Development of Test Instruments to Measure Improvement in Problem Solving Skills After Using the Augmented Reality Module

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**Abstract**. This study aims to produce a test instrument for problem solving ability that is valid and has high reliability. This research is a research and development conducted using the ADDIE model. Instrument validation, including expert validation and empirical validation. The results of expert validation showed that the test instruments obtained good categories. Empirical validation results show that the five valid questions with the reliability coefficient obtained r\_11 = 0.677. Based on the criteria for the level of reliability, this shows that the level of instrument reliability is good. Based on the calculation results, the five questions have a significant different power. the level of difficulty of the calculation results obtained 5 questions given obtained 1 included in the easy category, 3 questions included in the medium category and 1 question included in the difficult category. Based on these results, the test instrument for problem-solving ability is very feasible to be used to test the improvement of the problem-solving ability of an augmented reality assisted module.

1. Introduction

At this time technology-based learning is being intensively developed to cope with the demands of the times. Students really like technology-based learning because they grow with the ease that is obtained from this technology. One of the technologies currently developing is augmented reality (AR) [1]. AR is a technology that combines 2D and 3D in real time on a smartphone[2]. There are a lot of studies that aim to improve students' cognitive abilities using AR, one of which is the problem-solving ability. One of them is research conducted by ikhsan who uses the literature study method gets a lot of research aimed at improving problem solving abilities using AR in the learning process and the majority of the results can improve problem solving abilities [3].

Problem solving ability is one of the important abilities that students must have [4][5], Belland also explained that problem-solving skills allow students to be able to continue to compete in the future [6]. This is reinforced in the Partnership for 21st Century Skill which states that one of the abilities that needs to be mastered in order to be successful in life and work is the ability to solve problems[1]. The importance of problem-solving abilities is also evident from the large number of current studies that examine problem-solving abilities. One of the studies conducted by Waller & Kaye examines how to teach problem-solving skills to nuclear engineering students at the University of Ontario Institute of Technology [7].

The rise of research that examines problem-solving abilities certainly requires instruments that can be used to measure problem-solving abilities. Measurement instruments in the form of tests that are less precise will also result in incorrect measurements. Therefore, we need the right instrument to make the right measurements. The right measuring instrument can minimize measurement error [8]. The problem-solving ability test was developed based on the four indicators of advanced problem-solving abilities described by Butterwoth and Thwaites. The four indicators include (1) combining skills - using imagination, (2) developing models, (3) conducting investigations, and (4) analyzing data and concluding[9]. According to Afandi, to measure problem-solving abilities must use instruments in the form of descriptive questions [10]. This was also done by Sinaga to develop problem solving ability test instruments [11].

The instrument developed in this study focuses on vector material. The selection of this material is based on the fact that there are student difficulties with this material [12][13][14]. Research conducted by ikhsan explains that in theory AR can improve problem-solving abilities [15]. in the future, further research is needed to see whether AR can improve problem-solving abilities. Before the research is carried out in this study, a problem-solving ability test instrument will be developed first. purpose of this study was to develop a problem-solving ability test instrument for class X students. The instrument developed was then implemented to determine the improving students' problem-solving abilities after going through augmented reality assisted vector-learning.

1. Method

This research is a Research and Development (R&D) research. The instrument developed is a problem solving ability test instrument developed by adapting the ADDIE development model from [16]. The five stages of ADDIE, namely (1) analyze, (2) design, (3) develop (4) implement and (5) evaluate.

* 1. *Test Material and Form*

The material used to compile the test questions is vector material in the form of description questions. Steps to Arrange the Toolkit The steps for the preparation of the test kits are as follows. (l) Limitation on the material tested, namely vector material. (2) Determine the form of the question. The test questions used in this study are questions in the form of description. (3) Determine the number of questions and the amount of time provided. (4) Determine the grid for the test questions. (5) Prepare test questions.

* 1. *Intsrumnet Validity*

Instrument validation in this study includes: (l) Expert Validation. Logical validity is fulfilled if the instrument has been well designed, following existing theories and conditions [17]**.** Validation in this aspect is carried out by proposing an instrument to be assessed for its validity to 2 validators who are experts in the vector field. The assessment aspects include material content, language, and question writing. (2) Empirical Validation. The instruments that have been prepared and validated by experts are then validated empirically through instrument trials in the control class. From the trial results then analyzed to determine which questions are included in the good category which is suitable for use for research instruments.

* 1. *Analisis perangkat tes*

aims to identify good, bad, and bad questions, so that information can be obtained to improve the questions for further interest [17]**.** The analysis of the test equipment includes question validity, reliability, difficulty level, analysis of difference power.

* + 1. Validity of Question Items

The validity of the questions was determined using the product moment correlation formula by correlating the total score of the items with the total score.

$$r\_{xy}=\frac{n\sum\_{}^{}xy-(\sum\_{}^{}x)(\sum\_{}^{}y)}{\sqrt{\{\sum\_{}^{}x^{2}-\left(\sum\_{}^{}x\right)^{2}\}\{n\sum\_{}^{}y^{2}-(\sum\_{}^{}y)^{2}-(\sum\_{}^{}y)^{2}\}}}$$

Information:

$r\_{xy}= $product moment correlation coefficient

n = number of test takers

x = item score

y = total score

The calculation results are then consulted with the critical price r product moment with a significance of 5%, if $r\_{xy} $then the question item is valid [17].

* + 1. Reliabilitas

A set of tests is said to be reliable if the test can provide consistent results. The reliability of the description questions is determined using the Alpha formula

$$r\_{n}=\left(\frac{n}{n-1}\right)\left(1-\frac{\sum\_{}^{}σ\_{b}^{2}}{σ\_{b}^{2}}\right)$$

Information:

$r\_{n}=$ reliability sought

$n =$ the number of items

$\sum\_{}^{}σ\_{b}^{2}=$ the number of score variants of each item

$σ\_{b}^{2}=$ total variance

The test reliability test criteria is after getting $r\_{11}$ then consulted with the product moment r price in the table. If $r\_{hitung} > r\_{tabel}$then the question tested is reliable [17]

* + 1. Difficulty level

The number that shows the difficulty and ease of a problem is called the difficulty index, which is given the symbol P. The formula for determining the difficulty index is as follows.

$$p=\frac{B}{JS}$$

Information:

P = difficulty index

B = the number of students who answered correctly

JS = the number of all students who took the test.

The difficulty index is classified as follows. Problems with $0,00 < P \leq 0,30$ are difficult problems. Problems with $0,30 < P \leq 0,70$ are moderate problems. Problems with $0,70 < P \leq 1,00 $are easy problems [17].

* + 1. Discernment

The distinguishing power of a question is the ability of an item to distinguish between high-skilled and low-skilled students. The steps for calculating the distinguishing power for the essay problem are as follows.

1. Sort the test results from highest to lowest score.
2. Determine the upper and lower groups, namely the upper group as much as 27% of the total number of test takers and the lower group. The discrimination index (difference power) in the description questions is determined using the t test formula as follows.

$$t=\frac{(MH-ML)}{\sqrt{\left(\frac{\sum\_{}^{}x\_{1}^{2}+\sum\_{}^{}x\_{2}^{2}}{n\_{i}(n\_{i}-1)}\right)}}$$

Information:

MH = the average of the upper group

ML = the average of the lower group

$\sum\_{}^{}x\_{1}^{2}$ = the sum of the squares of the upper group's individual deviations

$\sum\_{}^{}x\_{2}^{2}$ = the sum of the squares of the individual deviation of the lower group

$n\_{i} = 27\%$ of the number of test questions

The calculation result is compared with $t\_{tabel}$ , with $dk = (n\_{1} – 1 )( n\_{2}– 1).$. If $t\_{hitung} > t\_{tabel}$Then the power of difference is significant 15, p. 141]. In this study, researchers used α = 5%.

Hasil perhitungan dibandingkan dengan $t\_{tabel}$ , dengan $dk = (n\_{1} – 1 )( n\_{2}– 1).$ Jika $t\_{hitung} > $

1. Result and discussion

The following is the result of developing a problem-solving problem

1. Diketahui titik A (1,2,3), B(2,4,6) dan C(5,10,15). Buktikan bahwa A, B dan C Kolinier. (given the points A (1,2,3), B (2,4,6) and C (5,10,15). Prove that A, B and C are Collinier)
2. Diberikan balok ABCD. PQRS dimana vektor $\vec{AP}$,$ \vec{AB}, \vec{AD} $berturut-turut disimbolkan dengan $\vec{a},\vec{b},$ dan $\vec{c}.$ Nyatakan vektor $\vec{QD}$ dalam $\vec{a},\vec{b},$ dan $\vec{c}$.

(Given the ABCD beam. PQRS where the vectors $\vec{AP}$,$ \vec{AB}, \vec{AD}$ are denoted by$\vec{a},\vec{b},$ and $\vec{c}$, respectively. Express the vector vektor $\vec{QD}$ in $\vec{a},\vec{b},$ and $\vec{c}$)

1. Perhatikan balok ABCD. EFGH dimana vektor $\vec{AC}, \vec{CH} $berturut-turut disimbolkan dengan $\vec{y}$ dan $\vec{z}.$ Jika $CS$: SH= 1:1 dan $AP$: $PS$ = 2:1 Nyatakan vektor $\vec{CP}$ dalam $\vec{y},$ dan $\vec{z}$.

(Look at the ABCD block. EFGH where the vector$\vec{AC}, \vec{CH}$ is denoted by $\vec{y}$ and $\vec{z}$, respectively. If CS: SH = 1: 1 and AP: PS = 2: 1 Express the vector $\vec{CP}$ in $\vec{y},$ and $\vec{z}$.)

1. ABCD adalah segi empat sembarang. Titik S dan T masing-masing titik tengah $AC$ dan $BD$. Jika vektor $\vec{ST}=\vec{u}$, maka $\vec{AB}+\vec{AD}+\vec{CB}+\vec{CD}=\cdots ⋅$

(ABCD is an arbitrary rectangle. Point S and T, respectively, the midpoint of AC and BD. If the vektor $\vec{ST}=\vec{u}$, then $\vec{AB}+\vec{AD}+\vec{CB}+\vec{CD}$ = ⋯ ⋅)

1. Diketahui $\vec{a},\vec{b} $dan $\vec{c}$ adalah vektor-vektor pada bidang. Dimana vektor $\vec{a} $tegak lurus $\vec{b}$ dan vektor $\vec{c}$ tegak lurus ($\vec{a}+\vec{b}). $Jika |$\vec{a}$|=3, |$\vec{b}$|=4, dan $\vec{a}.\vec{c} $= −24 maka tentukan |$\vec{c}$|= ……… (Given that $\vec{a},\vec{b} and$  $\vec{c}$ are vectors on the plane. Where vector $\vec{a} $ is perpendicular to $\vec{b}$ and vector$\vec{c}$  is perpendicular ($\vec{a}+\vec{b}). $If |$\vec{a}$|=3, |$\vec{b}$|=4, dan $\vec{a}.\vec{c} $= −24, then determine |$\vec{c}$|= …….)

Analysis of learning achievement test trials

* 1. *The validity of the items*

From the results of calculations using the alpha formula and in consultation with the r table, it was found that all items were valid.

* 1. *Reliabilitas*

Reliability means trustworthy or dependable. From the calculations carried out with n: 5, it is obtained $r\_{11}$ = 0.677. Based on the reliability level criteria, this shows that the instrument reliability level is good.

* 1. *Distinguishing power*

The results of the calculation obtained 5 questions given, all questions have a significant difference power.n.

* 1. *. Problem difficulty level*

From the results of the calculation of 5 questions given 1 is in the easy category, 3 questions are in the medium category and 1 question is in the category

difficult.

1. Conclusions

Based on the data analysis carried out, it can be concluded that the problem-solving ability test instrument is declared expertly and empirically valid. The empirical test results show that the instrument is said to be reliable, so it can be used at any time and condition. Based on these results, the problem-solving ability test instrument is very feasible to be used to test the increase in the problem-solving ability of augmented reality assisted modules.

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