Effectiveness of innovative gamified learning among undergraduate medical students

M H Ohn¹, K M Ohn², U D Souza³, S Yusof² and Z Ariffin⁴

¹ Medicine based department, Faculty of medicine and health sciences, Universiti Malaysia Sabah, Malaysia
² Surgery based department, Faculty of medicine and health sciences, Universiti Malaysia Sabah, Malaysia
³ Biomedical Sciences department, Faculty of medicine and health sciences, Universiti Malaysia Sabah, Malaysia
⁴ Medical Education department, Faculty of medicine and health sciences, Universiti Malaysia Sabah, Malaysia

Email: mayhoney.ohn@ums.edu.my

Abstract. In today’s world of technology, gamification has become increasingly popular in education. Previous studies have reported that gamified learning enables 21st century students to motivate and engage in academic fields. However, there is a paucity of information on empirical studies on effectiveness of gamified learning in various fields of medicine. This lack of empirical evidence is evident in the varying recommendations for the implementation of gamification in medical education. This research aimed to investigate the effectiveness of gamified learning among undergraduate medical students. This was an quasi-experimental study comparing digital online gamified learning with conventional electronic learning (e-learning) at undergraduate level in medicine. Modified Kirkpatrick evaluation was used to appraise the outcome of educational intervention. The change in pre and post-test score was used to measure cognitive gain. There were twenty-one knowledge and skill assessment questions (twenty multiple choice questions and one objective structured clinical examination question respectively) to assess the knowledge and skill acquisition. The findings from this study revealed that gamified learning is more effective than conventional e-learning in improving ECG diagnostic accuracy while gamified learning is as effective as conventional e-learning for improving ECG interpretation skill.

Key words: Gamification, gamified learning, medical students, undergraduate, effectiveness

1. Introduction

Gamification is defined as “the use of game design elements in non-game contexts” [1]. The term “gamification” was first used in 2008 by Brett Terrill [2], but wide adoption of the term “gamification” was began during 2010 [1]. Since then, it has been commonly used in various fields like marketing, economist, research, and healthcare. Despite its rapid acceptance in business industries [3], the education field has been slow to implement [4]. Nevertheless, following the advances of technology-enhanced learning (TEL) using new digital tools such as social networks [5,6], digital media [7], and the Internet [8], there was an influx of various electronic educational games [9], virtual patient simulations [10], online gamified quizzes and puzzles [11,12], with varying successes in recent years. As a result, many medical schools have begun to incorporate gamification in preclinical and clinical medical education in recent years.
Gamification has drawn the consideration of medical educators due to the possibility of making medical learning more motivating and engaging; this led to an increase of research in the medical education field. The earliest systematic review was done by [13] on the effectiveness of educational games on learning outcome among medical student. It was highlighted that more rigorous studies were needed to ratify or negate the effectiveness of gamified learning as an effective educational strategy for medical students. Recently, McCoy, Lewis and Dalton [14] did a landscape review study on gamified learning platforms used in medical education. Game based learning in medical curricula has been proved to enhance students’ engagement [15], collaborative learning [16,17], and decision making [18]. However, it was similarly uncovered like [13] that rigorous research about the effectiveness of gamified learning in medicine is still in its infancy. The reason could be because of not much gamified training platforms are yet developed by medical education fraternity which results in the lack of well-designed research evaluating the advantages of gamification on learning outcome for medical education. Furthermore, there are multiple challenges in conducting randomized controlled trial to examine the learning gains due to gamified learning.

As evidence by aforementioned studies, not much is known about the impact of gamified medical learning on learning process and its success. This lack of empirical evidence is evident in the varying recommendations for the implementation of gamification in medical education. In the view of paucity of information on empirical studies on effectiveness of gamified learning in medicine, this research was aimed to investigate the effectiveness of gamified learning among undergraduate medical students. The study was conducted on a learning outcome involved in a medicine module teaching entitled ‘Electrocardiogram (ECG) interpretation’. ECG is commonly used bedside investigation in diagnosis of several heart diseases, including many life-threatening disorders [19–21]. ECG interpretation is one of the crucial learning outcome as well as essential skill for graduating medical students to master upon completion of undergraduate program [22–24]. As such, the specific objective of the study is to investigate the impact of gamified learning on improvement in the ECG diagnostic accuracy.

2. Materials and Methods

This was an quasi-experimental study comparing digital gamified learning with conventional electronic learning (e-learning) at undergraduate level in medicine. The study was conducted with clinical year medical students (year 3,4 & 5) in the academic year 2017-2018 at the Faculty of Medicine and Health Sciences in Universiti Malaysia Sabah (UMS). Having consented to involvement in the study, a total of 218 students were selected. One hundred and eight students were assigned to the experimental group (gamified e-learning) and 110 students were placed in the control group (conventional e-learning group) by stratified random assignment. A chance procedure such as tossing a coin is used to decide which student in each academic year gets which e-learning teaching. The control group utilized the conventional e-learning platform (MOODLE a.k.a SMART2UMS). The experimental group studied through web-based gamified e-learning (GaMED™). Pre-test was conducted to test the baseline preformed knowledge before online learning while post-test was conducted two-weeks after online learning.

GaMED™ is a new gamified learning tool developed by a UMS research team which comprises of programmers, IT technician, graphic designer, gamification expert, and leads by an ECG context expert physician [25]. It uses a principle of gamification in which gamification element, such as experience points, badges and Leaderboard system that ranks high performers in the system, incorporates in the learning platform to deliver knowledge and skills [26]. Both group students were made sure everyone had access to internet computer to study learning materials online in different platforms. Both platforms were password protected with admin control to protect contamination bias in the study outcome. They were informed that they were not allowed access to alternative platform during the experiment period. Learning materials on both platforms were same contents which were selected from various sources including recommended ECG textbooks and real ECG cases from patient and online resources. All ECGs included were assured high-quality images by audio-visual department.

Modified Kirkpatrick evaluation was used to appraise the outcome of educational intervention. The change in pre and post-test score was used to measure cognitive gain. There were a total of twenty-one ECG diagnostic accuracy and interpretation skill questions (twenty multiple choice questions and one
objective structured clinical examination question) to assess the knowledge and skill acquisition respectively. Maximum test for MCQ test was 20 and OSCE was 10 marks. Both post-test questions were constructed as same that of pre-test questions, but the sequence of the questions were shuffled. ECG interpretation speed was also measured digitally in both pre- and post-test for comparison. Ethics approval was obtained from Faculty of Medicine and Health Sciences, University Malaysia Sabah (Ethics number-JKEtika 1/17(5)).

3. Results
Most of the participants in clinical year students were 76(35%) third-year, 64(30%) forth-year and 78(35%) fifth-year students of which 157 (72%) were female. Mean (SD) age was 21.32 (0.87) years and 22.28 (1.10) in experimental group and control group respectively. There were no significant differences found in age, gender, ethnic, academic year, academic achievement and influence by the distribution between two cohort groups (P>0.05) as shown in Table 1. 100% of participants from both groups answered that they didn’t have any prior experience in gamified learning before. A total of 18 (8%) of students had exposure to ECG course but it was not statistically significant between two groups.

As the parameters were not normally distributed, Mann-Whitney test was used to analyze the differences between pre- and post-test ECG scores. Mean pre-test scores in the gamified group was 9.26(3.27) and 4.83(3.45) for MCQ and OSCE respectively. On the other hand, mean pre-test scores in the control group was 9.97(3.08) and 4.37(3.87) for MCQ and OSCE respectively. Post-test MCQ marks for gamified group and e-learning group and control group are as follow: 17.43(4.16) and 15.37(3.87) respectively; while OSCE marks are 8.7(4.06) and 8.62(3.39) respectively.

Considering the between group analysis of clinical year students, as regards to their pre-test results, the mean scores (ECG, OSCE and interpretation speed) of both experimental and control groups are likewise comparable as indicated by the Z score of -1.635 (P=0.102), -0.189 (P=0.850) and -0.030 (P=0.976) respectively. As the statistical differences in all pre-test results between two cohort groups are greater than a P-value of 0.05 yielding no significant difference in the factual knowledge, ECG interpretation skill and speed between two cohort groups (Table 2). Due to the non-significant differences between two cohort groups in the pre-test scores, it could be said that both groups therefore have established comparability prior to the experimentation. This means that the impact of pre-test score on the post-test score achievement is unlikely confounding factor.

In order to test the learning changes, scores on the post-intervention test were compared between two cohort groups by using Mann-Whitney U-test. In particular, a statistically significant improvement was observed in post-test among gamified group (Mann-Whitney U-test= -3.020, P=0.003) while pre-test didn’t show any significant difference between two groups (Mann-Whitney U-test= -1.635, P=0.102) in terms of the mean scores obtained in MCQ test. Regarding OSCE test between two cohort groups, even though there was an improvement in gamified group’s post-test score from pre-test but it wasn’t statistically significant (Post-test: Mann-Whitney U-test=-0.052, P=0.959 versus Pre-test: Mann-Whitney U-test= -0.189, P=0.850). Notably, gamified group students were shown significant faster ECG interpretation speed than e-learning group (Z=4.17, P<0.001).

To estimate the size of the impact of gamified learning and conventional e-learning, the effect size based on means has been calculated. The gamified e-learning has a large effect (0.9) on the improvement of ECG knowledge and interpretation speed compared to the conventional e-learning, while there was a negligible effect (0.12) on the improvement of the ECG interpretation skill.

Table 1. Distribution of clinical year students by age, gender, ethnic, cGPA, prior gamified learning experience, and history of ECG course among clinical year students (N=218).

| Variables                | Total n(%) | Experimental Group n(108)(%) | Control Group n(110)(%) | Statistic | P-value | Sig. |
|--------------------------|------------|------------------------------|-------------------------|-----------|---------|------|
|                         |            | (n=108) (%)                 | (n=110) (%)             |           |         |      |
### Academic Year

| Year | Age | Sex | Ethnicity | cGPA |
|------|-----|-----|-----------|------|
| Year 3 | 22.3(0.98) | Female | Malay | 157(72) |
|       |       |       | Chinese | 62(28) |
| Year 4 | 21.32(0.87) | Male | Indian | 62(28) |
|       |       |       | Others | 46(22) |
| Year 5 | 22.28(1.10) |       | Malay | 62(28) |
|       |       |       | Chinese | 62(28) |
|       |       |       | Indian | 46(22) |
|       |       |       | Others | 48(22) |

### Sex

| Year | Sex | Female | Male |
|------|-----|--------|------|
| Year 3 | 0.01 | 157(72) | 61(28) |
| Year 4 | 0.910a | 78(71) | 30(28) |
| Year 5 | NS | 77(70) | 33(30) |

### Ethnicity

| Year | Sex | Malay | Chinese | Indian | Others |
|------|-----|-------|---------|--------|--------|
| Year 3 | 2.68 | 62(28) | 37(34) | 25(22) | 2.68 |
| Year 4 | 0.611c | 62(28) | 35(32) | 27(25) | 0.611c |
| Year 5 | NS | 46(22) | 25(23) | 21(19) | NS |

### cGPA (M(SD))

| Year | Sex | Malay | Chinese | Indian | Others |
|------|-----|-------|---------|--------|--------|
| Year 3 | 3.48(0.23) | 62(28) | 37(34) | 25(22) | 3.48(0.23) |
| Year 4 | 3.48(0.20) | 62(28) | 35(32) | 27(25) | 3.48(0.20) |
| Year 5 | 3.49(0.24) | 46(22) | 25(23) | 21(19) | 3.49(0.24) |

### History of ECG course attendance

| Year | Sex | Yes | No |
|------|-----|-----|----|
| Year 3 | 0.618 | 18(8) | 200(92) |
| Year 4 | 0.432a | 6(6) | 102(94) |
| Year 5 | NS | 12(11) | 98(89) |

* *cGPA*: cumulative grade point average; n: number; %: percentage; SD: standard deviation; a Pearson Chi-Square test; b Independent t-test

*P value <0.05 is statistically significant.

Sig(2-tailed); NS: Non-significant (P>0.05); S: Significant (P<0.05); VS: Very significant (P<0.001)

### Table 2. Comparison of the ECG scores and duration between gamified learning group and conventional e-learning group among clinical year (N=218).

| Group | MCQ test | OSCE test | Interpretation speed |
|-------|----------|-----------|----------------------|
|       | Z | P | Sig. | Z | P | Sig. |
| Pre-test | 1.63 | 0.102 | NS | 0.18 | 0.850 | NS | -0.03 | 0.976 | NS |
| Post-test | 3.78 | 0.001 | S | 0.15 | 0.874 | NS | -2.00 | 0.045 | S |
| Pre-post test | 2.77 | 0.001 | S | 0.38 | 0.410 | NS | 4.17 | 0.001 | S |

### Discussion

Previous data had shown suboptimal 12-lead ECG interpretation skills among medical students [25,27,28] and hence, there is a call for innovative pedagogical strategies to increase ECG competency which needs urgent attention by medical educators. Nilsson (2008) suggested that adding online ECG learning over traditional ECG teaching was beneficial in imparting ECG knowledge for medical students [29]. Nowadays,
online ECG learning is increasingly popular and used as a supplementary ECG instruction modality as it permits flexibility in learning and there is likewise inadequate time allocated for conventional face-to-face classroom teaching. Nonetheless, students’ participation and motivation in the online learning courses are yet unsatisfactory. To address this educational gap, a new gamified ECG learning platform (GaMED™) was innovated using gamified online active learning theory [30] with an aim to expand students’ engagement with learning in an competitive and interactive learning approach.

In this study, both online learning platform (GaMED™ and Smart2 UMS Model) showed significant similar improvement in level of ECG diagnostic accuracy and interpretation skills. Of note, the findings suggest that gamified learning is more effective than conventional e-learning in improving factual knowledge among clinical year undergraduate medical students. This is probably due to the fact of collaborative and competitive game element features in gamified learning which stimulated the learning environment and engaged students in the learning process. In a study by Kopeć (2018) examined two e-learning methods for ECG reading among medical students, it was similarly found that collaborative e-learning was better than self-directed e-learning [31]. On the other hand, gamified learning is as effective as conventional e-learning to improve ECG interpretation skill. To date, it is worth noting that there were no studies done to compare different ECG instruction method on improving ECG interpretation speed while maintaining ECG diagnostic accuracy. There is also a need to explore further studies how gamified learning impacts on facilitating thinking process.

4.1 Limitations
There are major difficulties in comparing different studies concerning ECG interpretation since electrocardiograms learning curriculum in each university from various country can be diverse and learning assessment can be different among the study centers. This study was done in a single center and hence, participated studies were using the same learning outcome as well as reading materials. As regard to ECG learning outcome assessment, there are two available tests: subjective (Multiple Choice Question) and objective (objective structured clinical examination) assessment to test ECG factual knowledge and interpretation skill respectively. The former uses closed-ended questions which gives more specific response alternatives while the latter uses open-ended questions which produces diverse set of answers and more missing data. However, Bridgeman (1992) demonstrated that there is similar pattern between those two formats of assessments [32].

5. Conclusion
On a whole, gamified learning is a dynamic and interactive innovative ECG instructional method that assists students to learn ECG through game-like elements and the platform has a high potential to cover a large variety of users in the field of medicine. Providing students with gamified learning activities in experiential active learning, this digital gamified learning has engaged learning outside classroom. Therefore, gamified learning is believed to be more effective to render collaborative and competitive learning in medicine.

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