
The Effect of Android Game-Based Learning Media on Student Learning Outcomes in Terms of Self-Directed Learning

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Abstract

The aim of this study was to investigate the effect of android-based game learning media on student learning outcome in terms of self-directed learning. This study conducted in experimental research using two-way Anova design with student learning outcome as the dependent variable. The independent variable in this study is the use of Android game-based learning media in acid and base. A total 45 students at SMA N 2 Wonosari participated in this study, consisting of 21 students in the experimental group and 24 students in control group. This sample drawn by cluster random technique. The treatment group received learning with the assist of android game-based media while the control group only used textbooks conventionally. Student learning outcomes are measured using multiple choice questions. This instrument was tested before being used to examine the validity and reliability. To test the hypothesis analysis of variance test was being carried out. Result for the main hypothesis shows that there are differences between experimental group and control group on student learning outcome. Class that used android game-based learning media gain higher cognitive learning outcome than the conventional class. There are no differences in student learning outcome at any level of student self-directed learning. Also there are no interaction between student self-directed learning and student learning outcome.

Keywords: android game-based learning; chemistry learning; digital learning; self-directed learning; student learning outcome

Abstrak

Tujuan penelitian ini adalah untuk mengetahui pengaruh media pembelajaran game berbasis android terhadap hasil belajar siswa ditinjau dari self-directed learning. Penelitian ini dilakukan dalam bentuk penelitian eksperimen dengan menggunakan desain Anova dua arah dengan hasil belajar siswa sebagai variabel terikat. Variabel bebas dalam penelitian ini adalah penggunaan media pembelajaran asam basa berbasis game Android. Penelitian ini diikuti oleh 45 siswa SMA N 2 Wonosari yang terdiri dari 21 siswa pada kelompok eksperimen dan 24 siswa pada kelompok kontrol. Sampel ini diambil dengan teknik cluster random. Kelompok perlakuan mendapat pembelajaran dengan bantuan media game berbasis android sedangkan kelompok kontrol hanya menggunakan buku teks secara konvensional. Hasil belajar siswa diukur dengan menggunakan soal pilihan ganda. Instrumen ini diuji terlebih dahulu sebelum digunakan untuk menguji validitas dan reliabilitasnya. Untuk menguji hipotesis dilakukan analisis uji varians. Hasil hipotesis utama menunjukkan bahwa terdapat perbedaan antara kelompok eksperimen dan kelompok kontrol terhadap hasil belajar siswa. Kelas yang menggunakan media pembelajaran berbasis game android memperoleh hasil belajar kognitif lebih tinggi dibandingkan kelas konvensional. Tidak terdapat perbedaan hasil belajar siswa pada tingkat pembelajaran mandiri siswa di semua kelas. Juga tidak terdapat interaksi antara self-directed learning siswa dengan hasil belajar siswa.

Keywords: hasil belajar siswa; pembelajaran berbasis game android; pembelajaran digital; pembelajaran kimia; pembelajaran mandiri

Introduction

Information and communication technology develop rapidly over time, impacted human life in various sectors. In the last five years the use of information and communication technology (ICT) in Indonesia shows gradual change with the most abrupt indicators that can be seen is the use of internet. The population who owns mobilephone is also growing rapidly and this device became the most favourable among people to access the internet. Mobilephone dominated people's choice to access internet with a portion of around 98,70 percent in 2021 and 98,44% in 2022 (BPS, 2023). This major change influences the educational sector inevitably. The way teachers deliver learning began to utilize digital devices in urban and rural areas. Moreover, since the world faced COVID-19, digital learning has increasingly become mainstream. Global pandemic compelled the academic sector to embrace online learning as a means of survival (Nadeem et al., 2023). The use of mobilephone became more prominent in the daily school life, including science learning.

One of the purposes of science education is to help students understand the natural world, using appropriate skills and scientific processes to develop their competencies ((Burrows & Mooring, 2015)). Chemistry as one of the disciplines in science education has been considered to have various difficulties and challenges due to the subject's complex, abstract, and multi-dimensional nature. Digital games are considered to have profound potential to meet these challenges and positively impact students' learning gain and attitudes (Wang et al., 2022). Chemistry material that has been presented in a mobile game will make students more interested and facilitate their understanding of the description of a chemical concept. Gaming activities are a good source of engagement and offer fun learning by providing an instant appraisal for players when tasks are completed

successfully, thereby motivating them to reach higher stages in the gameplay (Cahyana et al., 2017).

To measure the effect of digital game-based implementation, various dimensions can be considered. A commonly used criterion is learning achievement or student learning outcome, which evaluates the extent of learners' progression in their academic performance (Kim et al., 2018). Results from media comparison indicated that digital games significantly enhanced student learning outcomes relative to non-game conditions. This study investigated 209 papers to understand the effect of digital games toward student learning with the results highlighting the affordances of games for learning as well as the key role of design beyond medium (Clark et al., 2016).

Other than learning outcomes, digital game-based learning has a close relationship with self-directed learning skills. Self-directed learning is becoming increasingly important in the twenty-first century due to the rapid changes caused by technological advancement and automation, which necessitate a shift in the learning models adopted by students from a more teacher-directed to a more student-centered pedagogy. Digital games can be leveraged to develop self-directed learning in students because digital play environments are engaging and possess features conducive for independent learning, such as safe spaces and authentic environments (Toh & Kirschner, 2020).

Digital games used for the purpose of learning have been discussed using a variety of terms: digital education game (DEG), serious game, DGBL, DGBLL, game for learning, and DLG (Acquah & Katz, 2020). The use of special-purpose digital games was preferred during education. Based on the planned primary learning outcome, it can be distinguished into three types of special-purpose digital games: (1) knowledge transfer, (2) skill development, and (3) attitude change. Digital game-based learning

is primarily aimed at achieving a certain type of learning outcome, but these goals are not exclusive. Thus, a digital game whose primary goal is to improve students' cognitive learning outcomes can also lead to a change in attitude as a secondary learning outcome (Stewart et al., 2013).

In this study the Android game-based learning was developed by using Macromedia Flash CS 6. The application consist of chemistry content, demonstration, evaluation and games. The games using timer, standard reward whenever player accomplish the task, and hidden reward that put randomly as an element of surprise. The game will end when the player fail three times but sometimes they could gain additional attempt if they get additional live that hidden in random task.

Constructively student learning outcome is a measurement of student progress in their studies which include various things that exist in learning, both knowledge and skill which are then assessed. The changes obtained through learning activities can be said to be learning achievement. Operationally the measurement of student learning outcome is based on result, knowledge, attitudes and discipline (Cecilia & Samuel, 2022).

Student learning outcomes describe what we expect students to know and be able to do. Using active verbs facilitates clear student learning outcomes. Bloom's taxonomy can be used as a guiding framework in the development of student learning outcomes. There are three domains of learning in Bloom's Taxonomy that is cognitive, affective, and psychomotoric domain (Georgia Tech, 2024). This study focused on cognitive domain to be measured.

The cognitive domain is a goal related to thinking abilities including intellectual abilities, starting from memory or recognition of knowledge and information, as well as the development of intellectual skills. Among other modifications, Anderson and Krathwohl's (2001) revision of the original Bloom's taxonomy (Bloom & Krathwohl, 1956) redefines the cognitive domain as the intersection of the cognitive process

dimension and the knowledge dimension. The cognitive process dimension represents a continuum of increasing cognitive complexity from the lower order thinking skill to higher order thinking skill. The six hierarchy began with remember, understand, apply, analyze, evaluate and the highest continuum is create (Heer, 2024).

Self-directed learning skills are important, especially in the twenty-first century, and have been found to be moderately correlated to lifelong learning tendencies (Toh & Kirschner, 2020). The term of self-directed learning can be theoretically linked to the concept of self-regulated learning which focuses on the tendency of students to become independent learners. The students' dependent nature on learning is an aspect that consistently and continuously decreases, so that independent learning is a representation of the result achieved (Kusumawati et al., 2022). Self directed learning is a situation in which learners are in control of the information they experience by way of their ongoing decisions (Gureckis & Markant, 2012).

Student self directed learning is influenced by internal (endogenous) and external (exogenous) factors. Internal (endogenous) factors are related to students themselves both physiologically and psychologically such as mental health, motivation, interest, talent and perseverance. Besides, the external factors (exogenous) are related to the influence of educational milieu, that is the environment, home, and school (Mulyadi and Syahid, 2020).

Through this study we want to investigate the effect of android game-based learning on student learning outcome in term of self-directed learning. To directed the research there an effect of Android game-based learning media on student learning outcomes, an effect of student self-directed learning level on student learning outcomes, and interaction effect between self-directed learning and Android-based game media on students' cognitive learning outcomes.

Method

This study conducted in experimental research using two-way Anova design with student learning outcome as the dependent variable. The independent variable in this study is the use of Android game-based learning media in acid and base. A total 45 students at SMA N 2 Wonosari participated in this study, consisting of 21 students in the experimental group and 24 students in control group. This sample drawn by cluster random technique. The treatment group received learning with the assist of android game-based media while the control group only used textbooks conventionally.

Student self-directed learning level was measured using a questionnaire and then interval score was obtained which was then converted into 3 level ordinal data high, medium, and low. Student learning outcomes are measured using multiple choice questions. This instrument was tested before

being used to examine the validity and reliability.

This research employed quantitative data analysis techniques. Data analysis techniques are activities that are carried out after data from experiment were collected. Statistics are used in quantitative data analysis techniques. Descriptive and inferential statistics were used in this study. Inferential data analysis techniques are performed using two-way anava to testing the hypothesis.

Result and Discussion

The collected data were analyzed using SPSS 26.0 to gain the descriptive statistics of the test and survey results as follows.

Student self-directed learning were categorized into three level, high, medium and low. This classification were made by following the table below (Widoyoko, 2011).

Table 1
Category of Student Self-Directed Learning

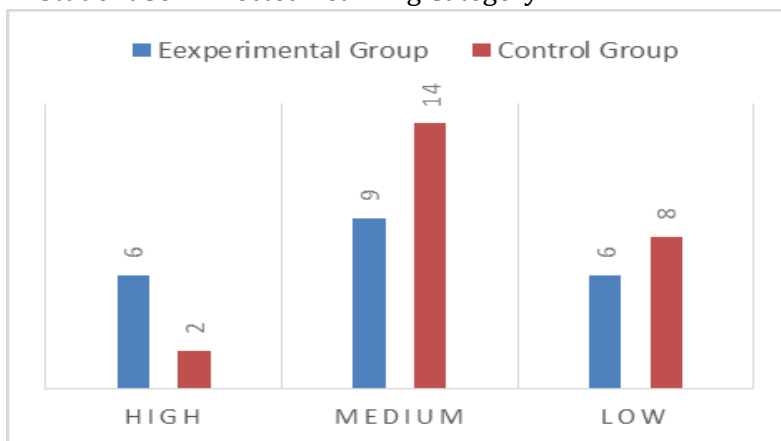
Score Range	Category
$X > X_i + S_{Bi}$	Tinggi
$X_i + S_{Bi} \leq X \leq X_i - S_{Bi}$	Sedang
$X < X_i - S_{Bi}$	Rendah

$X_i = \frac{1}{2} (\text{maximum score} + \text{minimum score})$

$S_{Bi} = \frac{1}{6} (\text{maximum score} - \text{minimum score})$

Based on the formula and criteria above, student self-directed learning level can be classified as follow.

Figure 1
Student Self Directed Learning Category



Most student have medium directed learning level and only few fall into high category. This classification will be use to see how android game-based learning affected student learning outcome.

To gather student learning outcome we conducted test using multiple choice in acid and base matter that consist of 20 number with various level of difficulty. The instrument were validated by expert and being tested to measure the validity and reliability before used. Rasch modeling were

used to calculate the validity and reliability. All item were fit into the model and the reliability of test was 0,81 that can be categorized as high. It means that the instrument was capable and consisten to measure student learning outcome.

The test was given before and after treatmen to both control and experimental group. The result of student learning outcome in acid base matter can be seen below in Table 2.

Table 2
Descriptive Statistic of Student Learning Outcome

Description	Control Group n=24		Experimental Group n=21	
	Pretest	Posttest	Pretest	Posttest
Mean	64.79	70.21	64.76	82.86
SD	12.11	8.66	10.30	6.63
Varians	146.69	74.95	106.19	43.93
Max	85	85	85	95
Min	35	50	45	70

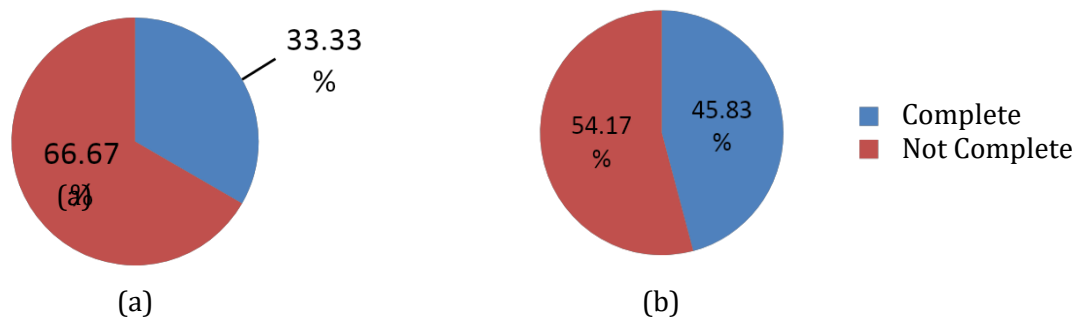
Based on the table, it can be seen that the maximum score for the two classes is the same at 85 point, while the minimum score for the control group is slightly lower by 35 compared to the experimental class, which is 45. The pretest score for cognitive learning outcomes for the control and experimental group is almost the same, 64.79 for the experimental class and 64.76 for the control class with standard deviation values that are also not far apart, 12.11 and 10.30. This shows that the distribution of data in the two classes is almost the same.

The chemistry learning standard score set by the school is 75. When viewed

from the minimum mastery criteria, there were 66.67% of students who did not meet the criteria and 33.33% of students who meet the criteria when working on the pretest questions for the control group. After the posttest was held, the number of mastery scores increased slightly to 45.83% and the number of unmastery scores became 54.17%.

The comparison of chemistry mastery scores during the pretest and posttest in the control class can be seen in Figure 2.

Figure 2
The Proportion of Mastery Learning in Control Group (a) Pretest; (b) Posttest



In the experimental group, the number of incomplete scores during the pretest was 71.43% and the number of completed scores was only 28.47%. After the posttest was carried out, the number of completed scores increased sharply to 91.1%

and the number of incomplete scores became 9.9%. A comparison of chemistry completion scores during the pretest and posttest in the experimental class can be seen in the following Figure 3.

Figure 3
The Proportion of Mastery Learning in Experimental Group (a) Pretest; (b) Posttest

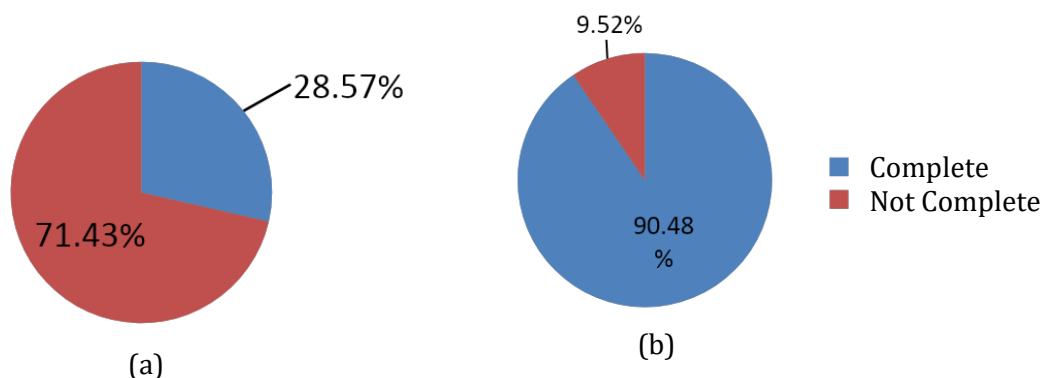


Table 3
Descriptive Statistics

Self-directed	Group	Mean	Std. Deviation	N
Low	Experimental	78.3333	5.16398	6
	Control	66.2500	9.16125	8
	Amount	71.4286	9.69309	14
Medium	Experimental	83.3333	6.61438	9
	Control	73.2143	7.99210	14
	Amount	77.1739	8.89664	23
High	Experimental	86.6667	6.05530	6
	Control	65.0000	.00000	2
	Amount	81.2500	11.25992	8
Amount	Experimental	82.8571	6.62786	21
	Control	70.2083	8.65764	24
	Amount	76.1111	9.99368	45

The table below is a summary of the Analysis of variance table for this research. Before testing the hypothesis, the analysis prerequisites are first tested. There are two prerequisite analysis tests for statistics with an anova design, namely the normality test and the homogeneity test.

The normality test is intended to see whether the data comes from a normally distributed group. The normality test in this study was calculated using the Shapiro-Wilk univariate approach. This test was carried out on each group, both the control group and the experimental group. The test criteria

used are if the significance value obtained is greater than alpha (0.05), then the assumption of normality is met. Based on the test results using SPSS 20, significance values were obtained for each group as listed in the Table 3.

From the Shapiro-Wilk normality test above, the significance value of cognitive learning outcomes for the control class was 0.127 and the experimental class was 0.90. All significance values obtained are greater than α (0.05), so that the normality assumption is met. This means that it can be

concluded that the data comes from a group with a normal distribution.

The homogeneity test aims to test the similarity of the variants of the dependent variable. Data is declared homogeneous if the significance value in the Lavene statistic is greater than α (0.05).

Based on the table from the Lavene statistical test, it is found that the significance value is 0.308, which is greater than α (0.05), so that the assumption of homogeneity is met. This means that it can be concluded that the data comes from groups that have the same variance. After the assumptions of normality and homogeneity are met, hypothesis testing using two-way ANOVA can be carried out. The hypotheses to be tested in this research are as follows.

H_{01} = There are no mean differences in the student cognitive learning outcomes between the experimental class and the control class.

H_{a1} = There are mean differences in the student cognitive learning outcomes between the experimental class and the control class.

H_{02} = There are no mean differences in cognitive learning outcomes between students who have high, medium and low levels of self-directed learning.

H_{a2} = There are mean differences in cognitive learning outcomes between students who have high, medium and low levels of self-directed learning

H_{03} = There are no interaction effect between self-directed learning and Android-based game media on students' cognitive learning outcomes

H_{a3} = There are no interaction effect between self-directed learning and Android-based game media on students' cognitive learning outcomes.

To answer these three hypotheses, a 2-way Anova test was carried out using SPSS 20 with the following results. Based on the test of between subject effects table, this

research hypothesis can be answered one by one, namely as follows.

The hypothesis of the influence of Android-based game media on students' cognitive learning outcomes is shown by the F value of 31.56 with a p-value of $0.000 < 0.05$ or H_0 is rejected. This means that there is a mean difference in the student cognitive learning outcomes between the experimental class and the control class.

The hypothesis of the influence of student learning independence on cognitive learning outcomes is shown by an F value of 2.825 with a p-value of $0.072 > 0.05$ or H_0 is accepted. This means that there is no mean difference in cognitive learning outcomes between students with high, medium or low levels of learning independence.

The hypothesis of the influence of the interaction of Android-based game media and learning independence on students' cognitive learning outcomes is shown by an F value of 1.475 with a p-value of $0.241 > 0.05$ or H_0 is accepted. This means that there is no interaction effect between learning independence and Android-based game media on student cognitive learning outcomes.

Based on the hypothesis testing that has been carried out, only the first hypothesis was accepted, it was the effect of Android game-based media on student learning outcomes. This finding is in line with many previous expert findings which state that the use of game-based digital media can improve students' cognitive learning outcomes (Cahyana et al., 2017; Wang et al., 2022; Yu et al., 2021).

Digital game-based learning has more positive impact on student engagement and motivation compared to traditional activities (Nadeem et al., 2023). The game design of digital game-based learning plays important role in student engagement. One key element of game-based learning that being provided in this study is reward and punishment. When student complete the task they will get point and if they fail three times the game will end. There are also extra point hidden in random task that will give the player an element of hope or surprise. The game began from easy level and increase to

hard level gradually. Other key element that also important to keep student interest is feedback (Serrano, 2019). This element that adopting behaviouristic psychology enhance student engagement that will lead to better learning outcome.

The second hypothesis about the effect of student self-regulated on student learning outcome is rejected, means that there is no difference on student learning outcome in any level of their self-regulated learning. The p-value has very slightly difference with the alpha critical value ($0,07 > 0,05$). This finding is slightly different with some finding before that stating the relationship between self-regulated learning and student learning outcome. Alotaibi (2016) found that there is strong link between student self-regulated readiness and student academic performance. Self-directed learning readiness influence student achievement positively. Self-directed learning co-relation with academic performance is high in students learning via online contrary to that of conventional university students (Khalid et al., 2020)

This contrary finding shows the complexity of self-directed learning as a variable. Game-based learning alone rooting their promise on engagement and motivation. Many scientific studies and reports start from the premise that games are motivating and thus productive for learning. Games are valued for their motivational power, which is ascribed to their dynamic, responsive and visualised nature that goes along with novelty, variation and choice, effecting strong user involvement and provide penetrating learning experiences (Dickey, 2005). Motivation in games is often driven by reward systems, that typically trigger and enhance extrinsic motivation (which is driven by pursued outcomes or external pressure) rather than intrinsic motivation (which is a personal trait of willingness, directly linked to the activity itself) (Westera, 2015). On the other hand self directed learning closely relates to self-regulation, self-efficacy and self-control. It also requires control over learning,

regulation, intrinsic, extrinsic motivation and success during learning activities.

Knowles (1975) as the first person that bringing up self-directed learning (SDL) as a process argues that in SDL, an individual motivates learning intrinsically (Khalid et al., 2020). Game-based learning on the other hand affect student extrinsic motivation more through reward system (Dickey, 2005). This argumentation supported by Neck & Houghton (2006) who stating that natural rewards are intrinsic rewards for task performance. This finding for the rejected hypothesis need further study and investigation.

The third hypothesis about interaction effect between self-directed learning and Android-based game media on students' cognitive learning outcomes also been rejected. It can be predicted because the second hypothesis also been rejected. Because there are no differences in student learning outcome on any level of student self-directed learning, Tukey post hoc test which had previously been planned was not carried out.

Conclusion

This research aimed to investigated the effect of Android game based learning media on student learning outcomes. It was also aimed to test the effect of student self directed learning level on student learning outcomes and the interaction between self-directed learning and Android-based game media on students' cognitive learning outcomes. It was concluded that Android game-based learning media affected student learning outcome positively. Class that used android game-based learning media gain higher cognitive learning outcome. There are no differences in student learning outcome at any level of student self-directed learning. For the third research question, this study find there are no interaction between student self-directed learning and student learning outcome.

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