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Teaching and Learning Computer Programming Using Gamification and Observation through Action Research

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Abstract

This study was conducted to explore the effectiveness of teaching and learning programming using gamification approach. The research design used was an action research and a total of 225 students of Community College in Selangor, Malaysia has taken part in this study. All participants are divided into ten cycles of action research. Data collection has been done through structured observation and analysed using SWOT analysis techniques. The findings show that various weaknesses, strengths, opportunities and threats have been identified from reflection of teacher, students, educational expert as well as the researcher itself. Improvements have been made in every cycle and at the end of cycle shows that gamification is a good approach to teaching and learning computer programming as well as increasing student's achievement and motivation. This study has given the best impact on the field of computer programming education. However, the enhanced of this study should be done and the experimental design is suggested to be used for future studies.

Introduction

Computer programming is a significant education to everybody, but it always considered difficult. Among the main reasons is that most students are not able to solve the given programming problems and failed to master various different skills at one time such as syntax and semantic programming language (Hooshyar et al., 2015; Malik & Coldwell-Neilson, 2017; Javadi et al., 2013). Creative problem solving skills, programming, computer hardware and applications form a concept that is also known as computational thinking (Park, 2016). According to Wing (2008), when humans use logical thinking to solve complex problems by understanding the problem in small parts and using the Mathematical approach to solve it, they are using computational thinking that ultimately leads to the construction of computer applications. Wing also stated that

computational thinking is scientific and capable of generating command-line algorithms to the computer to carry out tasks to solve problems. In addition, programming is a medium to computational thinking with application systems and hardware used in various fields (Voogt et al., 2015). In fact, computational thinking is closely linked to science, technology and society because of the logical, analytical, systematic and effective solution of problem solving that is needed all the time to meet the needs of human life (Swaid, 2015). Hence, the importance of computational thinking in human life also makes education relate to computational thinking is very relevant.

Computational Thinking in Computer Programming

In Computer Science, education related to computational thinking is introduced through programming subjects. Among the skills that make up the concept of computational thinking is wise to formulate problems, make decisions and solve creative problems (Kafai, 2016). In addition, human capabilities solve problems through logical thinking and code-writing skills leading to the construction of computer applications and hardware creation illustrating success for computational thinking (Djambong & Freiman, 2016). Since programming is still the most challenging subject to be mastered by students from the computing field (Park 2016), the main elements in computational thinking need to be explored. For that purpose, programming modules using problem-solving approaches should be used to study the level of computational thinking of the students.

Teaching Programming using Gamification

One of the teaching method that can keeps students engaged in the learning process is gamification (Kapp, 2012). Gamification is a learning concept that uses game elements as a medium of delivery for a content of teaching (Kapp, 2014). In this regard, the advantages of using game elements in teaching computer programming are identified as having the ability to build meaningful knowledge among students (Verber, 2016). Next, the elements of the game used in a learning process can also make the student more self-reliant (Chiou, 2016). This is due to the elements of the game allows students to manage their own learning based on a set of instructions that have been given for each project of gamification (Johnson et al., 2016; Moncada & Moncada, 2014). Additionally, gamification can also increase student motivation to explore their own learning (Johnson et al., 2017). Hence, the concept of gamification is a suitable teaching method for computer programming. According to Kapp (2012), gamification consists of two types, structural gamification and content gamification as follows.

a) Structural Gamification

Structural Gamification is an application that contains game elements to encourage students to explore the contents of the lesson without making any changes to the content. The kind of teaching method focus to motivate students to start learning and to engage in the learning process by promising the rewards at the end of the game. Examples of rewards always given are badges, scores or reach levels. Students not only share their learning progress with friends, but their teachers can also track student learning progress without their knowledge. Either than that,

structural gamification also allows students to add storylines, characters or other game elements, but teaching content remains unchanged into a game and remains a teaching process.

b) Content Gamification

Content-based gamification is an application that contains game elements and game thinking to alter content and make it more game-minded. Typically, content gamification allows students to add story elements into existing content so that they can change learning objectives. Such activities can make the learning session more playful but still do not alter the context of learning to the game.

Main Features Teaching Method uses Gamification

In this study, structural gamification has been used in accordance with the context of the content and applications used. Furthermore, the main features of the teaching method using adapted gamification from view of Kapp (2012) are listed as follows:

a) Encourage Student Engagement

Challenges, goals and progress are things that can encourage students to be involved permanently in the learning process. The structural gamification used also enable students to be actively involved and remain in the learning process without relying entirely on teachers. However, gamification does not mean game-based instruction that relies on failure or success of spending the game. Instead, the elements of the game are used as a substitute for the criteria of mastery the teaching content that has a certain benchmark for the students to strive and explore, so that they can enhance their mastery and skills.

b) Encouraging Action

Gamification helps students to act fast and can be creative without any limitations. This means that students playing games not because of the fun of playing, but the desire to improve their mastery or skills about the content being studied.

c) Influencing Behaviour

Gamification can influence the behaviour of students to become leaders when they seem to be a superhero in a game that's being worked out. Students themselves will be proud to help other students solve a given problem and encourage student-centred learning. Students who are faster in terms of learning progress will have the responsibility to expose how they understand and master something and guide other friends to solve the problem.

d) Build innovative Power

One of the concepts needed in gamification is the diversity of techniques and strategies to solve a problem using game elements. Different techniques and strategies will allow students to receive different rewards. The desire for greater rewards each time solving a given problem will encourage the development of innovation among students.

Portfolio Assessment

Assessment criteria cover various elements that are indicator of the success or effectiveness of an education program. Accordingly, some activities, tasks or projects that will be provided to students should be designed to as collection of assessments expected to achieve the desired learning outcome (Bender, 2012). All activities, assignments or projects designed will be provided to the students as an evidence of learning outcome (Balaban et al., 2013). The collection of activities also define as portfolios and much needed as an instrument for measurement activities in learning (Balaban et al., 2013; Butcher et al., 2006). The evidence of learning gathered in the portfolio assessment will be used as a final assessment of the student at the end of the PdP process.

Learning Outcome

Learning outcomes are the goals to be achieved for an educational activity. Generally, the learning outcome designed for a module should be aimed at solving the current problem of educational activities (Butcher et al., 2006; Felix & Ortin, 2014) and detailing the desired behavioural changes to the target students (Butcher et al., 2006; Keshavarz, 2011; Berg, 2001). This includes the expected improvement to student goals such as the improvement in skills, academic achievement and attitudes towards learning (Black et al., 2003). In addition, the learning outcomes that are being developed should be detailed in line with the teaching content to be used (Creswell, 2012). Hence, in the context of programming education, learning outcomes need to be built with the clear goal of achieving student behavioural change in skills, achievement and student attitudes towards learning and appropriate programming content to be used.

Methodologies

The purpose of this study is to Explore the integration of creative problem solving in teaching and learning programming through gamification based teaching methods. The research design used in this study was an action research and the data collection structured observation. SWOT analysis has been used to analysed the data that has been observed. A total of 225 students participated in the study consisting of community college students in Selangor, Malaysia.

a) Action Research

In general, the actions research performed at each cycle consists of five steps as adapted from (Norton 2009) as follows;

Step 1 Identify problems of teaching and learning process.
Step 2 Determine the problem-solving method
Step 3 Doing the teaching and observed the teaching process
Step 4 Evaluate lessons based on reflection of students and experts
Step 5 Modify the teaching method for the next cycle

Steps 1 to 5 are activities carried out for the first cycle of action research as shown in Figure 1. Starting from cycle 2 and next cycle, activity begins with step 3 followed by steps 4 and 5. An overview of the ten cycles of action studies that have been performed are shown in Figure 2. The time interval between the cycles is not uniform as the implementation of the action study is rely

on the permission and the convenience provided by the organization in which the study is conducted.

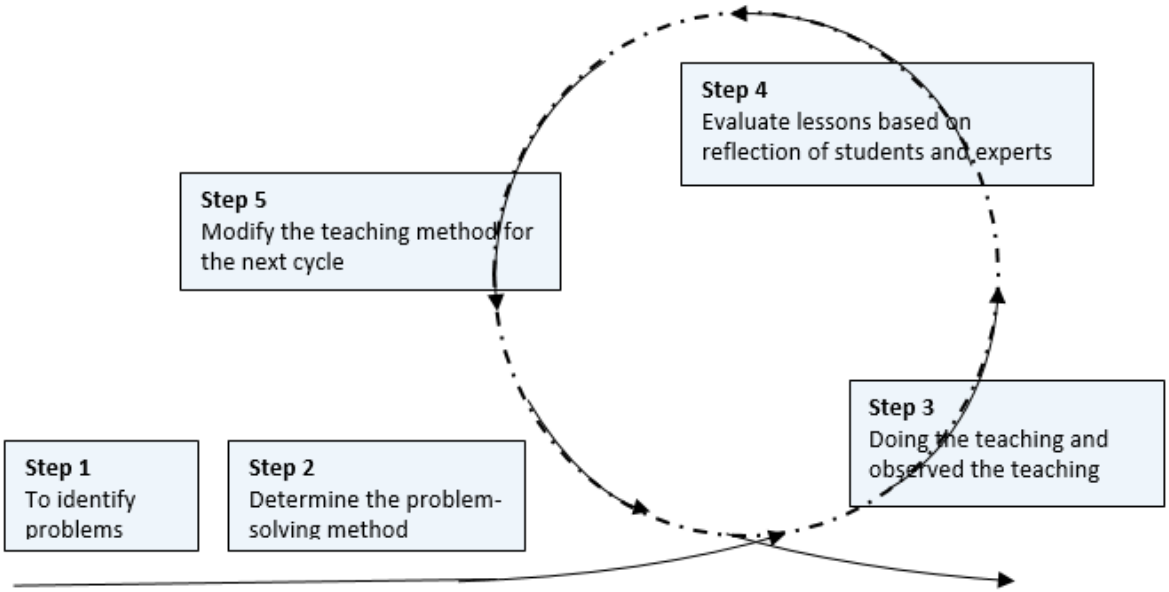

Figure 1: Activity in Action Research Cycle

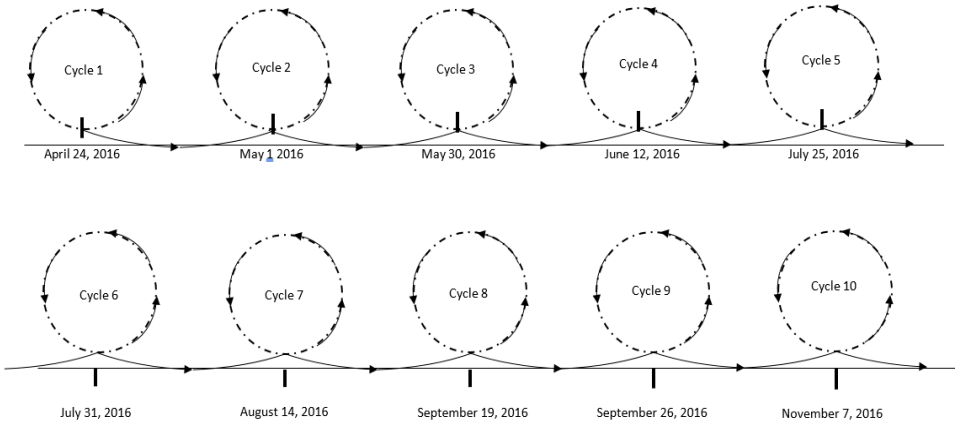

Figure 2. Ten Cycles of Action Research

b) Content and Evaluation

The contents of the teaching modules are constructed of gamification projects that are structured into a learning path. Each gamification project will be provided by the Learning Outcomes as a criteria reference to the student's achievement. The following is a description of each gamification project and the learning outcome that has been constructed.

CodeMonkey is a basic programming game to learn the concept of simple problem solving through programming algorithms. CodeMonkey is a programming game to introduce basic programming algorithms through problem solving logic. Student achievement will be assessed based on the criteria set out as assessment rubrics that uses scores of 1 to 5 where score 1

represents 'very weak' achievement, score 2 represents 'weak' achievement, score 3 represents 'simple' achievement, score 4 represents 'good' achievement and score 5 represents 'Excellent' achievement as in the table below.

Table 1. Rubric Score for CodeMonkey

	Score 1	Score 2	Score 3	Score 4	Score 5
Learning Outcome	Can identify problems but writing code error.	Can identify problems and write code by needs guidance from teacher.	Can identify problems and writes code without error but score low marks.	Can identify problems and writes code without error but in form of examples given.	Can identify problems and writes code without error and score very high marks.

Another gamification using in this research is Ruby Warrior system based learning. Student achievement will be assessed based on the assessment rubrics generated from predetermined criteria. Components in this gamification also uses scores of 1 to 5 where score 1 represents 'very weak' achievement, score 2 represents 'weak' achievement, score 3 represents 'simple' achievement, score 4 represents 'good' achievement and score 5 represents Achievements are 'very good' as in the following table.

Table 2. Rubric Score for Ruby Warrior

	Score 1	Score 2	Score 3	Score 4	Score 5
Learning Outcome	Can identify problems but writing code error.	Can identify problems and write code by needs guidance from teacher.	Can identify problems and writes code without error but score low marks.	Can identify problems and writes code without error but in form of examples given.	Can identify problems and writes code without error and score very high marks.

c) Structured Observation

Structured observation is a data collection technique performed by observing the strengths, weaknesses, opportunities and threats that existed during the teaching and learning process conducted in each cycle in the action research. The results from the checklist analysis are guided by observations made in subsequent cycles. The observation was performed by teacher, students and educational expert.

d) SWOT Analysis

SWOT (Strength, Weakness, Opportunity, Threat) analysis is a technique that have used during the observation by listing the strengths, weaknesses, opportunities and threats that existed when

the module was implemented by action research. Through SWOT analysis, several strategies were successfully developed for use as an improvement to the teaching and learning process.

Results and Discussion

The discussion of the findings illustrates how SWOT analysis had been carried out while performing the data collecting and analysis of every cycle of action research by SWOT analysis.

a) SWOT Analysis

Action research approach has been done to identify weaknesses and strengths through student reflection, expert reflection and self-reflection of researchers for improvement of teaching and learning process. In the context of this research, teaching process is evaluating through SWOT analysis with several strategies as shown in Table 3.

Table 3. SWOT Analysis

External / **Internal**	**S (Strength)** List the strength of teaching and learning using gamification	**W (Weaknesses)** List the weakness of teaching and learning using gamification
O (Opportunities) Listing all the opportunities	**Strategy 1 (SO)** How strength of teaching and learning using gamification can be used for grabbing the opportunities	**Strategy 2 (WO)** How the weaknesses of teaching and learning using gamification can be used for grabbing the opportunities
T (Threat) Listing all the threat	**Strategy 3 (ST)** How strength of teaching and learning using gamification can be used to overcome the threat	**Strategy 4 (WT)** How weaknesses of teaching and learning using gamification can be used to overcome the threat

b) The Analysis of Observation

Next is a summary of successful analysis for each cycle of action research as shown in Table 4.

Table 4. SWOT Analysis Summary Result.

Cycle of Action Research	**Total of Student**	**Summary of Analysis**
Cycle 1	10	Teaching method must be modified in term of technology driven.
Cycle 2	30	Learning path must be clear and need to be restructured.
Cycle 3	25	Assessment element need to be improved.
Cycle 4	15	Assessment element need to be improved.
Cycle 5	20	Teaching method is good but the software given should be more flexible.
Cycle 6	50	Teacher seems like don't master the criteria used to assess the students.
Cycle 7	30	Teacher can assess student well.
Cycle 8	10	Teaching method using gamification is good as well as the assessment criteria but did not performed clear where is the computational thinking elements.
Cycle 9	20	Teaching method using gamification is good as well as the assessment criteria.
Cycle 10	15	Teaching method using gamification is very good as well as the assessment criteria and the integration of creative problem-solving shows clear the computational thinking elements.

Table 4 shows that gamification is very good as teaching method. In addition, the study also finds that gamification has increase student's motivation when students have more engagement with their learning process. In fact, the increase of intrinsic student's motivation is also a catalyst for student engagement to continue learning programming in class up to the career nature. The overall of the study shows that the ten cycle of action study attempts to produce the effectiveness of teaching and learning programming using gamification has been done well not only for teaching method but also student's motivation. Furthermore, the action research has also succeeded in producing the best strategies to be used in the effectiveness study to ensure success for the implementation of the study. However, this study will be more significant if it continues with future research using experimental designs, so that it will measure the detail of student's achievement and motivation.

References

Balaban, I., Mu, E., & Divjak, B. (2013). Development of an electronic Portfolio system success model: An information systems approach. *Computers & Education* 60(1): 396–411. doi:10.1016/j.compedu.2012.06.013

Bender, W. N. (2012). *Project-Based Learning: Differentiating Instruction for the 21st Century*. California: Corwin Press.

Black, P., Harrison, C., Lee, C., Marshall, B., & William, D. (2003). *Assessment for Learning-Putting*

it into practice. Berkshire: Open University Press.

Butcher, C., Davies, C., & Highton, M. (2006). *Designing Learning: From Module Outline to Effective Teaching*. London and New York: Routledge.

Chiou, A. (2016). Data Visualisation Self-Explanatory Systems in Intelligent Game Inference Engines. *Journal of Advanced Research in Applied Sciences and Engineering Technology* 2(1): 1–8. Retrieved from http://www.akademiabaru.com/doc/ARASETV2_N1_P1_8.pdf

Creswell, J. W. (2012). *Educational Research fourth Edition*. Boston, MA: Pearson Edu.

Djambong, T., & Freiman, V. (2016). Task-Based Assessment of Students' Computational Thinking Skills Developed Through Visual Programming or Tangible Coding Environments. *13th International Conference on Cognition and Exploratory Learning in Digital Age (CELDA 2016)*, hlm. 41–52.

Felix, J. M., & Ortin, F. (2014). Aspect-Oriented Programming to Improve Modularity of Object-Oriented Applications 9(9): 2454–2460. doi:10.4304/jsw.9.9.24454-2460

Hooshyar, D., Ahmad, R. B., Yousefi, M., Yusop, F. D., & Horng, S.-J. (2015). A flowchart-based intelligent tutoring system for improving problem-solving skills of novice programmers. *Journal of Computer Assisted Learning* 1–17. doi:10.1111/jcal.12099

Johnson, D., Deterding, S., Kuhn, K.-A., Staneva, A., Stoyanov, S., & Hides, L. (2016). Gamification for health and wellbeing: A systematic review of the literature. *Internet Interventions* 6: 89–106. doi:10.1016/j.invent.2016.10.002

Johnson, D., Horton, E., Mulcahy, R., & Foth, M. (2017). Gamification and serious games within the domain of domestic energy consumption: A systematic review. *Renewable and Sustainable Energy Reviews* 73(January): 249–264. doi:10.1016/j.rser.2017.01.134

Kafai, Y. B. (2016). From computational thinking to computational participation in K--12 education. *Communications of the ACM*, hlm. 26–27. doi:10.1145/2955114

Kapp, K. (2012). The Gamification of Learning and Instruction: Game-based Methods and Strategies for Training and Education. *John Wiley & Sons*. https://books.google.com.my/books?id=M2Rb9ZtFxccC [19 March 2015].

Kapp, K. (2014). Gamification: Separating Fact From Fiction. *Chief Learning Officer*. http://ww.w.cedma-europe.org/newsletter articles/Clomedia/Gamification - Separating Fact from Fiction (Mar 14).pdf [19 March 2015].

Keshavarz, M. (2011). Measuring Course Learning Outcomes. *Journal of Learning Design* 4(4): 1–9.

Malik, S. I., & Coldwell-Neilson, J. (2017). Impact of a New Teaching and Learning Approach in an Introductory Programming Course. *Journal of Educational Computing Research* 0(0): 1–31. doi:10.1177/0735633116685852

Moncada, S. M., & Moncada, T. P. (2014). Gamification of Learning in Accounting Education. *Journal of Higher Education Theory & Practice* 14(3): 9–19. Retrieved from http://uproxy.library.dc-uoit.ca/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=eue&AN=100405004&scope=site%5Cnfiles/20719/Moncada and Moncada - 2014 - Gamification of Learning in Accounting Education.pdf

Javadi, M. H., Ghandehari, M., & Pouyandeh, H. V. (2013). Locating of Bicycle Stations in the City of Isfahan Using Mathematical Programming and Multi-Criteria Decision Making

Techniques. *International Journal of Academic Research in Accounting* 3(4): 18–26. doi:10.6007/IJARAFMS/v3-i4/271

Norton, L. S. (2009). *Action Research in Teaching and Learning*. London and New York: Routledge.

Park, N. (2016). Development of Computer Education Program Using LOGO Programming and Fractals Learning for Enhancing Creativity: Focus on Creative Problem-Solving. *International Journal of u- and e- Service, Science and Technology* 9(2): 121–126.

Swaid, S. I. (2015). ScienceDirect Bringing computational thinking to STEM education. *Procedia Manufacturing* 3(Ahfe): 3657–3662. doi:10.1016/j.promfg.2015.07.761

Berg, V. M. (2001). The Assessment of Learning Outcomes in Study Abroad. *Intercultural Education* 10(2): 31. doi:10.1016/j.sbspro.2014.12.297

Verber, D. (2016). Learning Basic Programing Skills With Educational Games : A Case of Primary Schools in Slovenia. *Journal of Educational Computing Research* 0(0): 1–26. doi:10.1177/0735633116680219

Voogt, J., Fisser, P., Good, J., Mishra, P., & Yadav, A. (2015). Computational thinking in compulsory education: Towards an agenda for research and practice. *Education and Information Technologies* 20(4): 715–728. doi:10.1007/s10639-015-9412-6

Wing, J. (2008). Computational thinking and thinking about computing. *Philosophical Transactions of The Royal Society* (July): 3717–3725. doi:10.1109/IPDPS.2008.4536091