deciding the level or depth needed in the course and how to motivate and capture the interest of learners whose minds and focus are already fix on a different major [27].

According to [13], programming learning requires effort and motivation. The researchers also mentioned in the study the lack of motivation among learners, strategies used in teaching need to be revisited and improved to help these students to retain their motivation throughout the course. In a study conducted by [29], there is a significant difference among non-major learners compared to programming major learners in terms of commitment in doing the practices, assignments, and group projects. The factors causing these are due to interest, learning motivation, poor understanding on the programming topics and lack of self-directed learning. In consideration of these cases, design of the course may need to be altered to accommodate the challenges faced.

2 Objectives

The objectives of this study:

- To measure the effect of gamification on learners' academic performance.
- To investigate learners' self-directed learning level within gamification learning environment.

3 Methodology

In this research, the researcher used quantitative method for data collection which is in a form of survey (questionnaire) as an instrument to collect data. In order to analyze the learners' academic performance with gamification intervention, a pre and post assessment test was carried. The learners self-directed level was analyzed via a survey done before and after gamification learning experience. The relationship between the variables were analyzed based on the results.

3.1 Research procedure

- *Phase 1: Problem discovery and problem understanding.* A preliminary investigation was done by studying previous and similar study on the gamification element, Self-Directed learning issues and Online Learning Environment from previous literature.
- *Phase 2: Designing the course learning environment.* Instruments for the research was developed for collecting data and tested using pilot study. Instruments was constructed and selected based on literature in phase 1. The gamification learning environment was designed and constructed here.
- *Phase 3: Pre-Experimental Design.* A pre-experimental design (one-group pre-test – post-test) were conducted on all non-major computer science learner registered and learn in the Programming Language course. Learning will happen in an online learning mode. Learning and Teaching was administered for four weeks. Data were collected from e-learning system used for the course which consists of performance test and quiz scores. Apart from that, survey (questionnaire) was carried out on the

experimental group before and after the gamification learning intervention. Data was analysed using descriptive and inferential statistics.

The sample is second year, non-major computer science undergraduate learners who took Programming Language course at one university, which accounts to 29 non-major computer science learners. Sample for this study selected by using purposive sampling technique. This group and subject were selected because Programming courses require extensive practice, however many learners show low motivation for engaging in non-graded, self-directed learning activities [20].

3.2 Instructional design

The learners went through the learning process for about four weeks in online learning environment with gamification injection in Programming Language Course and were monitored throughout the completion of Topic 4 & 5 (Introduction of Python Part 1&2) and Topic 6&7 (Python Programming Structure Part 1 & 2). The choice of topics in this study based on the topic's learner have difficulties to grasp in learning programming and areas where learners show low motivation and engagement during the course.

The platform used for gamification element introduction is Moodle version 3.1 where lectures upload notes, videos, assignments, quiz, and all other relevant content for learners to access and complete. The formative assessments (quiz and assessments) were subjected to gamification elements in this research. The learners will need to complete all three quizzes for python programming and Python Assessment in the LMS to earn the respective badges. The badges are visible in user profile of learner in the course section. Refer Figure 1.

The ranking for the leader board were analyzed by extracting the score of quizzes from the LMS. Ranking placements were done based on the number of highest scores obtained followed by the earliest submission criteria.

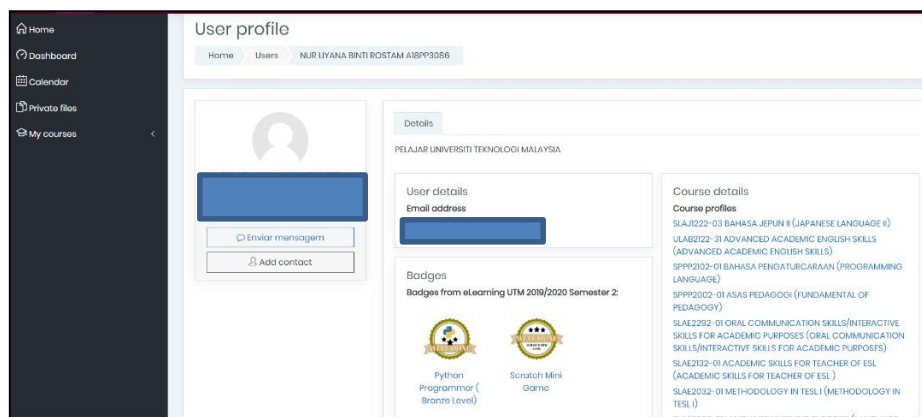


Fig. 1. User profile with the badges earned throughout learning in the Gamified Learning environment

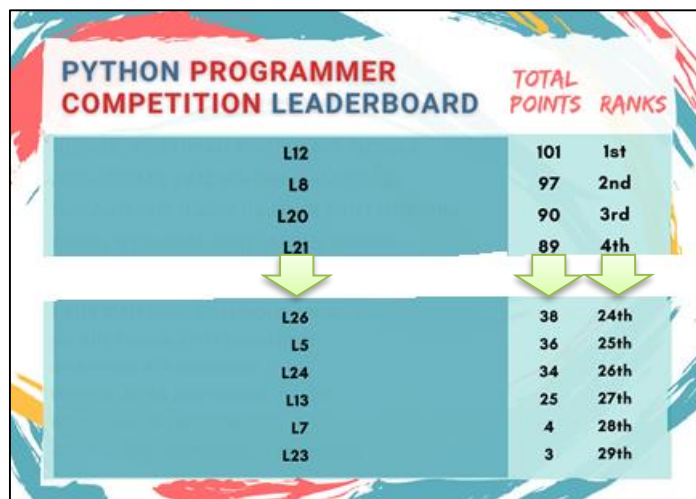


Fig. 2. Leaderboard showing students ranking in the gamified learning environment

3.3 Research instruments

In this research, two instruments were used, which are questionnaire and performance test (pre-test and post-test) on the experimental group. The performance test was based on Python programming concept which were given to the learners before and after they go through the gamified learning environment.

The questionnaire on Self-Directed Learning, were given to the sample during pre-test and post-test. The developed questions in the questionnaire were in the form of five (5) scale statements by indicating whether they do 5-strongly agrees (SA), 4-agrees (A), 3-undecided (U), 2-disagrees (D), or 1-strongly disagrees (SD). The SDL questions was adapted from [1], The Self-Directed Learning Aptitude Scale (SDLAS) comprised of 26 likert-scale questions. Pilot study was done as pre-testing of the instrument on 10 learners who took the same course previously. The reliability test done shows total coefficient value of 0.972 for SDL.

4 Findings

The results of gamification elements (points, ranks in leaderboard and badge) used in the study were briefed. Then, inferential statistics of learner’s performance analysis with gamification injection using paired sample test was discussed. Later on, inferential statistics of learners self-directed learning (SDL) and descriptive statistics of their gamification experience (GE) such as mean, and frequency were elaborated. Lastly, the correlation of variables was discussed. All the results of the quantitative data analysis and interpretation from the study was briefed here.

4.1 To measure the effect of gamification on learners' academic performance

The distribution of learners scoring level in performance test as shown in Table 1 during pre-test showed that majority of the sample got a medium scoring level 17 learners (68%). Meanwhile in post-test, majority of the sample got a high scoring level 14 learners (56%).

Table 1. Distribution of learners scoring level in performance test

Performance Test Score	Level	Pre-Test		Post-Test	
		Frequency	Percent	Frequency	Percent
0 – 9	Low	2	8%	0	0%
10 – 19	Medium	17	68%	11	44%
20 – 30	High	6	24%	14	56%

Descriptive analysis as showed in Table 2 showed that the mean of post-test was higher ($M = 19.44$) compared to the pre-test ($M = 15.66$).

Table 2. Descriptive statistics of learners 'academic performance

	N	Mean	Std. Deviation	Minimum	Maximum
Pre-Test	25	15.5600	4.18410	6.00	22.00
Post-Test	25	19.4400	3.17648	13.00	24.00

In Learners' pre and post-test performance result of paired sample test (Wilcoxon Signed - Rank), the number of positive ranked score ($N=20$) is higher compared to negative ranked score ($N=1$) and ties ($N=4$). This shows there was an improvement in the overall grade of learners through the teaching and learning process.

Table 3. Wilcoxon signed ranks test of learners 'academic performance

		N	Mean Rank	Sum of Ranks
Post-Test – Pre-Test	Negative Ranks	1 ^a	3.50	3.50
	Positive Ranks	20 ^b	11.38	227.50
	Ties	4 ^c		
	Total	25		

^aPost-Test < Pre-Test, ^bPost-Test > Pre-Test, ^cPost-Test = Pre-Test

Table 4. Test Statistics of learners 'academic performance

	Post-Test – Pre-Test
Z	-3.903
Asymp. Sig. (2-tailed)	.000

The findings of the test was $Z=-3.903$ and $p= 0.000$ (less than $\alpha = 0.05$). Thus, there is enough evidence to conclude gamification injection in learning environment was successful to improve learners’ academic performance and there is significant difference between pre and post-test score after gamification injection.

4.2 To investigate learners’ self-directed learning level within gamification learning environment

The mean of SDL - before and after gamification strategy introduced in the learning environment for all participants (N=29) shows no negative scores in data difference. The mean of SDL was at the lowest $M=2.38$ and highest $M=4.73$ before the gamification strategy introduction. After introducing gamification strategy in the online learning environment, the obtained mean was lowest at $M=3.65$ and highest at $M=5$.

Table 5. Descriptive statistics of participants’ SDL

	N	Mean	Std. Deviation	Minimum	Maximum
SDL (Before)	29	3.5902	.54415	2.38	4.73
SDL (After)	29	4.2228	.41518	3.65	5.00

The results analyzed using paired sample test to see the difference in participants’ SDL before and after the gamification strategy introduction in the online learning environment with Wilcoxon signed-rank test shows the test was $z=-4.706$ and $p= 0.000$, which is less than $\alpha = 0.05$. The SDL Level was rated higher (mean rank = 15) after they experiences the gamified learning environment (mean rank = 0.0). Thus, there is a significant difference between participants’ SDL level before and after gamification strategy in the learning environment.

Table 6. Wilcoxon signed ranks test of participants’ SDL

		N	Mean Rank	Sum of Ranks
SDL (After) – SDL (Before)	Negative Ranks	0 ^a	.00	.00
	Positive Ranks	29 ^b	15.00	435.00
	Ties	0 ^c		
	Total	29		

a. Average Mean SDL (Post) < Average Mean SDL (Pre)

b. Average Mean SDL (Post) > Average Mean SDL (Pre)

c. Average Mean SDL (Post) = Average Mean SDL (Pre)

Table 7. Test statistics of participants’ SDL

	SDL (Post) - SDL (Pre)
Z	-4.706 ^b
Asymp. Sig. (2-tailed)	.000

b. Based on negative ranks

5 Discussion

5.1 What is the effect of gamification on learners' academic performance?

The study on the impact of gamification strategy in the learning environment on learners' academic performance shows some game elements that were introduced in the gamification strategy (goals, points, ranks and leaderboard) in basic programming language course. In the gamification element analysis 4 out of 29 participants (13.8%) did not obtain their Python Programmer (Bronze Level) badge and achieve the goal as the participants did not manage to complete at least one task (quiz or assessment) that was given. This is supported with the findings from [14], in their meta-analysis study, previous research pointed out that certain learners voiced their desire to convert badges into marks that was taken into count of actual grade of the course. The points or score obtained via the gamification strategy in this gamification-learning environment does not count into their final over grade. Thus, this can be the reason why 4 out of the 29 students did not attempt to complete the gamified activities (quiz and assessment) while the remaining worked towards reaching their goal of obtaining highest rank in the relative leaderboard and obtain the digital badge.

As for the learner's academic performance, 24 learners showed improvement in their academic performance. The top five highest rankers of Python Programmer Competition leaderboard show they perform higher in the post assessment after the gamification strategy introduced. The paired sample test analysis showed the mean score of post-tests was higher ($M = 19.44$) compared to the pre-test ($M = 15.66$) and a significant difference present between the tests. This pointed out the fact that the learners' academic performance improved after the gamification strategy used in the learning process. This finding is similar to research done by [28] and [31] that shows their experimental group samples (pre and post-test) results improved in the gamified learning and significant after the intervention. Furthermore, according to the findings of the study by [16], students studying programming in the gamification-assisted flipped classroom were shown to be more enthusiastic to participate in coding training and have favorable views following the deployment. However, [8] [18] claim that depending on the user characteristics, different game elements can alter learning outcomes.

5.2 What are the learners' self-directed learning level within gamification learning environment?

The learners SDL level with the gamification-learning environment showed improvement after the gamification strategy introduced. Learners who are self-directed takes upon responsibility and exhibit control of their own programming language learning process. SDL learners who exhibit high level of SDL after the gamification intervention, shows their awareness in their own learning needs, have goal and objectives as well able to perform well. The changes in terms of the mean values of SDL before ($M=3.59$) and after ($M=4.22$) the intervention can be seen from the results of the study which shows improvement. SDL in this gamification-learning environment emphasizes the responsibility of learners to tackle their own learning process in the online learning

with the guide or educators who is a facilitator in this situation. All the individual learners yielded medium (3.4%) to high (96.6%) SDL level upon gamification strategy completion.

The learners given enough control to perform their learning process through the gamification activities and resources in the e-learning platform. They are able to decide their pace to learn, the suitable approach to gain knowledge in the gamification-learning environment. At the same time, educator's facilitation on learners learning by guiding and keeping them on track with their goal was a success. The reward structure (Top 5 Winners Reward) introduced in the gamification environment able to increase learner's motivation. Learners were motivated to join the gamification learning process when they felt the learning goals were achievable and relevant to their learning objectives. When students were learning in a gamification learning environment, they demonstrated an increase in motivation, an acknowledgement of strong teaching techniques, and an obvious boost of felt favourable sentiments toward science teaching and scientific topics, according to [34].

When the gamification elements introduced and educators stated the rules and conditions as well the rewards in accordance with the goal, learners were driven to join the online learning environment and continue their learning activities within the learning environment. Similar with the study done by [21] the gamification environment did able to nurture self-directness among learners as well improve their learning performance. Research done by [25] [17] also claim in his research that students still find the subject difficult after learning in the gamified learning environment, however, the strategy improves their performance and motivation toward the discipline.

6 Conclusion

Online learning has a lot of potentials to transform the learning process in higher education. With the use of online platforms, learners can access learning resources anytime and anywhere. As attending online classes is economical for learners and does not have to be physically present in class, learners' motivation and self-determination to complete the learning process are within their hands. Learners' need to sustain their motivation and show commitment in the tasks given to obtain or maintain excellent academic performance. At the same time, educators should equip learners with ample resources to perform and practice self-directed learning, which will be an asset for the learners in their lifelong learning process.

This study showed how gamification was used in an online learning environment using Learning Management System (LMS) as the medium to support learner's self-directed learning. As learners exhibit some level of self-directed learning before the gamification strategy was introduced, the extend of this SDL in the gamified learning environment was studied. If a learner possesses a low level of self-directness, they may not complete their assigned task at a given time. This is where a gamification-learning environment comes in place where learners may feel motivated and pulled back into the learning environment through gamified lessons or activities. This strategy will eventually improve their engagement in the learning process.

It is prominently important, especially for first-time learners, who need the motivation to kick start their learning journey, particularly when learning something new from their usual scope of education. Thus, gamified learning was demonstrated in this research to increase learner's performance and self-directedness towards a meaningful learning experience in an online learning environment. On that note, this leads to the conclusion that the gamification strategy supports self-directed learning within the online learning environment.

7 Limitation and future studies

The study done do exhibit some limitations. In this study, the targeted sample were just 29 non-major computer science learners from one higher education institution. In the future, it will be interesting to study among major computer science learners or even among primary and secondary students how they perform in gamification learning environment. The gamification elements used in various education level and major is a crucial area to study. It is also important to study on the feel, attitude, and technology readiness of educators towards gamification. This is because, educators play an important role in facilitating SDL and carry out gamification activities among learners.

8 Acknowledgment

This research was supported by Ministry of Education (MOE) through Fundamental Research Grant Scheme (FRGS/1/2020/SSI0/UTM/02/5, Vot No. 5F324).

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Article submitted 2021-10-11. Resubmitted 2021-11-09. Final acceptance 2021-11-10. Final version published as submitted by the authors.