Effectiveness of Game Robot Learning to Students Achievement for Respiration Topic

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Abstract: The purpose of this study is to investigate the effectiveness of learning robot game on student achievements for cell respiration topic. A total of 695 students one year module 1 & 3 involving three colleges Kedah Matriculation College, Perlis Matriculation College and Perak Matriculation College. The achievement test is developed by researcher was used in the study to measure student performance. This study uses a quantitative non-survey approach with quasi-experimental design involving treatment and control groups. Robots developed using the Arduino-uno brain and coding processes for robot coordination through the software Scratch for Arduino (S4A). Student achievement was measured at three different time periods (pre-test, post-test 1 and post-test 2). The statistical test was performed on repeated analysis of variance (ANOVA) at significant level p <0.05, Mauchly test and also the effect size as measurement was performed at three different time periods. The results of the analysis showed that both control and treatment groups showed significant improvement in three periods based on achievement with p <0.05. However such a size effect shows that the treatment group has a high impact and the desired zone effect from the learning material compared to the control group.

Key words: Robot game · Achievement · Respiration · Quasi eksperiment · Matriculation

INTRODUCTION

Respiration is an abstract, complex and difficult topic [1-4] involving complex processes and the use of technical terms causes some of the concepts of cell respiration to be difficult to learn and lead to information storage temporarily while in the classroom [5, 6]. Respiration is the key to a comprehensive process of understanding the functioning of other systems in living organisms for example respiratory, excretion and circulatory system. Students who fail to master the concept in respiration will have difficulty understanding other Biology disciplines [7]. The use of video, animation, multimedia, interactive images to real objects as a teaching tool to make it easy for students to remember each sub topic in the process of abstract cell respiration [8]. Robot as a real object can be used as a primary teaching tool for teachers to facilitate the learning process by attracting students interest in content [9]. Robots began to be used in the classroom as an overdeveloped educational technology over the last 20 years [10, 11, 12]. The learning process of using robots in the classroom often involves gaming [13,14]. The concept of gamification is a new idea that leads to an educational system to enable students to explore content through the mechanics and dynamics concepts found in the game process [15]. The gamification combines play elements and does not play in a comprehensive process to sustain motivation of students to continue learning and give huge impact to performance of students even though involving abstract complex such as respiration [16, 17].

Statement Problem: The difficulties of studying Biology have been studied by many researchers around the world [18]. There are many reasons why students are difficult to learn the concepts in Biology [6, 8]. Respiration is the most difficult topic compared to other topics in the Biology subject [19]. Many studies have been conducted to explore students’ understanding of respiration [7]. The main issues highlighted in past studies are that...
students fail to remember well in several sub topics in cell respiration, the definition of respiration, glicolysis, Kreb cycle and the relationship with electron transport chain. Students can not apply the concept of respiration in life because they cannot mastery the information about this concept over a long period of time [1]. The students will memorize all the facts and concepts of respiration for examination only [4]. Respiration is an abstract, complex and difficult topic [1, 2, 3, 4] involving complex processes and the use of technical terms causes some of the concepts in respiration difficult to learn and lead to information storage temporarily while in the classroom [5, 6]. Matriculation (pre university) students who failed to remember the concepts in the respiration, had a low score in a achievement test. Students score low because they can not connect two or more concepts of cell respiration in a whole structure of respiration [6]. Matriculation lecturers just emphasize the transfer of information or facts to students using traditional techniques simply to answer the tutorial questions because the time allocated is quite short to finish the syllabus. Consequently, the integration of robot gaming in the process of learning can open up new dimensions so that students can mastery the content of respiration topics by getting high scores in achievement tests.

**Research Objective:** In this research the researcher will investigate the effect of using robot games on performance of students through three periods of time. Here are the research objectives set by the researchers

- Identify the difference in the mean score of the achievement test within the three periods of the treatment group.
- Identify the difference in the mean score of the achievement test within the three periods of the control group.

**Research Questions:** Based on the objectives of the study, this study aims to answer the following questions:

- Is there a difference in the mean score of achievement test in the three periods of the treatment group?
- Is there a difference in the mean score of achievement test in the three periods of the control group?

**Hypothesis:**

- There was a significant difference in the mean score of respiration achievement test in three periods of treatment group.
- There was a significant difference in mean score of respiration achievement test in three periods of time for control group.

**Game Theory:** The game theory contains psychological concepts primarily related to motivation, behavior and personality [20]. The game is a concept design that combines many learning theories such cognitive theory, Piaget's cognitive theory, Vygotsky's social constructivism theory and the expectation-value motivation theory [21]. The combination of these many theories makes a mechanical game to students motivation to achieve the desired objectives especially involving achievement test [21]. The game-based learning environment has differences with other learning genres and needs to be described in unique models or theories [22, 23]. Game-based learning process design should have the elements of behavior, cognitive and constructivist [24]. A game-based learning activity needs to undergo a transition from behavior, cognitive to constructivist in order to reinforce the knowledge, skills and values among students [21]. The game theory combines many theories of learning act as catalysts to the learning process that facilitates information processing involving short-term memory to long-term memory more comprehensive especially involving abstract topic such as respiration [11]. The game design process begins by preparing a task that the student has to perform and sets the reward or punishment after the student completes the assigned task [25]. In addition, teachers need to provide staged game levels with each level increase, the level of difficulty will increase [26]. This creates an active learning environment as it creates a healthy competition among students. In this study, the respiration robotic gaming has three levels of gameplay involving major processes in respiration glycolysis, Kreb cycle and electron transport chain. The respiration robotic gaming design is based on a combination of Piaget's cognitive theories, Vygotsky's social constructivism theory, information processing theory and predictive-value motivation theory. The diagram and table below show the integration of these theories in the design of this learning.
Table 1: Game Description Level 1 & 2

<table>
<thead>
<tr>
<th>Instruction</th>
<th>Description and Theory</th>
</tr>
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<tbody>
<tr>
<td>The students will be divided into small groups of three groups of students</td>
<td>Effective communication between students (in groups) is needed to solve problems</td>
</tr>
<tr>
<td>Students need to discuss to arrange molecules in glycolysis/kreb cycle / electron transport chain</td>
<td>Students need to discuss dividing tasks to solve the game</td>
</tr>
<tr>
<td>Each molecule coding in the S4A software has specific movement instructions</td>
<td>Use of S4A software. Students need to have good computer usage level (computer literacy)</td>
</tr>
<tr>
<td>The movement of the robot will depend on the order of the molecules in glycolysis/kreb cycle / electron transport chain that has been discussed among students.</td>
<td>Students need to remember processes in cell respiration</td>
</tr>
<tr>
<td>Correct arrangement of molecules/structure in glycolysis/kreb cycle / electron transport chain allows the robot to reach the finish line.</td>
<td>Learning major concepts in cell respiration involves robots (objects that exist)</td>
</tr>
<tr>
<td>If the robot does not reach the ending point, the students will need to repeat until the robot reaches the ending point</td>
<td>Repetition (punishment) if the robot did not reach finish line</td>
</tr>
<tr>
<td>The group of students whose robot is up to the fastest will be declared the winner</td>
<td>Students will recall all concepts or facts in cell respiration</td>
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</tbody>
</table>

Table 2: Game Description Level 3

<table>
<thead>
<tr>
<th>Instruction</th>
<th>Description and Theory</th>
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<tbody>
<tr>
<td>The students will be divided into small groups of three groups of students</td>
<td>Effective communication between students (in groups) is needed to solve problems</td>
</tr>
<tr>
<td>Each group gets 10 question card (based on the glycolysis, kreb cycle and electron transport chain) representing certain stops.</td>
<td>Students need to discuss the tasks to complete the game</td>
</tr>
<tr>
<td>The students will choose the answer and the robot movement represents the chosen answer</td>
<td>Use of S4A software. Students need to have good computer usage level (computer literacy).</td>
</tr>
<tr>
<td>Students must choose the route based on the given question card</td>
<td>--Students need to remember processes in cell respiration</td>
</tr>
<tr>
<td>If the students choose the wrong answer for each stop, then the robot will not get to the finish line</td>
<td>Learning major concepts in respiration involves robots (objects that exist)*</td>
</tr>
<tr>
<td>The group of students whose robot reaches the right and fastest at finish line will be declared the winner.</td>
<td>Piaget constructivism theory</td>
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<td></td>
<td>Operant Conditioning Theory</td>
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</table>

MATERIALS AND METHODS

The study is quantitative and experimental research is the only type of research that can test the hypothesis to determine the causal relationship [27]. Researchers in this study chose a quasi-experimental method that deliberately planned to impose treatment on samples. Quasi experimental are often used in educational studies for two main reasons assessing the effectiveness of intervention and expanding resources in specific issues [28]. In this study, pre test was used to determine the differences between experimental group and control performance score. Low difference in pre-test score between these two groups indicates they have many of the same characteristics [29]. Two post-test (post 1 and post 2) were used to measure students' performance in respiration involving three periods of time.

Sample: In this study, the population to be selected consists of matriculation students of the Matriculation Division of the Ministry of Education Malaysia (BMKPM) who took the Biology subject involving 10 matriculation colleges. Researchers use a non-probability sampling method with purposive sampling techniques. Sampling aims can be used for studies that want to see the effectiveness of an intervention or program [30]. In addition, this type of sampling allows researchers to select samples that can provide researchers with information, knowledge or experience [30]. The sample of the study involved 695 students one year module 1 and 3 involving three colleges Kedah Matriculation College, Perlis Matriculation College and Perak Matriculation College.

Instrument: Pre test, post 1 post 2 contains 40 objective questions and 4 structural questions that need to be
answered within 90 minutes. To ensure that students are not able to recall the answers given during the pre-test, post 1 & 2 test items will differ and the order of choice will be rearranged. In addition, some post 1 & 2 test questions will be modified but still in the same level as the pre-test. All questions developed by the researchers will be reviewed by two biologists who have been appointed by BMKPM. They have been teaching for 20 years. This is to enable all questions that have been developed by the researchers within the scope of content in matriculation.

In addition the researcher ensures that all questions represent the entire cognitive domains within Bloom's Taxonomy's current edition of the latest revision Andersen et al. [18] remembering, understanding, applying, analyzing, evaluating and creating. The question will be concentrated on the level of remembering as parallel to the question of study to improve student achievement in respiration. Students need to remember these abstract concepts to enable them to link the entire respiration comprehensively. Table 3 shows the entire pre test items for measuring understanding of respiration according to Bloom's cognitive domain revisions. Researchers also determine the difficulty index and discrimination index of each item of objective questions in pilot study. Difficulty Index (F) is the percentage or frequency of students who answered the item correctly [31]. The greater the value of F, the more easily the item and otherwise the item is considered to be difficult if it has a low F value. This study uses the F value recommended by the Macintosh [32] interpret the good F value is between 0.4 to 0.6. According to him these are in the middle balance value of left and right. The F values are below 0.4 are categorized as difficult and exceed 0.6 are categorized as easy and should be removed from a set of study questions. The discrimination index (D) is a comparison of high performing students with low performing students [33]. The high discrimination index (D) indicates that the students give different answer variants if the lower D value indicates the variability of the less answer among the students [34]. This study uses the recommended value of D by Macintosh & Morrison [32] which states that good D value and can be included in the set of study questions is greater than 0.4 while the value D between 0.20 to 0.39 is categorized moderately and less than 0.2 categorized as negative. In the pilot study conducted 12 items of objective questions should be removed from the set of questions because they do not have good F and D values as suggested by Macintosh & Morrison [32].

Furthermore, researchers use two methods of measurement of reliability testing namely the Kuder-Richardson Formula 20 (KR20) method for objective questions and interrater reliability methods for structured questions. KR20 is a measure of internal reliability involving the selection of dichotomy [34]) interrater reliability methods is refers to the degree of consistency of the assessment between two expert assessors [34]. Researchers conducted pilot tests on 70 Matriculation College students in Kelantan and the data obtained were analyzed using the KR20 method because the difficulty index of objective item items was different. The KR20 value of 40 items of objective questions is 0.83. According Fraenkel and Wallen [35], a good coefficient of reliability for research purposes should be at least 0.70 or greater. Researchers also use four structural questions with each question bringing 10 marks with 40 maximum marks. Hence the reliability of two expert assessors should be made to ensure the answer scheme for each question is reliable. The two expert assessors will examine a sample response of 70 people and both the total item scores for each student are then compared to using the formula to ensure the consistency of the same score is given by both experts. The reliability value of the assessor obtained was 82.8%. If the reliability ratio between the assessors obtained from the formula is 90% and above then the reliability between the assessors is high and if the score obtained is 40% and below the level of reliability is low [36]. Therefore, in this study, all structural questions constructed have high reliability (82.8%). In addition, the scores were analyzed using the SPSS data analysis to find the reliability and the value of agreement between the two inspectors using the Cohen Kappa Index method. The value of the Cohen Kappa coefficient obtained is at the level of 0.80, which is at a very good level of agreement [37]. Therefore, the reliability analysis of all items in the pre-subjective (subjective and objective) test designed by the researcher is suitable for use as a research instrument to see the effects of intervention on the achievement of respiration.

**Tool:** There are two of the most important research tools of robots and software that drive robots. Robots used by researchers are robots COMEL, while S4A software is used for coding processes.

**Comel Robot:** The COMEL Robot is designed by combining components in the open market. COMEL Robot can perform the same functionality as LEGO robots...
(often used in education) but at much cheaper prices. Researchers use 50 robots from Community Education Robotics Education (CERA) who have been funded by the Ministry of Science, Technology & Industry (MOSTI) for the development of COMEL Robot.

**S4A:** The S4A software is available for free on-line that will be used for coding of robot movements. The use of this software is simpler than any other software. However, such facilitators and students need to undergo the training set out in this study to enable the play of well-functioning and effective.

**Procedure:** Most experimental quasi studies are carried out within 8 to 16 weeks [38] 8 week, [39] 10 week, [40] 12 week and [40] 16 week. Hence the duration of the study was 13 weeks involving pre-test, 9 interventions, post 1 & 2 test.

<table>
<thead>
<tr>
<th>Week</th>
<th>Description</th>
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<tbody>
<tr>
<td>Week 1</td>
<td>Introduction of robot components and S4A software to lecturers.</td>
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<tr>
<td>Week 2</td>
<td>Prt test</td>
</tr>
<tr>
<td>Week 3</td>
<td>Glycolisis 1</td>
</tr>
<tr>
<td>Week 4</td>
<td>Glycolisis 2</td>
</tr>
<tr>
<td>Week 5</td>
<td>Glycolisis 3</td>
</tr>
<tr>
<td>Week 6</td>
<td>Kreb cycle 1</td>
</tr>
<tr>
<td>Week 7</td>
<td>Kreb cycle 2</td>
</tr>
<tr>
<td>Week 8</td>
<td>Kreb cycle 3</td>
</tr>
<tr>
<td>Week 9</td>
<td>Electron transport chain 1</td>
</tr>
<tr>
<td>Week 10</td>
<td>Electron transport chain 2</td>
</tr>
<tr>
<td>Week 11</td>
<td>Electron transport chain 3</td>
</tr>
<tr>
<td>Week 12</td>
<td>Post test 1</td>
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</table>

**RESULT**

**Descriptive Statistics Analysis Min Score:** It is found that the mean score of the achievement test (pre, post 1 & 2) obtained after the student following the entire experimental study is 135.09 with the standard deviation of 12.78. Meanwhile, the minimum score and the maximum score for achievement tests (pre, post 1 & 2) min score is 96 and 171. The results of the analysis showed that the mean score of treatment groups was relatively higher (M=61.62, S.P=7.57) when compared to the control group (M=46.23, S.P=8.71)

**Inference Statistics Analysis:** Repeated measure ANOVA is used to investigate the effects of using a game robot on the score of the achievement test. Before testing the hypotheses related to the variables dependent on the mean score of the students' achievement test, the researchers conducted a series of tests to ensure that the requirements of the repeated measure ANOVA were fulfilled ie the normalization and homogeneity of the sample. The normality distribution of the achievement test min score by looking at the value of skewness and kurtosis. Pre-test score (-0.357, -0.110), post1 (-0.373, 0.096) and post 2 (-0.278.0.259), are between -1 and 1 respectively. The value of skewness and kurtosis is considered to approach zero if it is between -1 and 1 which leads to the conclusion that the shape of the mean score distribution of the achievement test is likely to approach normal. Pre test was used as a test to determine the homogeneity of the sample with t-test of independent samples conducted to differentiate the mean score of the treatment and control group achievement test for pre test. The results showed that there was no difference between treatment group and control group for pre test with p = .055. This p value exceeds 0.05 significant level of a study which states that there is no difference in a group [41]. This shows that there is no significant difference between the mean score of the achievement between the treatment group and the control group for pre-test.

**Hypothesis Testing 1:**

- There is a significant difference in the mean score of the respiration achievement test in three periods of treatment group.

Alternative hypotheses are accepted with Wilk's Lambda = .046, F (2, 472) = 4916.10, p <.05 with multivariate Partial Eta Squared = .954. The output of a multivariate test containing Wilk's Lambda and Partial Eta Squared values. The value of Wilk's Lambda = .046 with a probability value of .000 (which means a value less than p <.05). The researchers looked at Partial Eta Squared value given in the multivariate test box output. The value obtained is .954. Tests of within subjects contrast showed that the comparison between post-test
pre-test [F (1, 473) = 8939.01, p <.05] and post 1-exam post-test [F (1, 473) = 568.169, p <.05]. The mean score of achievement test of respiration in post 1 test score and post 2 test score (post test 1 mean score = 68.35; post test 2 mean score = 71.42) that outperform pre test min score (pre test mean score = 45.09) shows that robot gaming learning process in respiration improving the performance of group of treatment students. These results are also shown pairwise comparison which shows a significant difference for each test pair after the Type I error is controlled by the Bonferroni method.

**Hypothesis Testing 2:**

- There is a significant difference in the mean score of the respiration achievement test in three periods of treatment group.

Alternative hypotheses are accepted with Wilk's Lambda =.591, F (2, 219)=75.709, p<.05 with multivariate Partial Eta Squared = .409. The output of a multivariate test containing Wilk's Lambda and Partial Eta Squared values. The value of Wilk's Lambda = .591 with a probability value of .000 (which means a value less than p <.05). The researchers looked at Partial Eta Squared value given in the multivariate test box output. The value obtained is .409 shows that the differences is not base on the learning material. Tests of within subjects contrast showed that the comparison between post-test pre-test [F (1, 220) = 77.28, p <.05] and post 1-post test [F (1, 220) = 118.60, p <.05]. However, such a decrease in the mean score of the respiration test on post 1 and the post 2 test (the post 1 test mean score = 48.02; the post 2 test score min score = 45.01) with the pre test min score also overcome the min score of post 2 exam pre test = 45.09) showed that the traditional learning process in respiration learning process was ineffective in improving the performance of the group of treatment students. These results are also shown in pairwise comparison which shows no significant difference between the post 2 test.

**DISCUSSION**

The findings reveal that there has been a significant change in student achievement for both groups of students treatment and control. However base on size effect shows that the group of treatment students has a high impact towards learning materials. The findings of this study are in line with the study conducted by Faazlilan [27] that the use of multimedia in the topic of cell respiration improves student achievement in the tutorial class for matriculation students. This shows that intervention of respiration learning process that involves the latest technology has a positive impact on student achievement.

**CONCLUSION**

The use of game robots in abstract topics such as respiration has a positive impact on student achievement. Hence the use of this game robot needs to be extended to other subjects, especially involving an abstract process or concept.

**REFERENCES**


