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Game-Based Learning Kit Method in Isometric Transformations: Usability and Effects on Students' Achievement and Motivation

Siti Munirah Mohd Nasir

Sultan Idris Education University,
MALAYSIA

Zamzana Zamzamid*

Sultan Idris Education University,
MALAYSIA

Nor'ain Mohd Tajudin

Sultan Idris Education University,
MALAYSIA

Sabarina Shafie

Sultan Idris Education University,
MALAYSIA

Norhayati Ahmat

Sultan Idris Education University,
MALAYSIA

Norsida Hasan

Sultan Idris Education University,
MALAYSIA

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Abstract: This study focused on the development of teaching aids for the topic of Isometric Transformations for Form 2 students in Malaysia. The first objective was to determine the usability of teaching aids in the isometric transformations kit integrates game-based learning (GBL) Method (KitTI Method) and the second objective was to examine the effectiveness of using the KitTI Method on students' achievement and motivation. This study was directed by the Design and Development Research (DDR) model with survey and quasi-experimental designs. The sample selection was conducted by cluster sampling involving Form 2 students from schools in the district of Muallim and Batang Padang in the state of Perak. The instruments used were KitTI Method Teaching Aids Usability Questionnaire (KMTAUQ), Isometric Transformations Topic Achievement Test (ITAT), and KitTI Method Motivation Questionnaire (KMMQ). The findings showed that the mean score of KitTI Method's usability was high, the treatment group obtained significantly higher improvement in achievement compared to the control group while the mean scores of pre-test achievement as a covariate and students' motivation in learning Isometric Transformations were high. Therefore, the KitTI Method is suitable to be implemented as a guide for mathematics teachers in designing dynamic teaching and learning and is able to improve students' achievement and motivation.

Keywords: *Game based learning, isometric transformations, mathematics, motivation.*

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Introduction

The curriculum for mathematics subjects in Malaysia's education is consistently changing. Teachers are encouraged to incorporate various pedagogies in their teaching so that students' perceptions of the learning environment, motivation and achievement in mathematics are improved. Appropriate approaches, methods, strategies, and techniques have assisted teachers in comprehensively bridging skill development and understanding of mathematics.

The rapid development of technology in the education system plays an essential role in teaching and learning of mathematics (Ministry of Education Malaysia [MoEM], 2016). As such, appropriate learning methods, such as GBL, should be implemented in teaching and learning sessions in classrooms. According to Kailani and Rohani (2011), GBL helps develop students' mathematical skills and understanding. Moreover, the GBL also stimulated students' interest in mathematics and increased students' creativity and knowledge (Papastergiou, 2009). As stated by Mohd Nor and Idris (2009), GBL helps students solve the problems by providing a more suitable visual representation of the geometric shapes.

One of the Malaysian education system's aspirations is to become one of the top three countries in international assessments such as Trends in International Mathematics and Science Study (TIMSS) before 2028 (MoEM, 2013). However, the public awareness towards science, technology, engineering, and mathematics (STEM) is still unsatisfactory (Mohammad Ayub, 2018). The quality of teaching is a factor that contributed to the difficulty of achieving the 60:40 policy

*** Corresponding author:**

Zamzana Zamzamid, Department of Mathematics, Faculty of Science and Mathematics, Sultan Idris Education University, Malaysia.

✉ zamzana@fsmt.upsi.edu.my



(Mohd Sabri, 2017). Teaching method is an important component of a teaching and learning session that contributes to the effectiveness of the teaching delivered (Jasmi & Tamuri, 2014). In Malaysia, the teacher-centered teaching method is frequently practised by teachers, where the teacher acts as the only individual who provides input in the teaching and learning session in the classroom (Mohd Sabri, 2017; Nik Hassan, 2017). According to Bahador et al. (2019) mathematics teachers need to change their teaching method from the conventional method to the latest or more sophisticated method so that the teaching and learning session becomes more systematic, interesting, and not boring for students.

Some students stated that the teaching and learning of mathematics are not interesting and is a factor to their lack of motivation (Naidoo et al., 2016). According to Albertus et al. (2019), in order to motivate students as well as improve their achievement, effective and interesting teaching of science and technology should be applied. Hence, GBL method is an alternative teaching method to develop motivation in students because according to Perrotta et al. (2013), the game approaches in learning allows students to see a direct impact of their efforts. Previous studies also showed that the game approach increased students' motivation because students are able to enjoy the interactive and fun activities (Faiella & Ricciardi, 2015).

In addition, according to Wong and Osman (2018), studies related to GBL in Malaysia are still poorly conducted and documented especially at the secondary school level for mathematics subjects such as the Isometric Transformations topic. Translation, reflection and rotation concepts are discussed in the topic of Isometric Transformations. Mohd Nor and Idris (2009) stated that typical mistakes made by students are identifying the center of rotation and reflection lines. In addition, students also unable to differentiate between the translation and coordinate notations. According to Milovanovic et al. (2013), students have difficulty in giving a clear visual of translation, reflection, and rotation and thus it becomes more difficult for them to find the relationship between these transformations. Thus, instead of forcing students to memorize all the formulas, it will be better to provide them the teaching aids which are capable of helping the students to explore and have the opportunity to learn mathematics using the concrete materials provided.

This study has successfully developed an Isometric Transformations Kit Integrates GBL Method (KitTI Method) with satisfactory validity (Mohd Nasir et al., 2021). Therefore, in this article, we focus on determining the usability of teaching aids in the KitTI Method and examining the effect of using the KitTI Method on students' achievement and motivation for learning Isometric Transformations. The research questions are:

- (1) Is the mean score of usability of teaching aids in the KitTI Method for the Isometric Transformations topic among Form 2 students in the treatment group high?
- (2) Is there a significant difference in the mean score of the post achievement test of Form 2 students for the Isometric Transformations topic between the treatment group and the control group when the mean scores of pre-achievement test for the Isometric Transformations topic are utilized as a covariate?
- (3) Is the mean score for students' motivation after completing a teaching and learning session using the KitTI Method for the Isometric Transformations topic in the treatment group high?

In this study, we chose the Isometric Transformations topic which is in the Measurement and Geometry learning area in the Curriculum and Assessment Standard Document (DSKP) of the Secondary School Standard Curriculum (KSSM) for Malaysian Mathematics (MoEM, 2016). This is also supported by the need analysis findings which were conducted before the development of the KitTI Method (Mohd Nasir et al., 2020).

Methodology

Research Design

This entire study utilised a quantitative approach (Creswell & Creswell, 2018). The quantitative approach is an approach that uses appropriate questionnaire and test instruments and involves the measurement of study variables through the statistical description (Darusalam & Hussin, 2021). According to Trifandi et al. (2016), the study model is a model that describes the relationship, association, and interaction between the variables in the study. In this study, the research model used was DDR (Richey & Klein, 2007).

DDR is a development model that is often used by researchers in product development studies (Darusalam & Hussin, 2021). DDR is used to design and explore the design innovation of artifacts, models as well as some concrete aspects such as programs, activities, foundations, and curriculum (Alias & Hashim, 2012). According to Richey and Klein (2007), DDR can be defined as a systematic study of the process of design, teaching, and evaluation aimed at creating instructional and non-instructional products or tools or new models.

In this study, a survey design is used because this study involves the process of data collection through the administration of questionnaires and tests. Questionnaires were used to collect needs analysis data, determine the usability score of teaching aids in the KitTI Method, and determine the student's motivation score, while the test was used to determine the effect of using the KitTI Method on the achievement of the Isometric Transformation topic of Form 2 students.

Furthermore, a quasi-experimental design was chosen to test the effects of the developed KitTI Method. A quasi-experimental design was used because in sample selection, random sampling techniques cannot be used completely. The treatment group and the control group were randomly selected, but the samples in these two groups were not randomly selected. This is because the intervention of this study was conducted during the school session in progress where the sample consisted of students in the existing class.

Research Instrument

The data were collected by using three instruments, namely the KitTI Method Teaching Aids Usability Questionnaire (KMTAUQ), Isometric Transformations Topic Achievement Test (ITTAT), and KitTI Method Motivation Questionnaire (KMMQ). KMTAUQ was adapted from the instrument in Suparmin (2016) according to the appropriateness of the KitTI Method which had been developed. In this study, only three constructs were used to build KMTAUQ, namely the construct of usefulness, ease of use, and satisfaction. According to Lund (2001), these three constructs are sufficient to test the usability of a product because the construct of usefulness and the construct of ease of use are mutually influencing and the combination of these two constructs produces more accurate results and subsequently affects user satisfaction. There are 17 items in the KMTAUQ. For each item, students need to express their agreement according to the 4-point Likert scale provided. This scale is represented by 1 for strongly disagree, 2 for disagree, 3 for agree, and 4 for strongly agree.

The instrument used to test student achievement in Form 2 Mathematics subjects for Isometric Transformations is ITTAT. Since the ITTAT was administered to the same students but at different times, i.e., before and after the implementation of the teaching and learning session, this study provided two equivalent sets of ITTAT with the aim of reducing the threat of testing. To facilitate the discussion, the acronyms Pre ITTAT and Post ITTAT are used where they represent the Isometric Transformation Topic Pre-Achievement Test and the Isometric Transformation Topic Achievement Post Test respectively. Pre ITTAT and Post ITTAT have the same number of questions which are eight questions, while the content of each corresponding question is equivalent. Equivalent question content means the questions are similar, but either have different letters, numbers or figures. The construction of the ITTAT is based on the questions found in the Form 2 Mathematics textbook (Baharam et al., 2017), the Form 2 Mathematical Literacy book (Gan & Chong, 2018), and the revised Bloom's (2001, as cited in MoEM, 2019) taxonomy. Eight questions in ITTAT are subjective and students are required to answer all questions. The total score for this test is 40 marks while the time allocated for students to answer the ITTAT is one hour.

KMMQ was adapted from the Intrinsic Motivation Inventory (IMI) instrument by Ryan (1982) which was translated by Baharudin (2017) using the back to back translation method and this translation has obtained expert validity. The translation using this method aims to obtain accuracy, meaning, and sentence structure. According to Ryan, the IMI is an instrument that aims to assess the subjective experience of the participants related to the target activity in an experiment. In this study, KMMQ was only administered to students in the treatment group after they learned the Isometric Transformation topic using the KitTI Method. KMMQ contains six constructs which are interest or pleasure, perceived competence, effort or interest, pressure, value or usefulness, and relationship. The constructs of interest or pleasure and value or usefulness are represented by seven items, six items represent the construct of perceived competence, five items represent the construct of effort or interest and the construct of pressure, and finally eight items represent the construct of relationship. The KMMQ format is a closed questionnaire. Each item is followed by an answer space marked with a 7-point Likert scale so that students can express their level of agreement with the given items. The scale indicator for this Likert scale is 1 for not true at all to 7 for very true.

In this study, the types of validity used to verify each research instrument are face validity and content validity. The validity of each instrument was determined by two experts. According to Waltz et al. (2010) and Polit and Beck (2006), the number of experts accepted to assess validity is at least two experts. The selected experts are experts in the field of Mathematics Education, module and model development, pedagogy, or instrument construction. Two instrument validity experts played a role in determining face validity and content validity for each study instrument. The face validity items evaluated for each instrument are from the aspects of format, instructions, common words, and appropriateness of font, spelling, grammar and terminology. Items for content validity are evaluated based on items that represent each variable in the research instrument.

In order to check whether the research instrument in this study had satisfactory content validity, this was determined through the value of the Content Validity Index (CVI) recommended by Lynn (1986). The CVI values for the face validity and content validity of the KMTAUQ, Pre ITTAT, Post ITTAT, and KMMQ instruments were 1.000, 0.889, 1.000, and 1.000 respectively. Therefore, all these instruments had satisfactory validity. The reliability of the KMTAUQ, ITTAT, and KMMQ study instruments was obtained through a pilot study on 47 students from the study population who were not involved in the actual study. The data obtained from this pilot study were analyzed to determine the value of the reliability coefficient which is Cronbach's alpha. Cronbach's alpha values for the KMTAUQ, ITTAT, and KMMQ instruments were .875, .755, and .895 respectively. Therefore, all these instruments had satisfactory reliability.

Sample and Data Collection

One of the 23 secondary schools in Muallim and Batang Padang districts in the state of Perak was randomly selected to be used as the study location. Hence, the study population consisted of all Form 2 students at a secondary school in Muallim and Batang Padang districts. The sampling technique used to select the study sample was the cluster random sampling technique. This technique is suitable if the sample is selected according to the group (Sharma, 2017). According to Idris (2013), cluster random sampling is like random sampling where a group is randomly selected instead of an individual, while each individual in the selected group is sampled. This technique is appropriate to be used because according to she stated that this technique can save on research time as the population of this study were all Form 2 students in one school. Furthermore, according to Creswell and Creswell (2018), simply classifying randomly selected students into two groups can disrupt class learning.

Existing groups of students were each categorized according to class. Two classes were selected through the cluster random sampling technique to be nominated as the treatment group and the control group. Finally, one class from the two classes which had been selected was chosen again through a simple random sampling technique to be used as the treatment group, while the unselected class was used as the control group.

There are 51 students in the study sample which was a total of 31 students in the treatment group and 20 students in the control group consisting of Malay students. There were no Chinese, Indian or other respondents. Out of a total of 51 respondents, a total of 24 respondents were male students and 27 respondents were female students. In the treatment group there were 12 male respondents and 19 female respondents, while in the control group there were 12 male respondents and eight female respondents. All of them had studied all topics in Form 1 Mathematics subjects as well as Polygons and Coordinates topics in Form 2 Mathematics subjects, but they had not learnt the Isometric Transformations topic. The study sample in the treatment group and the control group were of approximately the same age to avoid the threat of maturity. This sample was Form 2 students who were around 14 years old. The student's math achievement level was more or less the same based on the score analysis report when the student was in Form 1. The student's socioeconomic level was moderate according to the student's personal data information.

The implementation of the quasi-experiment began with a discussion session with the principal and teachers involved in the actual study. After the teacher had verbally agreed to be involved in the actual study, the principal issued a letter of appointment to the teachers and observers. The teacher involved filled out the teacher consent form provided. Then, the KitTI Method and the lesson plans for the conventional method were handed over to the mathematics subject teachers who were involved as teaching teachers and observing teachers for the independent reading and the research process within a week. In addition, a detailed explanation of the KitTI Method and the lesson plans of the conventional method as well as an explanation of the purpose of the study were also given to the teachers. The quasi-experimental study was started by administering the Pre ITTAT to students in both the treatment group and the control group.

Next, the teaching and learning sessions for nine lesson plans were conducted for three weeks with a total of nine hours of teaching time. This teaching and learning session was conducted by two teachers each on students in the treatment group using the KitTI Method and on students in the control group using the lesson plans of the conventional method. The observation of the teacher's teaching in both the teaching and learning sessions of the treatment group and the control group was carried out by other mathematics teachers to ensure that the teaching and learning sessions carried out by the instructors were in line with the lesson plans provided. This was done in order to avoid the bias of the teacher who taught the sessions. The observing teachers filled in the observation form during the teaching and learning session and the observation certificate form which was provided for both the treatment group and the control group.

After all the teaching and learning sessions were completed, the next day the KMTAUQ, Post ITTAT, and KMMQ were administered to the treatment group, while only the Post ITTAT was administered to the control group. The administration of KMTAUQ, Post ITTAT, and KMMQ were not conducted on the same day as the ninth teaching and learning session because according to Gay et al. (2012), test results administered immediately after completion of the intervention did not accurately reflect the treatment effect. According to Novak (1998), most of the information learned by rote during teaching and learning sessions at school will disappear within eight weeks. Therefore, in this study, the time considered appropriate to determine the usability of teaching aids in the KitTI Method by students as well as to study the effect of the KitTI Method on the achievement of the title of Isometric Transformation and student motivation is one day after all teaching and learning sessions for three weeks have been completed. The data obtained from the administration of KMTAUQ, Pre ITTAT, Post ITTAT, and KMMQ were then analyzed.

Therefore, there were two things that should be considered before conducting this quasi-experimental study, namely the threat of internal validity and external validity. The types of interference with internal validity which needed to be controlled in this quasi-experimental study were history, maturity, testing, instrumentation, statistical regression, selection, mortality, sample behavior, and implementation. This study also took into account several threats that could affect external validity when the experiment was conducted, namely the interaction of pre-test and treatment, the interaction of selection and treatment, the interference of multiple treatments, and the specialization of variables.

Analyzing of Data

The data collected through the administration of research instruments were analyzed with the help of Statistical Package for Social Sciences (SPSS) software version 23. The statistical analysis used was descriptive statistical analysis and inferential statistical analysis. The data for the quasi-experimental design study conducted was analyzed to answer the first, second, and third research questions (RQs). The second RQ was answered through the research hypothesis, which was created. This could be resolved with the help of Analysis of Covariance (ANCOVA) inferential statistics. Before implementing the ANCOVA test, according to Chua (2014), the basic conditions for the use of the ANCOVA test should also be reviewed. The basic conditions of the ANCOVA test were from the aspect of sample size, variance equality, data normality, linear data, and regression equality.

The first and third RQs were answered through the fixed research hypothesis. The test value set for the mean usability score was 42.500 while the hypothetical median value set for the mean motivation score was 152.000. Before the one sample t-test was implemented, the assumptions of the t-test needed to be tested, namely from the aspect of measurement scale, sampling type, and data normality (Chua, 2006). A one sample t-test was used to determine whether the two research hypotheses were rejected or failed to be rejected. The significance level of the one sample t-test was set at five percent (.05). If the obtained p value was less than .05, then the research hypothesis was rejected. On the other hand, if obtained p value was greater than or equal to .05, then the research hypothesis was not rejected. However, if the characteristics of data normality were not met, then a non-parametric test would be used to answer the second and fourth RQs. According to Bluman (2009), a non-parametric test that is an alternative to the one sample t-test is the one sample Wilcoxon signed-rank test. In summary, the selection of appropriate data analysis methods for this study was based on the RQs and research instruments as shown in Table 1.

Table 1. Summary of Statistical Analysis

No.	Research Questions	Research Instruments	Analysis Methods
1	Is the mean score of usability of teaching aids in the KitTI Method for the Isometric Transformations topic among Form 2 students in the treatment group high?	KMTAUQ	One sample t-test
2	Is there a significant difference in the mean score of the post achievement test of Form 2 students for the Isometric Transformations topic between the treatment group and the control group when the mean scores of pre achievement test for the Isometric Transformations topic are used as a covariate?	Pre ITTAT and Post ITTAT	ANCOVA
3	Is the mean score for students' motivation after completing a teaching and learning session using the KitTI Method for the Isometric Transformations topic in the treatment group high?	KMMQ	One sample Wilcoxon signed-rank test

Findings / Results

The findings of this study were described according to the RQ of this study, which were the usability of KitTI Method and effectiveness of KitTI Method on students' achievement and motivation, respectively.

RQ1: Is the mean score of usability of teaching aids in the KitTI Method for the Isometric Transformations topic among Form 2 students in the treatment group high?

The data analysis method used to answer RQ1 was one sample t-test. The data were analysed based on the results of KMTAUQ which contained 17 items and used a 4-point Likert scale. Thus, the test value for the mean score of usability of teaching aids in the KitTI Method was 42.500. The one sample t-test results are shown in Table 2. Based on Table 2, the t -value for the mean score of usability of teaching aids in the KitTI Method was [$t(30 = 33.339, p < .05)$]. This significance level was less than $p = .05$. Thus, the mean score of usability of teaching aids in the KitTI Method for the Isometric Transformations topic among Form 2 students in the treatment group was considered as high.

Table 2. One Sample t-Test Result for the Mean Score of Usability of Teaching Aids in the KitTI Method

	t	df	Sig. (2-tailed)	Mean Difference	Test Value = 42.5	
					95% Confidence Interval of the Difference	
					Lower	Upper
Mean Score of Usability	33.339	30	.000	20.72581	19.4562	21.9954

RQ2: *Is there a significant difference in the mean score of the post achievement test of Form 2 students for the Isometric Transformations topic between the treatment group and the control group when the mean scores of pre achievement test for the Isometric Transformations topic as a covariate?*

The data analysis method used to answer RQ2 was the ANCOVA test. The independent variable was the teaching method (KitTI Method, conventional method), and the dependent variable was the mean score of Post ITTAT. The mean score of Pre ITTAT was used as the covariate in this analysis. The achievement of isometric transformations topic was analysed based on the achievement scores of students in the treatment group and control group using ITTAT.

The results of the ANCOVA test in Table 3 showed that there was a significant difference between the two groups on the mean score of Post ITTAT [$F(1,48)=4.184, p<.050$]. These results showed that there was a significant impact by the teaching methods used in the treatment group and control group on the mean score of Post ITTAT.

Table 3. ANCOVA Result

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	173.713 ^a	2	86.857	2.379	.103	.090
Intercept	5404.301	1	5404.301	148.035	.000	.755
Pre ITTAT	34.908	1	34.908	.956	.333	.020
Group	152.744	1	152.744	4.184	.046	.080
Error	1752.326	48	36.507			
Total	23999.000	51				
Corrected Total	1926.039	50				

a. R squared = .090 (Adjusted R Squared = .052)

These results indicated that there was a significant difference in the mean score of Post ITTAT between the treatment group and the control group when the mean score of Pre ITTAT was used as a covariate.

RQ3: *Is the mean score for students' motivation after completing a teaching and learning session using the KitTI Method for the Isometric Transformations topic in the treatment group high?*

The effect of the KitTI Method on students' motivation was measured based on the KMMQ results after students in the treatment group completed all the teaching and learning session using the KitTI Method. The data analysis method used to answer RQ3 was one sample Wilcoxon signed-rank test because the Shapiro-Wilk test results showed the score data was not normally distributed. Since the KMMQ instrument contained 38 items and used a 7-point Likert scale, the hypothetical median for the score of students' motivation was 152.000.

The Wilcoxon signed-rank test results in Table 3 showed that at a five percent significance level, there was enough evidence to reject the null hypothesis ($p<.050$). Moreover, the sample median value (245.000) was higher than the hypothetical median (152.000) as shown in Figure 1. Therefore, it can be concluded that the mean score for students' motivation after completing a teaching and learning session using the KitTI Method for the Isometric Transformations topic in the treatment group was considered as high.

Table 4. Wilcoxon Signed-Rank Test Result for the Score of Students' Motivation

Null Hypothesis	Test	Sig.	Decision
The median of mean motivation equals 152.000	One-sample Wilcoxon Signed-Rank Test	.000	Reject the null hypothesis

Asymptotic significances are displayed. The significance level is .05.

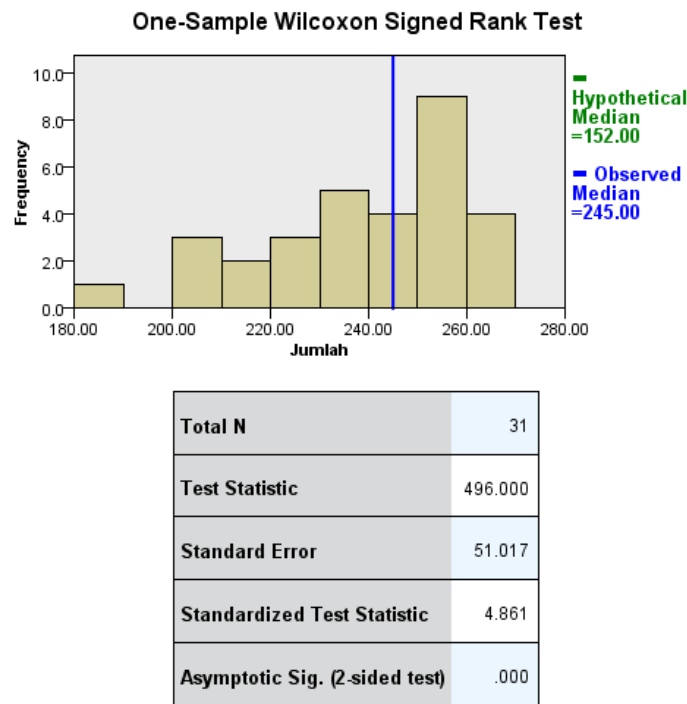


Figure 1. Median Wilcoxon Signed-Rank Test for the Score of Students' Motivation

Discussions

Usability of Teaching Aids in the KitTI Method

The findings of the study showed that the mean score of the usability of teaching aids in KitTI Method for the Isometric Transformations topic among Form 2 students for the treatment group was high. This finding indicated that teaching aids in the KitTI Method was suitable for use by Form 2 students in mastering the topic of Isometric Transformations. This was because the teaching aids developed were compatible with activities that integrate GBL in the classroom. In-class activities which are fun and require student involvement can help create an active atmosphere throughout the teaching and learning session. This finding is in line with the study of Khalid (2019) when the usability of the developed STEM teaching module obtained a high percentage of agreement. This study is also in line with the study of Ali and Mahamod (2016) who found that teaching and learning sessions should not take place passively, but should be actively constructed by students themselves through concrete materials, and in the context of the study, the concrete materials developed are teaching aids.

In addition, the research findings showed that teaching aids in the KitTI Method can achieve learning outcomes, is easy to use, and gives satisfaction to students. This is because, the applicability of teaching aids in the KitTI Method was determined based on the student's perception when giving feedback on the items found in the KMTAUQ instrument, that was after undergoing a teaching and learning session using the KitTI Method. This instrument contains three constructs, namely the construct of usefulness, ease of use, and satisfaction. The usefulness construct focuses on whether the teaching aids criteria in the KitTI Method can achieve the desired learning outcomes. The ease of use construct focuses on the convenience of students using teaching aids in the KitTI Method while the satisfaction construct focuses on the comfort and positive attitude of students towards teaching aids in the KitTI Method. These three constructs are suggested by Suparmin (2016) and Lund (2001).

The Effect of the KitTI Method on the Achievement of the Isometric Transformations Topic

The findings of the study showed that there was a significant increase in student achievement between the pre-test scores and the post-test scores for the treatment group and the control group. This increase proved that teaching and learning sessions using both teaching methods had an impact on students' knowledge in learning the Isometric Transformations topic. The mean pre-test scores for the treatment group and the control group were 2.290 and 2.650 respectively. This value is reasonable if we take into account the situation of students who have not yet learned and mastered the topic of Isometric Transformations. This finding confirms the study of Nik Hassan (2017) and Abdul (2016) who stated that the low pre-test score is due to the limited knowledge of the students because they have not yet understood the concepts found in a topic and applied it in the pre-test.

The results of the ANCOVA test found that there was a significant effect between the treatment group and the control group on the mean score of the Isometric Transformations topic post-test. This finding showed that by controlling the

mean score of the Isometric Transformation pre-achievement test, the KitTI Method has a significant effect on the mean score of the Isometric Transformation post-achievement test. If you look at the mean score of the post test, the mean score for the treatment group was higher than the mean score for the control group which is 22.129 and 18.750 respectively. Thus, the mean score of the post test for the treatment group was better than the mean score of the post test for the control group. This proves that the teaching method using the KitTI Method is better than the conventional method to improve student achievement for Isometric Transformations.

This finding confirmed that the KitTI Method was effective in improving the achievement of Isometric Transformations among Form 2 students. This is because the KitTI Method focuses on GBL, where students explore, investigate and build their own experiences while learning. Students also have the opportunity to fully engage during the teaching and learning session. According to Ishak et al. (2021) and Rondina and Roble (2019), students who play games in teaching and learning sessions are more likely to have better achievements because they engage in more active and cheerful teaching and learning sessions. This finding also coincides with the findings of Mohd Yusof and Shahrill (2021), Lin et al. (2018), Jamaluddin et al. (2016), Chin and Zakaria (2015), Woo (2014), Chen et al. (2012), and Papastergiou (2009) who reported that teaching methods that integrate GBL are effective in improving student achievement.

The Effect of the KitTI Method on Motivation

The effect of the KitTI Method on student motivation is identified through the students' perception of their intrinsic motivation after learning the topic of Isometric Transformations using the KitTI Method. The analysis method used to determine the effect of the KitTI Method on student motivation was the one-sample Wilcoxon signed-rank test, in line with the analysis method used by Muhammad et al. (2021). The results of data analysis found that the p value was significant because the $p < .050$. This value shows that the KitTI Method has a positive effect in creating high intrinsic motivation among students. In addition, the results of the data analysis also showed that the median value for the motivation score at 245,000 was higher than the hypothetical median value set at 152,000.

Intrinsic motivation is the motivation that exists within the student voluntarily and not coercion or encouragement from external factors such as rewards (Alotaibi, 2020; Johnattan, 2020; Taat, 2012). According to Ryan and Deci (2000), intrinsic motivation encourages students to do an activity to achieve internal satisfaction as a result of the implementation of the activity. In the context of this study, the findings of the study show that even without rewards, students successfully create a high intrinsic motivation while learning the topic of Isometric Transformations. This may be due to the learning factor itself which is fun or makes students feel less stressed while learning. This point is proven through the comments written by the students on the additional column in the KMMQ instrument that was administered to the students after they had finished studying the Isometric Transformations topic using the KitTI Method.

Based on the discussion about the effect of the KitTI Method on the achievement of Isometric Transformations and student motivation, it can be concluded that when there is high motivation in students, then student achievement can also be increased as stated in the findings of Nik Hassan (2017). Furthermore, the increase in student achievement in the treatment group was higher than the increase in student achievement in the control group. This proves that high motivation encourages students to obtain higher achievement. This finding is in line with the study of Abdul (2016) who found that students in the treatment group showed better achievement than students in the control group because students in the treatment group had a high level of motivation towards the GeoGebra Integration Module that was developed.

Conclusion

Based on the data analysis, that mean score of usability of teaching aids in the KitTI Method among Form 2 students in the treatment group was high. This indicates that the teaching aids in the KitTI Method are suitable to use in teaching and learning sessions for the Isometric Transformations topic. The teaching aids are appropriate for activities that integrate GBL in the classroom. Activities using teaching aids are fun and require the students' participation as well as creating an active environment throughout the implementation of teaching and learning session.

In addition, the finding also showed that the teaching method using the KitTI Method is better than the conventional method to improve students' achievement for the Isometric Transformations topic. KitTI Method also has a positive effect on developing motivation among students. It can be concluded that when there is high motivation among students, then the students' achievement can also be improved. Furthermore, the improvement in students' achievement in the treatment group was higher than the control group. This proves that high motivation could motivate students to achieve higher achievement.

This study has resolved several gaps related to students' difficulties in mastering visualization techniques, lack of motivation in students, and gaps regarding the development of kit methods using the GBL method in mathematics teaching and learning sessions. The topic of Isometric Transformation is one that involves a lot of diagrams, visualization, and movement. Therefore, an alternative teaching method such as the KitTI Method is a suitable method to be used because according to Hess (2017), students can provide a visual representation more quickly and accurately to solve problems through games. In fact, teaching and learning that require a lot of visualization will be easier if one uses

alternative teaching methods compared to traditional teaching methods because the methods can save the teacher's time and energy, thus being able to solve more questions during the teaching and learning session (Kutluca, 2017).

A number of students stated that teaching and learning mathematics that is not fun is a factor that contributes to their lack of motivation (Naidoo et al., 2016). Thus, the KitTI Method is an alternative teaching method to foster motivation in students. The study found that game elements will increase student motivation because they can change boring tasks into more interesting ones (Faiella & Ricciardi, 2015). White and McCoy (2019) also support this statement by stating that the use of games is very effective in motivating students and making learning mathematics fun. Therefore, the teaching method using the KitTI Method can foster motivation in students because there are fun elements and students will not quickly feel bored during the teaching and learning session. The gap about the development of kit methods using the GBL method in mathematics teaching and learning sessions has been resolved where this study provides a process framework for developing teaching methods based on the ADDIE Model.

Based on this study, the researchers were able to identify the potential use of the KitTI Method in the teaching and learning session for the Isometric Transformations topic. Nowadays, along with the development of technology, the innovation in teaching and learning session such as the use of the KitTI Method is seen as an appropriate innovation for teachers and students. Form 2 students who learnt through GBL method could to engage actively and comprehensively which in turn attracted their interest to learn mathematics and this could counter the claim of mathematics as a boring subject. Hence, it is hoped that the KitTI Method can be used in teaching and learning session in the future. KitTI Method is suitable to be used as a guide for mathematics teachers in designing a more dynamic teaching and learning session and it is able to improve students' achievement and motivation.

Recommendations

The researchers suggested that a study on the use of the KitTI Method could be conducted involving a larger sample size, which is all Form 2 students in Malaysia. The study of GBL can be extended to other topics such as Polygon, Function Graph, and Simple Probability or other subjects according to the suitability of the curriculum and objectives of the subject. The researchers suggest that the effect of the KitTI Method is also determined through a qualitative approach, which is by using the interview method on students after they undergo a teaching and learning session using the KitTI Method. In addition, we also suggest that games in the KitTI Method can be upgraded into digital games. This is because digital games are more flexible as students can play them with friends or family members at home and they also can play the games individually instead of in groups.

Limitations

The population of this study involved Form 2 students at a boarding school in the districts of Muallim and Batang Padang in the state of Perak, Malaysia. The KitTI Method was developed specifically for the eleventh topic in DSKP KSSM Mathematics Form 2, which is the topic of Isometric Transformations. In addition, this study utilised a quantitative approach where the effects of using the KitTI Method were determined through a survey design and a quasi-experimental design. The developed KitTI Method was categorized as a kit-shaped product involving non-digital games.

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