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Development of M-Learning Teaching Materials on Trigonometric Materials to Improve Mathematic Connection Ability

Poppy Yaniawati[1)], Nenden Mutiara Sari[2,*)], Naímmatur Rokhmah[3)], Nurul Fitri[4)], Suhayat Hadiansyah[5)]
[1,2,3] Universitas Pasundan, Jawa Barat
[4] SMP Aisyiyah Boarding School
[5] SMA Negeri 5 Cimahi

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Abstract

Abstract Teaching material is given to students and assists students in learning something and making learning more interesting and easy to understand. M-learning is a learning media containing teaching materials that students can access with more attractive visuals and improve student learning outcomes. This study aims to produce M-Learning teaching materials on trigonometry and analyze the improvement of the mathematical connection abilities of XI-grade students after using these teaching materials. The approach in this research is a mixed method. The research design used in this study was the One-Group Pretest-Postest Design. This type of research is R&D (Research & Development). The instruments in this study were validation sheets, interviews, questionnaires, and mathematical connection ability tests, which were analyzed using t-test and N-gain and involved 26 students of class XI SMK Karya Pembangunan Pasirjambu Bandung. This study indicates that the M-Learning Application of valid (feasible) trigonometric material is used based on the validation assessment of media experts, material experts, and student responses. In addition, there are differences in improving mathematical connection skills before and after learning using M-Learning teaching materials. The results of this study indicate that the M-Learning Application of trigonometric material is valid (appropriate) to be used based on the validation assessment of media experts, material experts, and student responses. In addition, there are differences in improving mathematical connection skills before and after learning using M-Learning teaching materials. The results of this study indicate that the M-Learning Application of trigonometric material is valid (appropriate) to be used based on the validation assessment of media experts, material experts, and student responses. In addition, there are differences in improving mathematical connection skills before and after learning using M-Learning teaching materials.

Keywords: R & D (Research & Development), E-Learning, Vocational School Students, Plomp Model

(*) Corresponding Author: nenden.mutiara@unpas.ac.id

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INTRODUCTION

Mathematics learning previously carried out face-to-face has changed since the emergence Coronavirus Diseases 2019 (COVID-19) in Indonesia in early March 2020. This change in the learning process aims to prevent the spread of the COVID-19 virus.

Seeing these conditions, the Minister of Education and Culture of the Republic of Indonesia, Nadiem Anwar Makarim, issued circular letter Number 4 of 2020 dated March 24, 2020, containing the Implementation of Education Policies in the Emergency Period for the Spread of COVID-19. The circular explains that the learning process is carried out at home online or remotely while still providing meaningful learning experiences for students. This online learning utilizes information technology as a medium and teaching material to facilitate learning (Wiryanto, 2020).

Online learning must be optimized, and it is necessary to support facilities, one of which is teaching materials. Ramdani (2016)states that teaching materials are the format of the material given to students. The function of teaching materials for students, according to Prastowo (2012) is to help students learn something, a) provide various types of material choices; b) can be accessed anytime and anywhere; c) make it easier for teachers to carry out learning; d) and make learning activities more interesting, effective, and efficient. The utilization of teaching materials in the learning process has a very important role, both for teachers and students so that learning is more efficient and does not deviate from the competencies to be achieved. Meanwhile, one of the benefits of teaching materials is that they can increase learning effectiveness and improve the quality of learning (Gazali, 2016; Agustyarini & Jailani, 2015).

The teaching materials needed during the current pandemic are a form of material, data, tools, and reading materials that can be used and can help teachers and students carry out online teaching activities. In addition, the time of use must also be accessible by students anytime and anywhere. One of the teaching materials that can be accessed online and freely accessed by students at any time is teaching materials in the form of mobile learning or M-learning.

Majid (2012) stated that learning with M-Learning utilizes technology and mobile devices. Furthermore, Traxler (2014) explains that M-Learning is distance learning that can support conventional learning or e-learning. Following Pujiono (2016), M-Learning is part of E-learning. In addition, according to Setyadi (2016), when compared to conventional learning, M-learning allows more opportunities to collaborate directly and interact informally among students. So that it can be stated that M-Learning learning is learning that provides general educational electronic information through smartphone devices.

According to Yaniawati (2014), there are three functions of M-Learning in learning activities in the classroom (classroom instruction), namely as a supplement (additional) that is optional (optional), complementary (complimentary), or substitute (substitution).In addition, mobile learning can also be used as an alternative to solve problems in the field of education, especially the problem of equitable access to educational information, the quality of learning content in the form of learning materials in the form of text or images accompanied by examples of questions and improving the quality of teachers/teachers so that better at creating or delivering learning materials and managing teaching and learning activities (Ghozi, 2014).

Therefore, *M-Learning* in this study provides electronic educational information through smartphone devices. Its advantages include 1) can be to operate anywhere and anytime; 2) increasing student motivation in learning; 3) fostering students' self-confidence; and 3) improving learning according to student needs.

Based on previous research, it is stated that M-learning can facilitate the teaching and learning process both inside and outside the classroom, attract students' attention, and generate enthusiasm and motivation in learning so that the material being delivered can be conveyed properly and can be understood by students. (Pangalo, 2020). Drigas & Pappas (2015) stated that online and mobile learning in mathematics could help students solve problems, increase understanding of mathematical concepts, provide dynamic ideas,

and encourage metacognitive abilities in general. This statement follows one of the indicators of mathematical connection, namely understanding students' mathematical concepts. By understanding new mathematical concepts, it is possible to increase their confidence in working on the given problems, so that they are able to relate the concepts they are looking for wherever they are.

Mathematical connection ability is one of the abilities suggested by NCTM. Nurudini et al. (2019)stating students' understanding in connecting ideas to the ability to verify and formulate deductive conjectures between topics in mathematics is the definition of mathematical connections. In line with this, the ability to connect mathematics is the ability of students to connect various problems related to mathematics(Haji et al., 2017). Example: linking algebraic concepts with geometric concepts associated with other sciences in everyday life. According to the NCTM, the objectives in learning mathematics are mathematical communication, mathematical reasoning, mathematical problem solving, mathematical connections, and the formation of positive attitudes towards mathematics (Warih et al., 2016; Suprianto & Pujiastuti, 2020).

Mathematical connection ability is the ability to connect mathematical concepts with concepts in other topics in mathematics, connect mathematical concepts with ideas outside of mathematics, and connect mathematical concepts in everyday life (Sutihat, 2019); and(Sitting & Oktaviani, 2020). Meanwhile, according to Muchlis et al. (2018), the mathematical connection can connect mathematics to everyday life and associate mathematics with other disciplines. Dewi (2013) adds that mathematical connection ability is the ability to link mathematical concepts both between mathematical concepts themselves (in mathematics) and linking mathematical concepts with other fields (outside mathematics), which include: connections between mathematical topics, connections with other disciplines, and connection with everyday life.

Ramdani (2016)suggested that indicators of mathematical connection ability include: (1) finding and understanding the relationship between various representations of concepts in other fields of study or everyday life; (3) understanding the equivalent representation of the same concept or procedure; (4) look for the connection of one procedure with another procedure in an equivalent representation; and (5) using connections between math topics, and between math topics and other topics.

Thus, mathematical connections are an important ability and must be possessed by students. However, this is not directly proportional to the facts on the ground. Based on the results of an unstructured interview with one of the class XII mathematics teachers at SMK Karya Pembangunan Pasirjambu, which was the place of research related to mathematical connection thinking skills, it was found that the student's abilities at the school were homogeneous and many students complained about the difficulty of learning mathematics.

Purwaningrum (2016) states that mathematics is very boring because it is considered difficult. In addition, after conducting a preliminary analysis of students, it turns out that students are not used to doing or solving problems related to mathematical connection abilities. It happened because students were still working on routine or procedural questions. Therefore, researchers researched the school to improve mathematical connection skills using this M-learning-based teaching material.

Success in the learning process is strongly influenced by the role of a teacher, starting from planning to implementing to evaluating the learning process and results (Inayah et al., 2020). Therefore, research on M-Learning-based teaching materials was carried out to improve mathematical connection skills in trigonometry material for class XI students. So it is

In accordance with the purpose of this study, namely to produce M-Learning teaching materials on trigonometry and analyze the improvement of the mathematical connection abilities of XI grade students after using these teaching materials.

METHODS

The approach in this research is a qualitative and quantitative approach or a mixed method. The research design used in this study was the One-Group Pretest-Postest Design. This type of research is R & D (Research & Development), which is research-oriented to research, design, produce, test, and the validity of the resulting product (Sugiyono, 2019). The product produced in this research is M-Learning teaching materials in mobile-based learning on Trigonometry material.

The ability to be improved in this research is mathematical connection ability. The sample of this research is 26 students of class XI. The population chosen was all class XI odd semester students for the academic year 2020/2021, which consisted of four classes with 143 students. The research procedure in developing the M-Learning Application used is the PLOMP model. According to Kreano (2012), the PLOMP model is a general model used to solve problems in the field of education, especially those related to R&D. The activities carried out in the PLOMP development model are Preliminary investigation, design, realization/construction, evaluation, and revision, implementation (Kreano, 2012).

This research use data collection of mathematical connection ability data using tests and interview methods. They collect data to validate teaching materials through material validation questionnaires, media validation, and student responses. The mathematical connection ability test is given after studying the teaching materials developed, and then the results are analyzed to see the mathematical connection ability.

The development of teaching materials is done by designing the required features in advance, such as profiles, basic competencies of learning objectives, core materials and quizzes. After designing these forms, the researchers collaborated on the mastering math application with mathematical material. then tested for validation by several certified mathematics lecturers and teachers. then make revisions. when the revision is complete, a re-validity test has been carried out which states that M learning teaching materials in mathematics are feasible to use. the final stage is implementation to students.

RESULTS & DISCUSSION

Result

This section describes the research results in detail, including displaying the results of calculations, results of needs analysis, and so on. The results of this study can also be displayed in the form of tables or figures, provided that the tables or figures should not be too long, too large, and too numerous. The author should use variations in the presentation of tables or figures, and each table or figure presented must be referenced (not rewritten) in the text. We recommend that you do not include SPSS data processing results tables in the article (authors are required to re-summarize and create a separate table according to the format requested in this template).

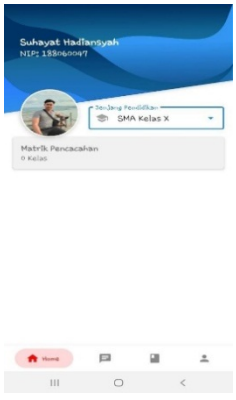
There are several stages in the process of developing this m-learning media. The first stage is needs analysis. Needs analysis is the first step in conducting research and development to know the development of M-Learning-based media products. The analysis obtained by the researchers includes a) In the process of learning mathematics, it

is still rare to use cellphone media when learning takes place. b) There are still problems in learning mathematics, where students lack self-confidence. c) Most students in schools already have Android phones to support the learning process. d) Schools that are used as research carry technology-based learning.

Second, school selection. The researcher chose SMK Karya Pembangunan Pasirjambu as the research site. From the results of an unstructured interview with one of the teachers in the field of mathematics who teaches at SMK Karya Pembangunan Pasirjambu, it was found that students at SMK Karya Pembangunan Pasirjambu still lacked focus and were not enthusiastic when learning. This matter causes students to be weak in understanding the material given. In addition, students' mathematical connection skills must also be improved.

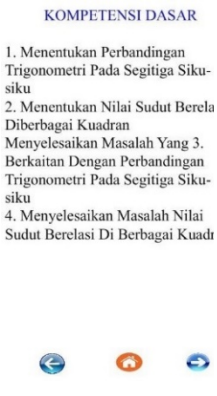
Third, material selection. The material selected in this research and development results from discussions with mathematics teachers. The specialization of this taken is two sub-chapters. The selection of this material is adjusted to the school's lesson hours that are used as a research location. That way, the material can be conveyed well to students.

Fourth, planning. After analyzing needs, selecting schools and materials, the next step is to plan research and develop M-learning-based learning products. The steps at the planning stage are as follows: 1) Collecting learning resources related to the material presented. Learning resources are obtained from textbooks, worksheets, modules, or the internet. 2) Make notes on the materials used in media development. This note is in the form of a PPT (PowerPoint) used as the basis for media planning. 3) Designing a design/layout for a display that matches the character of SMA/SMK level students and equivalent. Making a design in this m learning begins with a story board and then the rest of the math material is poured out. 4) Preparing an animation design used in teaching materials to make the display more attractive. 5) Preparing the materials needed in media development. 6) Prepare a questionnaire for two media validation people, seven material validation people consisting of 5 field practitioners and two mathematics lecturers, ten students as respondents to the teaching materials made. 7) Prepare evaluation materials in the form of pretest and post-test questions.



1a Intro

1b Main Menu



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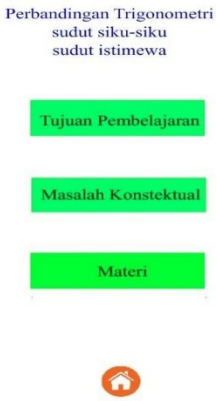
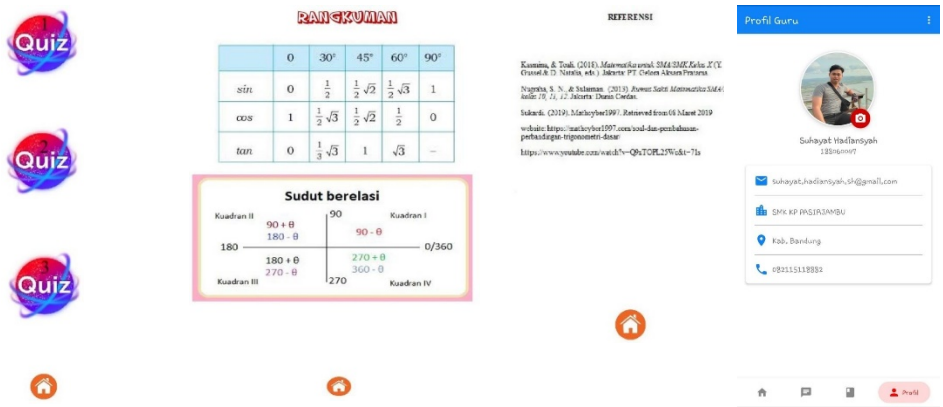


1d Material



1e Quiz 1f Summary 1g Reference 1h Author

Figure 1. Display of M-Learning-Based Teaching Materials

Display on the first m-learning media intro. There is a Home menu in the Intro scene, seen in Figure 1. This menu display shows which level was selected and the material being studied. Second, the main menu is shown in Figure 2. Some buttons are used to direct us to the menu to be selected in the main menu. The menu includes basic competencies, concept maps, history, materials, summaries, quizzes, tests, and references. In the basic competence scene shown in Figure 3, learning objectives show what students must achieve in the overall learning process. In the material scene shown in Figure 4, the sub is presented with icons that can be selected, including learning objectives in the realm of sub-chapters, contextual problems from sub-chapters, and learning materials.

In the quiz menu in Figure 5, students are presented with practice questions with three choices. Students can immediately answer and get corrections for incorrect answers in this session. In the summary scene in Figure 6, a summary of all the material made in the lesson is presented. Furthermore, in the reference scene shown in Figure 7, there is a bibliography of a collection of theories used to assemble this teaching material. Figure 8 shows the students or teachers who use teaching materials in the author's scene. In this scene, test in the form of questions given to measure students' cognitive abilities. The following is a documentation of M-learning-based teaching materials.

Then the product has been tested for validity. Based on the results of material expert validation, the highest percentage is the material aspect with a percentage of 91%, the question aspect is 88%, the language aspect is 80%, and the implementation aspect in learning is 81%. Thus, the average percentage of the four aspects of 85% is very feasible to be tested.

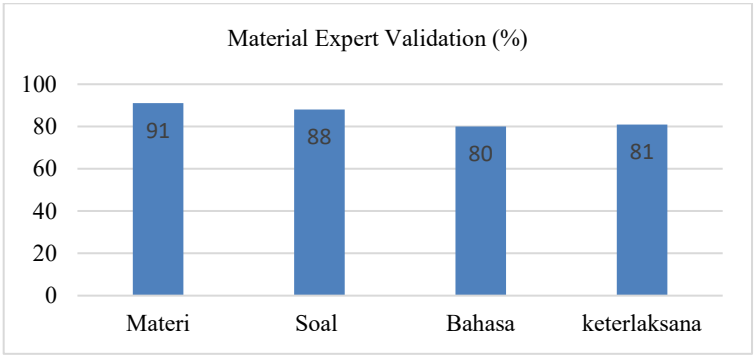


Figure 2. Material Expert Validation

While the assessment results of 3 media experts obtained the percentage of visual communication validation aspects of 63% and software engineering 83%, this means that the device presented in the form of an android application is quite feasible to be tested.

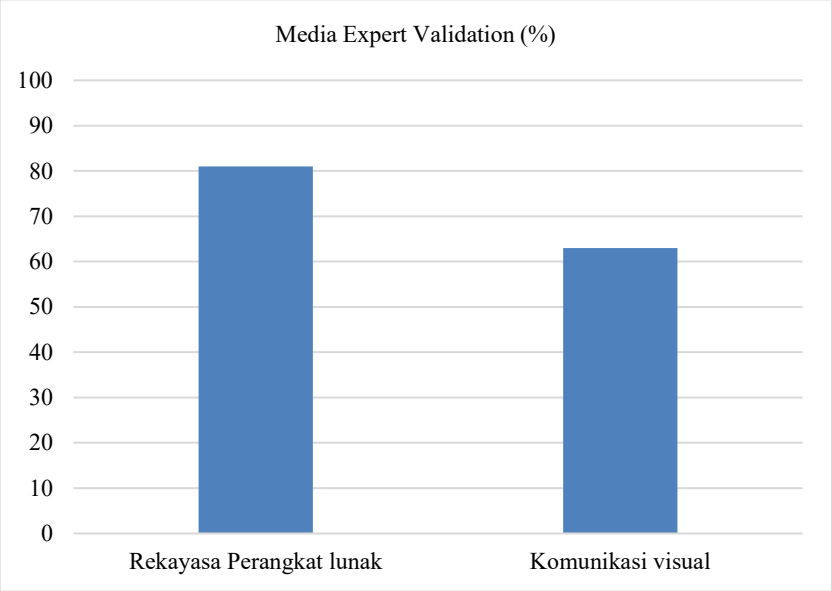


Figure 3. Validation of media experts

Then the validity of M-Learning. The validity of the M-Learning was determined by Application by media experts, and the Cochran Q Test statistic is used. The test is used for three or more paired samples (Riyadi et al., 2017). Cochran Q Test using the help of IBM SPSS statistics 20. And get the following results:

Table 1. Cochran Q Test

N	22
Cochran's Q	16.533a
df	2
asymp. Sig.	.000

a. 0 is treated as a success.

It can be seen that Asymp obtained media would expert validation test results. Sig 0.00 < 0.05, so the validators gave a different assessment. Furthermore, the researcher tested students in the field trial phase and obtained student responses to the developed teaching materials. While the data from student responses were obtained using a questionnaire. The following is a descriptive explanation of the results of field test research on products developed using the questionnaire method, which consists of 3 aspects, namely aspects of software, learning design, and visual communication. The results of student responses can seen at table 2.

Table 2. Test Results of Teaching Materials

Aspect	Percentage (%)	Category
software	68	worthy
learning design	66	worthy
Visual communication	67	worthy

Table 2 regarding student responses shows that this teaching material is categorized as suitable for use. Furthermore, students also feel that through mobile learning teaching materials, they can relearn the material that has been studied at another time.

Then the final stage, namely implementation. The implementation phase measures students' mathematical connection abilities before and after using mobile learning media through pretest and post-test questions. The two results were compared to determine the significant improvement between the two. As for the learning process, besides being assisted by M-learning teaching materials, students are also assisted by using the zoom application because learning is not done face-to-face. The field test showed increased student learning outcomes before and after using this Android-based M-Learning teaching material. This is in accordance with research(Nugroho, 2014; Nasution, 2016; Firdausi, 2016; Putra et al., 2017; Mulyana & Taufan, 2020). To determine the increase in the ability of the mathematical connection through again test with the following results:

Table 3. Gain Test of Mathematical Connection Ability

Pretest mean	Posttest average	Maximum score	Gain test results
34.67	60.83	100	0.40

The following is the ability of mathematical connections in Trigonometry material to be seen based on the results of student work. The gain score obtained is 0.40 in the "medium" category based on the above calculation. The increase in the average value shows that M-Learning teaching materials generally improve mathematical connection skills after students use mobile learning in learning. Measurement of mathematical connection ability is done through a post-test after learning is done through a zoom meeting.

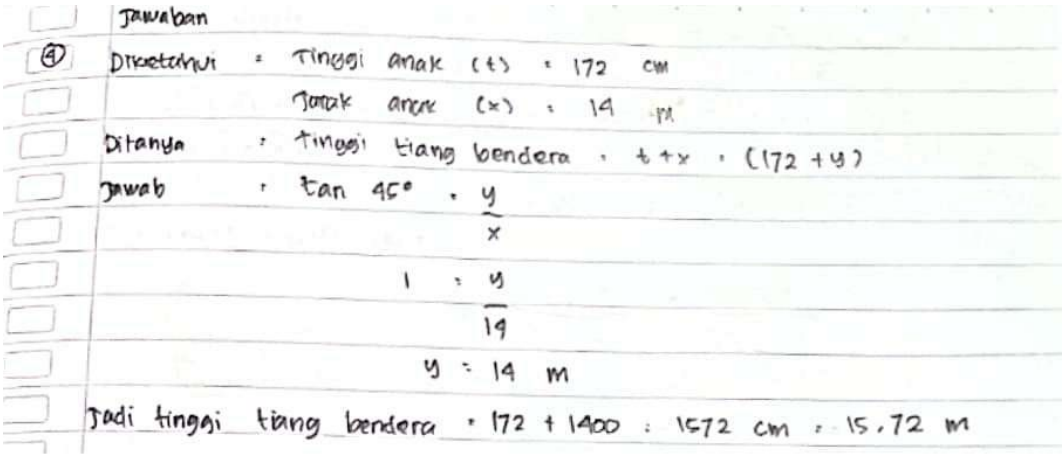


Figure 4. The results of student answers with criteria for easy questions

The answer shows that the students have mastered the questions well. In this answer, students can answer the questions correctly. Likewise, students can write down what is known and what is asked in solving the problem. Thus, students already understand the questions given following one of the indicators of mathematical connection ability, namely "connecting the Pythagorean concept and the concept of trigonometric comparisons to solve everyday problems."

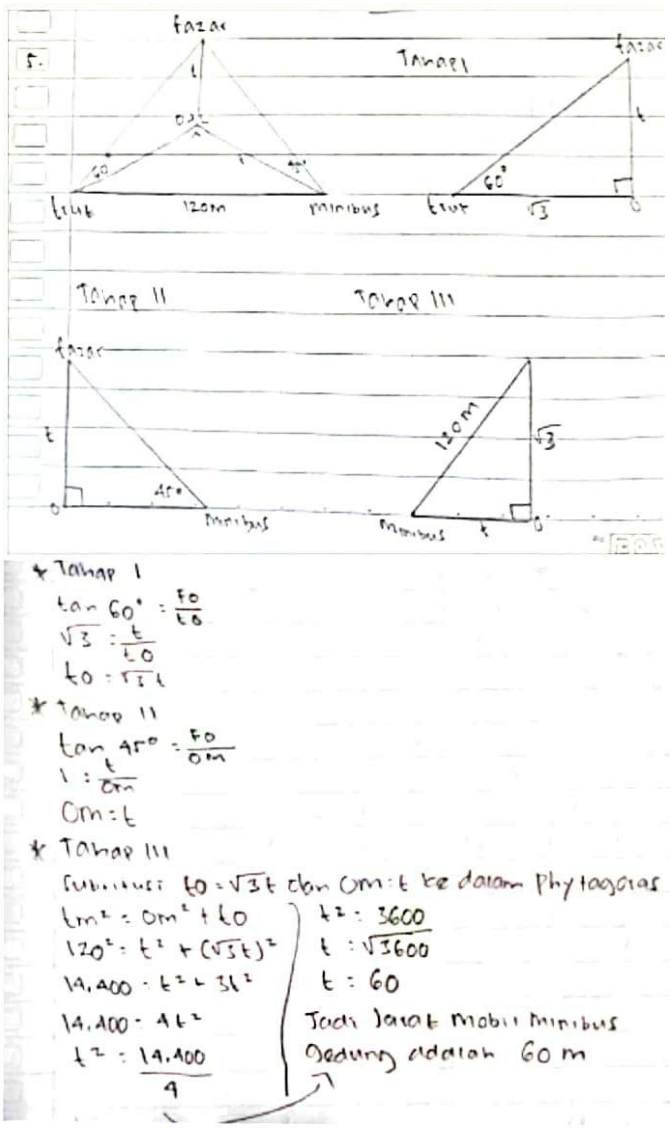


Figure 5. The results of students' answers with difficult question criteria

Students are taught to be more careful when doing calculations because mathematics is a hierarchical science. Students can produce correct answers to one of the questions with "difficult" criteria. However, I found one wrong solution behind their answer on the stage. The answer should be = 3 and indicate the student made an error when performing arithmetic operations. If the student initially works with the wrong answer, then the final answer will also be wrong. This statement is following research conducted by (Sahriah, 2012: Farida, 2015; Faizal, 2015; Rahmi et al., 2017; Ni'mah, 2017; and Wati & Ningtyas, 2020) where errors in performing arithmetic operations or

skills Computing is caused by the lack of students in mastering the steps or concepts of arithmetic operations that should be used and the lack of thoroughness of students when solving these problems.

However, most answered correctly based on the data obtained from the 20 students who took part in the lesson. Therefore, based on the discussion above, the study results indicate an increase in students' mathematical connections when using the teaching materials that have been developed.

Discussion

M-learning teaching materials allow students to repeat the material independently without being bound by time and place to improve memory of the material. This statement follows (Ibrahim & Ishartiwi, 2017; Hakim, 2017) that digital learning media can facilitate students in learning anytime and anywhere and increase students' motivation and memory because they can be used repeatedly. (Sakat et al. 2012; Alfarani, 2015) also stated that using technology learning media can increase motivation, students are more attractive so that learning becomes interesting and fun.

Researchers developed this m-learning teaching material to improve learning outcomes through characteristics, namely visualization that is attractive, flexible, and practical so that it can be used anytime and anywhere and has a varied evaluation of questions. Based on the research results, it was found that the mobile learning-based teaching materials developed were suitable for use in classroom learning. Several theories support this statement state that the Android-based M-learning learning media that was developed and declared feasible can be used in learning activities (Wibowo & Arifudin, 2016; Rubiantoro & Khotimah, 2021; Wahyuaji & Taram, 2018; Kadaryanto, 2017; Hanifah & Sari, 2021; andWahyono, 2018).

This development research produces a product of mathematics learning devices in a mobile learning application for trigonometry material. The Application has been said to be feasible by experts and was distributed to find out the attractiveness of the mobile learning application based on student responses. The development of the mobile learning application for trigonometry is carried out through stages based on the PLOMP development model using the following steps: (1) Preliminary investigation, (2) Design, realization/construction, (3) Evaluation and revision, (4) Test evaluation and revision, (5) Implementation.

The first stage is a needs analysis. This part follows Brown's statement (Shodikin, 2017), where needs analysis is a step to collect information and identify supporting and inhibiting factors in the learning process of learners to achieve learning development goals that lead to improving the quality of education. This stage is needed to identify the problem to determine the appropriate action. This development process analyzes student needs, curriculum adapted to KI, KD, and analysis of the material used.

The second stage designs. We are designing learning media at this stage, namely teaching materials and M-learning media. Media design is designing, layout, and display. The design of the instruments included media assessment and evaluation instruments obtained from media assessment questionnaires and test questions grids. The results of this stage are then developed at the stage of developing learning media, media assessment instruments, and test questions on the subject of trigonometry. This statement follows Soeyono (2014), who defines teaching materials as information, tools, and texts needed by teachers or instructors to plan and review implementation in learning.

Developing mobile learning applications as media experts and material experts validated learning media. Expert input is used as a revision, and validation tests are made to see the feasibility of teaching materials used in trials to students. Based on the results

obtained, it can be concluded that the learning media developed is categorized as very feasible according to the assessment of media experts and material experts, so that the teaching materials are feasible to be tested.

Furthermore, the researcher tested students in the field trial phase and obtained student responses to the developed teaching materials. Obtaining student responses on the media aspect is included in the appropriate category. In learning design, it is included in the feasible category. In the aspect of visual communication, it is in the proper category. So, based on student responses, this teaching material is feasible to use.

The next stage is the implementation of the media by measuring the achievement of students' mathematical connection abilities before using mobile learning media and after using mobile learning media using pretest and post-test questions on students. The two results were compared to determine whether there was a significant improvement in student learning outcomes using mobile learning applications. This statement is in line with Nasution's research (2016), which suggests that mobile learning-based learning is a new option in learning and is very effective in achieving learning goals.

The results showed an increase in students' mathematical connection abilities, as seen from students' work in working on mathematical connection questions. The statement supports this that the development of teaching materials can improve students' mathematical connection abilities (Abdullah, 2012; Firmansyah, 2016; Yunida, 2016; Yani, 2016; Setyadi, 2017; Nurhayati, 2017; Safitri & Noviarni, 2018; Arianti, 2021). These m-learning teaching materials that have been declared feasible are then used in the learning process to improve mathematical connection skills and as an effort to create innovative learning during the COVID-19 pandemic.

The N-gain analysis was taken from the pretest and post-test scores. Post-test and pretest are adjusted to indicators of mathematical connection ability. The average pretest score and the post-test mean score showed an increase. The increase is in the “medium” category. The increase in the average value shows that M-Learning teaching materials generally improve mathematical connection skills after students use mobile learning in learning. Increasing students' mathematical connection skills are still not maximal inaccuracy. This statement follows the research of Sahriah (2012); Faizal (2015); Ramdhani et al. (2016); Ni'mah et al. (2017); Sari & Yulianti (2020); and Wati & Ningtyas (2020), which states that errors in performing arithmetic operations or computational skills are caused by the lack of students in mastering the steps or concepts of arithmetic operations that should be used and students' lack of accuracy when solving the problem.

CONCLUSION

Based on this research, it can be concluded that the development of Android-based M-Learning teaching materials for class XI SMA/SMK/MA students using the PLOMP model through rating scale calculations shows valid (feasible) results to be used as student learning media. This teaching material has several advantages: having complete Trigonometry material according to KD and having a voice that can help in the learning process as a substitute for face-to-face learning. In addition, there are differences in the improvement of students' mathematical connection abilities before and after using M-learning learning media. Based on the conclusions, other researchers can make suggestions to develop this M-Learning learning media. It is hoped that this learning media can be disseminated using applications other than Android, such as iOS and Blackberry systems. So that the users of this product will be even wider because all student smartphone users can access M-learning teaching materials without exception.

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