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AN ANDROID-BASED APPLICATION TO IMPROVE THE ABILITY TO DRAW AND INTERPRET FBD

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Abstract

The aim of this study is to develop an Android-based learning application which is named worked example mechanics. This application was made for learning classical mechanics class IX Natural Sciences Program in Indonesia. This application is specifically designed to train and improve students' ability to draw and interprete Free Body Diagram (FBD). This application contains classic mechanic material content, animated learning of classical mechanics, drawing exercises and interpreting FBD and a self-evaluation system. This application has passed the feasibility test of both the material and the media by Yogyakarta Negeri University physics learning experts. The app is also useful in enhancing the ability to interpret FBD, in trials at Sekolah Menengah Atas 2 Kupang/SMAN 2 Kupang (State Senior High School 2 Kupang), SMAN 3 Kupang, SMA TIMPOLMAS Kupang and State Alyah Madrasah (MAN) 1 Yogyakarta.

Kata Kunci:

Worked Example Mechanics;
FDB Ability;
Mobile Learning;
Android

INTRODUCTION

In recent years, physics educators have begun to look specifically and be able to develop physical abilities that students must possess. These abilities are the key to the success of learning physics. These abilities will undoubtedly be known because every answer to the problem given by the teacher, of course, has a typical pattern that represents the level of understanding of concepts from students.

When talking about classical mechanics, the concept of force is the essence (Guo et al., 2014). Clasic mechanics is assumed to be a problematic and unattractive topic because there are very many subtopics (Alias & Ibrahim, 2016). One classic mechanical ability that must be possessed by students is the ability to interpret free body diagrams (FBD) (Roselli, Howard, & Brophy, 2007). FBD ability is a critical ability in how force are described and explained according to relative direction and magnitude (David Rosengrant, Van Heuvelen, & Etkina, 2009). Research conducted by (McCarthy, 2010); (D Rosengrant, 2007) states that students are often wrong in working on advanced mechanics..

The Rosegrant opinion above can explain how we draw and identify a free body diagram of an existing problem. Indicators of the ability to draw and interpret a force-free diagram are described in Table 1.

Table 1. Indicators of Drawing and Interpreting a FBD

Steps	**Draw an FBD.**	**Interpret an FBD**
Step 1	Describe the situation described in the problem	Identify the forces acting on the image
Step 2	Look for related objects in the image and name them systems	Identifies the center of the system style in the picture where the other force work
Step 3	Model the system like a particle system if possible. Place on the side of the sketch a "particle" which is replaced by a dot to represent the centre of the system	Identify external / external forces or objects that work on the system.
Step 4	Look for external objects outside the system that interact with the particles	Identify the direction and magnitude of the forces acting at the centre of the system based on the Cartesian system
Step 5	Draw all the external forces that interact with the centre of the system where the arrow sign represents these forces.	
Step 6	Label the arrow with information from external forces that work	

The ability to draw and interpret Free body diagrams (FBD) or Force-free diagrams is the primary key to mechanical problem-solving strategies for students of physics, physics education, and engineering students (Jonassen, 2010); (Viennot, 1998); (Ploetzner, Lippitsch, Galmbacher, Heuer, & Scherrer, 2009). This is important because graphs and charts are "powerful tool" in analysing physical problems. FBD representation ability is important and emphasised to be mastered by students. Physics teachers or lecturers are also required to use graphics or diagrams to be able to make textual descriptions and physical, symbolic and graphic phenomena from the concepts and principles of physics in learning. So it is concluded that the ability to interpret FBD is an important ability that must be possessed or "learning outcomes" by students of science and mathematics. Expert students (Heckler, 2010); (Taasoobshirazi & Carr, 2009); (McCarthy, 2012); (Aviani, Erceg, & Mešić, 2015) usually make a diagram that represents the relationship of the variables known to the problem, after that, it resolves the issue

A common problem is the lack of students' ability to draw or interpret an FBD in the question. A matter of advance mechanics can make students confused if they do not practice often in drawing and understanding FBD. Observations made in Yogyakarta's MAN (Madrasah Aliyah Negeri), it is known that students are often incomplete describing the force in a force drawing. This results in a lack of information to get the right final solution.

Another thing that makes students challenging to understand how to draw and interpret FDB is because the teacher uses the lecture method. The lecture method is very verbal and tends to make students very passive. The teacher must be able to visualise abstract concepts into things that are easier to understand. One solution that can be used is to use mobile learning (m-learning) based learning media (Alias & Ibrahim, 2016). M-learning can help students because the use of animation allows students to understand abstract concepts (Laddha, 2017) especially in drawing and interpreting FBD. The purpose of m-learning can make learning more flexible and even become the current digital learning trend (Martono & Nurhayati, 2014); (Bousmah, Jadida, & Kamoun, 2015); (Cabanban, 2013); (Toktarova, Blagova, Filatova, & Kuzmin, 2015); (Chiong & Shuler, 2010); (Sharples, Taylor, & Vavoula, 2005); (Woodcock, Middleton, & Nortcliffe, 2012). Therefore, researchers developed a learning application called "working example mechanics" based on Android. This application contains material and practice questions as well as an evaluation system for the ability to interpret FBD.

This study aims to develop Android-based mechanics learning media. This application aims to be a learning medium that can improve the ability of FBD interpretation. Detailed research questions are:

1. Are the applications developed suitable for use in the learning process?
2. Are the applications developed effectively in improving the ability of FBD interpretation?

The focuses of this research were as follows:

1. Develop the application of "worked example mechanics" that is suitable for use in learning.
2. Knowing the effectiveness of the "worked example mechanics" in improving the ability of FBD interpretation.

METHODOLOGY OF RESEARCH

This study uses a post-test only control group design research design. In general, it can be seen in table 2.

Table 2. Post-test only control grup design

R	O_1	X	O_2	(Experiment class)
R	O_3	Y	O_4	(Control Class)

Explanation:

X: Classes that use learning media worked on Android-based mechanics examples

Y: Classes that use media learning a collection of Android-based formulas

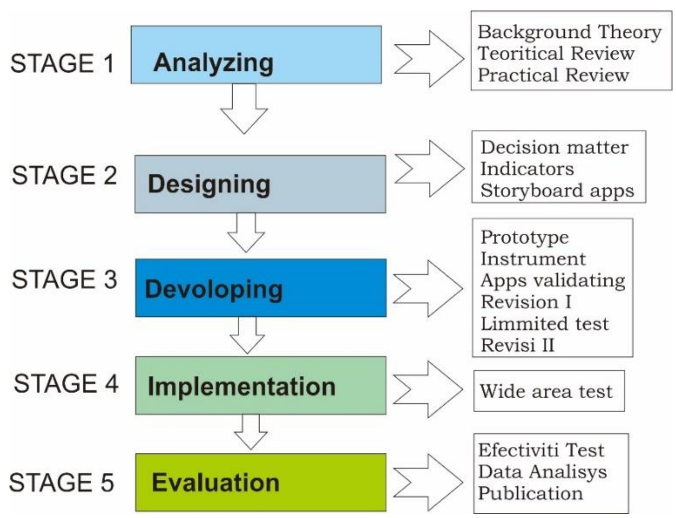
O: post-test value

Sample of Research

The subjects involved were nine material experts, nine media experts. The limited trial involved 37 students, and a large trial involving 70 students. To test item problems involving 316 students. The test of the effectiveness of the application worked mechanical example involving 70 class XI students from MAN 1 Yogyakarta. The object under study is the feasibility and effectiveness of the worked example mechanics apps, which consists of aspects of material validation, media, empirical validation, and improvement of free diagram interpretation.

Instrument and Procedures

The research methods used are ADDIE (Analyze, Design, Development, Implementation and Evaluation) (Dousay & Logan, 2010). Briefly can be described in the following picture.



Picture 1. Steps of research

The instruments used in this study are 1). Instrument to test the feasibility of the material in the application; 2). Instrument to test media feasibility; 3). Instrument to test the feasibility of the questions in the application; 4). Instruments to test the effectiveness of applications in improving the ability of FBD interpretation

Data Analysis

a) Media and material feasibility tests were carried out by nine media experts and nine material experts. The data were analysed by the Aiken's V formula to obtain the Aiken index used as the validation value.

$$V = \sum s/[n(c-1)]$$

(Aiken , 1985)

b) Analysis of items is done with the QUEST program. Quest will give you an outcome: (1). For the number of questions fit with the Partial Credit Model (PCM) model that meets the requirements for use; (2). The level of difficulty of the problem based on the difficulty of QUEST output with the PCM model, as well; (3). Reliability of items based on internal consistency. Question items are declared valid if the Infit Mean Square (INFIT MNSQ) value is in the range of 0.77 to 1.30 (Bambang Subali and Pujiyati, 2011: 10-11).

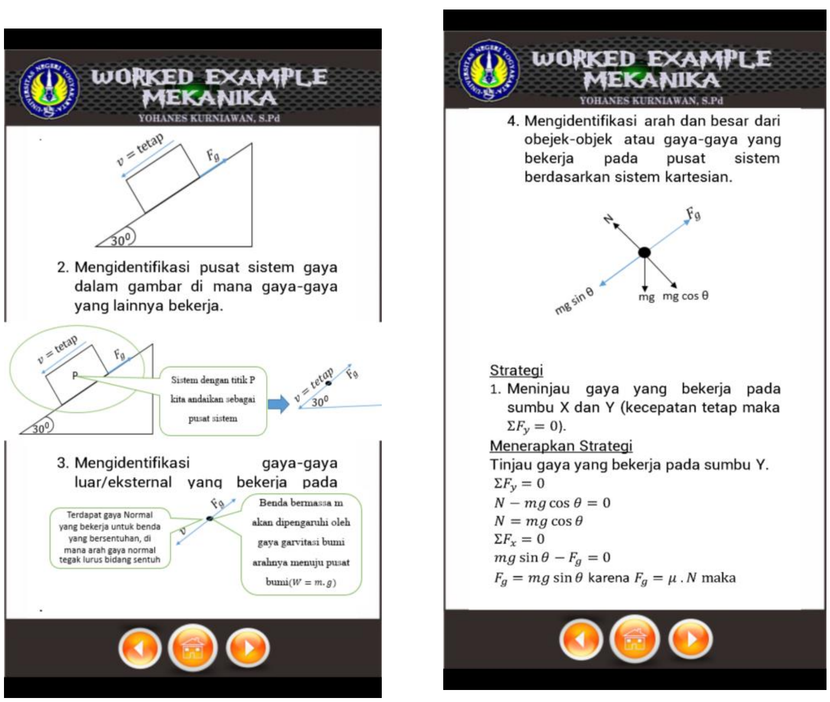
c) Character items question obtained from data analysis with 34 items of item amounted to 34. The results of the report produced 34 items of information curves, in which each item had their information curve (Boomsma, van Duijn, & Snijders, 2001).

d) Test the effectiveness of the application using Mixed Design ANOVA in the General Linear Model (GLM) because it combines two sub-analyses, namely Within-Subject Test and Between-Subject Test. Before the GLM test is carried out, a prerequisite test consists of a normality test and a homogeneity test.

RESULTS OF RESEARCH

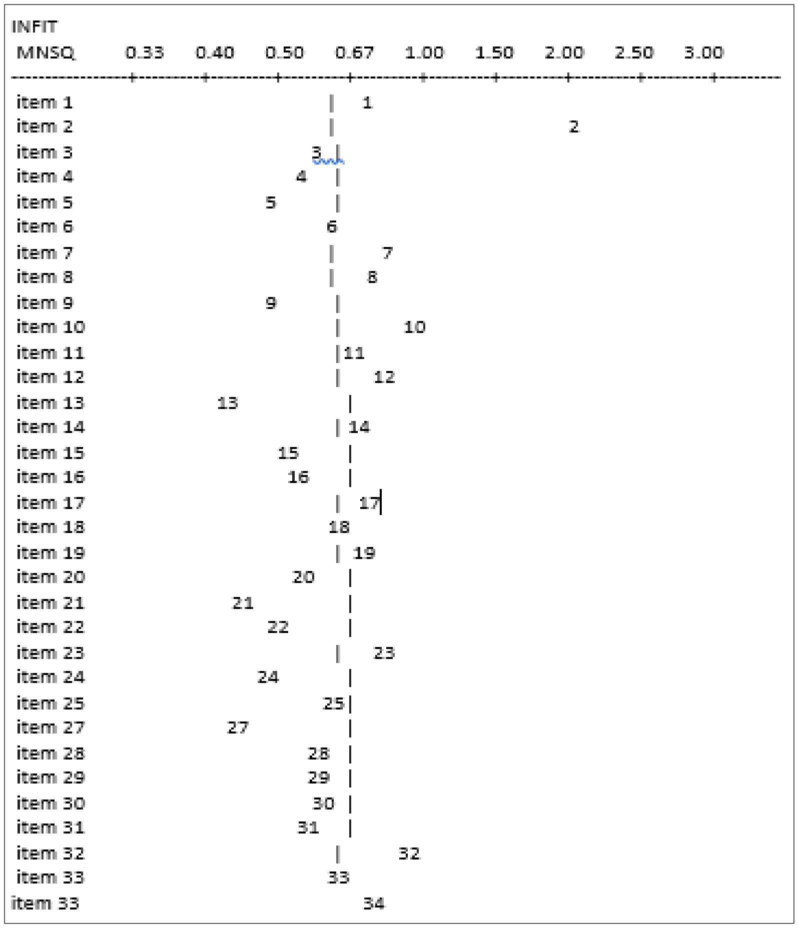
1. The application product worked example mechanics

Picture 2. Main Menu and Summary of material mechanics



Picture 3. Content and Discussion of the question

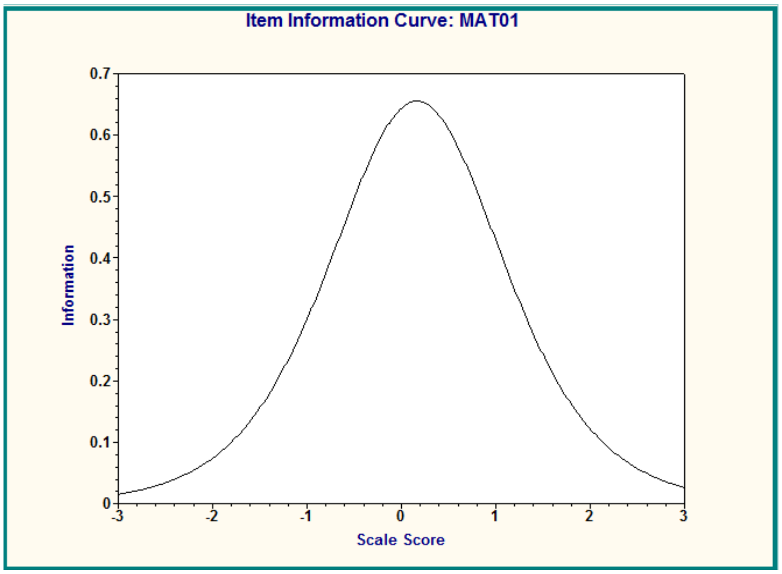
2. Appropriateness of Application and Application Effectiveness
   a. Results of Feasibility Analysis Material in Worked Example Mechanics Application.
      The material feasibility analysis was carried out by two material expert lecturers, three education practitioners and 4 peer groups (peers), so the total number of material validators was nine people. The contents of the validation questionnaire consist of 3 major parts, namely material, learning and language. Data were analysed using the Aiken's V formula. Based on the index V (Aiken, 1980), items 1,3,5,6,8,9 and 10 were in perfect categories and items 2, 4 and 7 had good categories. So that it can be concluded that the material in the application is feasible to use.
   b. Results of Validation Analysis of Example Mechanics Worked Media Application Assessment Instruments
      Media validation was carried out by two media expert lecturers, three education practitioners and 4 peer groups (peers), so the total number of material validators was nine people. The contents of the validation questionnaire consist of 3 major parts, namely material, learning and language. Data were analysed using Aiken's V formula. Based on the V index, according to Aiken (Aiken, 1980), all media validation items were in a perfect category. Therefore, it can be concluded that the elements of the learning media in the application have excellent validity, and are suitable for use.
   c. The validity of the Examples in the Worked Example Mechanics Application
      The validity of the questions was obtained from empirical data analysis with a sample of 316 students. According to Subali (Subali, 2011: 24); (Chapman & Hall, 2016: 402) items that fit the Rasch model have an INFIT MSQ value of 0.77-1.30. Data from the analysis are summarized in picture 7.



Picture 7. The compatibility of the Rusch model

d. Character item Of Question

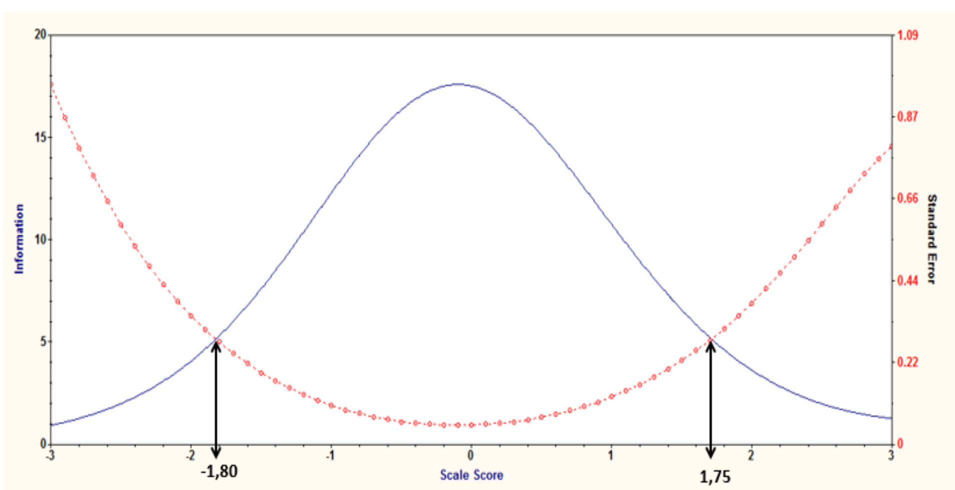
Character items obtained from data analysis using Bilog with the number of item items amounted to 34. The results of the analysis produced 34 item information curves, in which each item had their information curve. According to Ronald K. Hambleton (Hambleton, 1985: 37), the item is feasible if the form of logistic distribution of graphs follows the assumption of normal distribution. The meaning of this graph is that the higher the ability of a person, the higher the chance of answering correctly, or if someone can answer difficult questions, then an easy item will undoubtedly be answered correctly. Examples of item number 1 information are presented in Figure 8.



Picture 5. Information Curve for Item Number 1

e. Reliability of Item Questions

Item reliability was obtained from empirical data analysis with a sample of 316 students. Data were analysed using Bilog software, and are presented in Figure 10. The ability level chart on the analysis results above ranges from -1.8 to +1.75. According to Ronald K. Hambleton (Hambleton, 1985), all items of good questions are used if the intersection of the two difficulty level curves (b) ranges from -2 to +2. So it can be concluded that a reliable instrument when used for students with a level of ability (ϴ) categorised as -1.80 to 1.75.



Picture 6. Item Reliability Chart

f. Validation of Free Diagram Interpretation Ability Test Instruments

The validity of the content of the free diagram interpretation ability test was carried out by two material lecturers, three education practitioners and 4 peer groups (colleagues) so that the total number of validator test instruments was nine people. The main items validated are language, content and format. The results of data analysis using the Aiken's V formula (Aiken, 1980). Based on the index V, according to Aiken (Aiken, 1980: 956), items 1, 2, 3, 4, 5, 6, 7, 9, 10, 12, 14, and 15 on the validity of FBD interpret ability tests were excellent, and items 8.11, and 13 are in good category. Empirical Validity Item Problem Worked Sample

g. Reliability of Free Diagram Interpretation Ability Test Instruments

Instrument reliability was calculated using SPSS to find the alpha value and the ICC value. The results of the analysis are in Table 19.

Table 3. ***Reliability Statistics***

Cronbach's Alpha	N of Items
,894	15

The Cronbach value, the Alpha s obtained is 0.894, so according to Gliem & Gliem (Gliem, 2003: 86) is in a special category, meaning that the test instrument is very reliable and worthy of use.

h. Tests of Readability from Students

The trial of the readability of the application product worked this mechanical example was carried out by 67 students. Data were analysed using Likert categorisation analysis formula according to Arikunto (Arikunto, 2006: 293). The conclusion that can be drawn that all the test items readability gets very good category (SB), which means that the application worked example mechanics can be used or has high readability.

3. Data on Interpretation FBD Ability Test Results

Test data on the ability to interpret free diagrams is obtained from the tests of 70 students in MAN I Yogyakarta. For more clear values can be seen in the appendix.

Research Hypothesis Test

a) Normality Test

Normality test uses the Kolmogorov Smirnov formula with the help of the SPSS program. The results in the table show that the experimental and control classes are greater than 0.05, that is for the pretest in the experimental and control class is 0.2 and 0.57, while the posttest is 0.108 and 0.2. The conclusion that can be drawn is that all data comes from populations that are normally distributed.

b) Homogeneity Test

Homogeneity tests were carried out using Box's-M with the help of SPSS. The results in the table, the significance value is 0.65, it can be concluded that the sample comes from a homogeneous population.

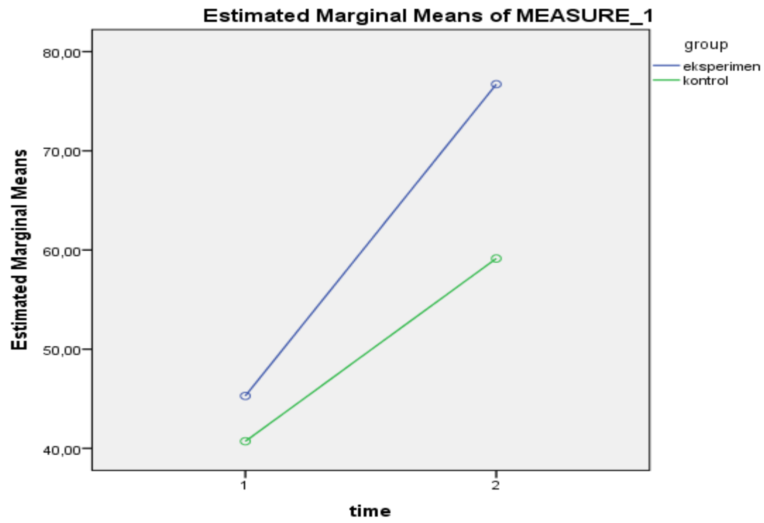
c) Hypothesis Test to determine the increase in the ability of free diagram interpretation in experimental and control classes.

The results of data analysis using Mixed Design ANOVA for the second hypothesis are in Table 4.

Table 4. The results of data analysis

group		Value	F	Hypothesis df	Error df		Partial Eta Square
eksperimen	Pillai's trace	,692	152,483[a]	1,000	68,000	,000	,692
	Wilks' lambda	,308	152,483[a]	1,000	68,000	,000	,692
	Hotelling's trace	2,242	152,483[a]	1,000	68,000	,000	,692
	Roy's largest root	2,242	152,483[a]	1,000	68,000	,000	,692
kontrol	Pillai's trace	,435	52,427[a]	1,000	68,000	,000	,435
	Wilks' lambda	,565	52,427[a]	1,000	68,000	,000	,435
	Hotelling's trace	,771	52,427[a]	1,000	68,000	,000	,435
	Roy's largest root	,771	52,427[a]	1,000	68,000	,000	,435

The results in the table show that the significance value for the experimental class and the control class is less than 0.05, so Ho is rejected. The conclusion is that there is a significant change in scores between the experimental and control classes. Another result in the Eta Square Partial column shows that there is an increase in scores in the experimental class from pretest to posttest higher (0.692) compared to the control class (0.435). Graphs of increasing the ability to interpret free diagrams between the experimental class and the control class are shown in Figure 7.



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Picture 7. Graph Comparison of Improvement in the Ability of FBD Interpretation

Discussion

The ability to interpret FBD is crucial in learning physics, especially classical mechanics. If we look at a problem of classical mechanics in real life, then we will find many external forces acting on that system. For example the motion of a car that is affected by air flow, smooth rough asphalt, tire quality, type of driving machine, and others. When we bring this example in a theoretical analysis in class, then we must be able to describe the style translation (FBD). Research looks at this crucial issue and supports the improvement of students' ability to describe and interpret FBD. This has a common thread with the opinions of experts (Barreto, Trigo, Menezes, Dias, & de Almeida, 1998); (Roselli et al., 2007); (Savinainen, Mäkynen, Nieminen, & Viiri, 2013); (Fbd, Diagram, Diagram, & The, n.d.); (Aviani et al., 2015); (David Rosengrant, Van Heuvelen, & Etkina, 2009); (McCarthy, 2010); (Hollabaugh, 1995); (Laddha, 2017); (Alias & Ibrahim, 2016a); (Guo et al., 2014); (Gende, Dolores, 2008) which states that the ability of FBD interpretation is crucial for students who study classical mechanics. This research can effectively improve the ability of FBD interpretation compared to the control class which only uses Android-based formula collection applications. The use of this application as explained by Laddha (Laddha, 2017) can help students visualise abstract concepts in mechanics. The stages of drawing and interpreting a style-free diagram (Aviani et al., 2015); (Nieminen, 2013); (Mcdermott & Emigh, n.d.) offered by Rosegrant, is critical in studying mechanics. These stages need to be visualised to be seen and trained in detail by students.

The use of Android as a platform, aims to enable students to learn without being limited by specific space and time, for example, students can study in the canteen, parking lot, waiting for their turn to play the ball, and others. Android has the advantage of being widely used throughout the world

(Hssina, Erritali, Bouikhalene, & Merbouha, 2014); (Martono & Nurhayati, 2014). Educational experts now say that the use of android in the world of education (m-learning) is a 21st-century education trend (Joshi, Shete, & Somani, 2015) and this cannot be rejected. The results found in the post-test scores and the students' answers show that when students draw FBD correctly, the final result will be correct. Likewise, if the picture is wrong, the result will be wrong.

CONCLUSION

From the topic of research and discussion, there are several conclusions of the study, among others:

1) The "worked example mechanics" application developed is suitable for use in classical mechanics learning, a). Judging from the material (the truth of the material, symbol, validity and reliability of the problem, test the character of the item, and the truth of the language) in the application, b).From the media (fonts, colours, clarity of graphics and fonts, ease of installation, innovation and completeness of identity).
2) The application of "worked example mechanics" developed effectively in improving the ability of FBD interpretation. The stages of drawing or interpreting the FBD created by the Rosegrant are displayed, visualised and trained in detail by the teacher and tutor so that all students can have this ability. The results found in the post-test scores and the students' answers show that when students draw FBD correctly, the final result will be correct.

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