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Development of proof-based student worksheets in trigonometry

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Abstract. Research has been conducted for: (1) Developing student worksheets based on valid trigonometric mathematical proofs, (2) Developing student worksheets based on practical trigonometric mathematical proofs and (3) Knowing the advantages and limitations of validation student product based on trigonometric mathematical proof developed. The research method used is research and development (R&D) with a development model developed by Rowntree, using three stages, namely: (1) the planning stage, (2) the development phase and, (3) the evaluation phase. The results of data analysis can be concluded The results give meaning that the developed: (1) is appropriate and appropriate to use, because it is in accordance with core competencies, basic competencies, indicators, objectives, scenarios of teaching and learning activities and has phases that are measurable and clearly easily understood by students and can develop Student that have been developed to meet the eligibility as a good Student, (2) both at one to one stage and small groups based on the criteria of practical use for each indicator in the practicality category on good level. (3) Excellence Developed Students can increase motivation, foster interest in learning, foster an attitude of confidence, can foster an honest attitude, increase discipline and foster cooperation among fellow students.

1. Introduction

Mathematical proof is one aspect that must be observed in mathematics learning. Evidence serves as an explanatory and discovery tool that helps us understand why a statement is said to be true. Evidence as a discovery tool is basically very related to exploration activities. Exploration as a function of evidence contains meaning that leads to further study of a definition to explore the meaning it contains as a whole. The role of evidence as an exploratory tool will also be evident when a proven theorem then leads us to the discovery of new ideas Proving is an important part of mathematics itself, [1].

Many students have difficulty learning reasoning, argumentation, and mathematical proof [2, 3, 4]. Difficulties experienced by students include students having difficulty writing formal evidence, students having difficulty writing their reasoning systematically, and students' knowledge of mathematical definitions and theorems. Thus, reasoning and proof in mathematics must be developed. This is in accordance with the opinion of [5] which states that the ability of mathematical reasoning needs to be developed because it can train students to better understand the mathematics taught. However, in reality the students' mathematical reasoning ability at this time in Indonesia is still relatively low based on the assessment conducted [6]. The objectives of this study are: (1) Developing valid student worksheet based on trigonometric mathematical proof worksheet, (2) Developing student worksheet based on practical trigonometric mathematical proof and (3) Knowing the advantages and limitations of the student worksheet based on mathematical trigonometric proof which was developed.

The research method used is research and development (R&D) with a development model developed by Rowntree, using three stages, namely: (1) the planning stage, (2) the development phase and, (3) the evaluation phase.

2. Method

The method used in this study is the method of research and development (R&D) using the Rowntree development research model using three stages, namely: the planning stage, namely the formulation of learning objectives and analysis of learning needs; the development stage, which is about developing topics, drafting, producing prototypes of one type of product that will be used for learning; the evaluation or appraisal stage by carrying out a product prototype trial and its improvement based on the input obtained previously. The procedure of rowntree model can be seen in Figure 1

Figure 1. The stages of the Rowntree Product Development Model [7].

The evaluation used is Tessmer's formative evaluation, the evaluation is to determine the practicality of a product being developed. Development is focused on 2 stages, namely the preliminary stage and the formative evaluation stage. Formative evaluation has 4 stages which include self evaluation, prototyping (expert reviews, one-to-one, and small groups), and field test. The formative evaluation design flow as shown in Figure 2.

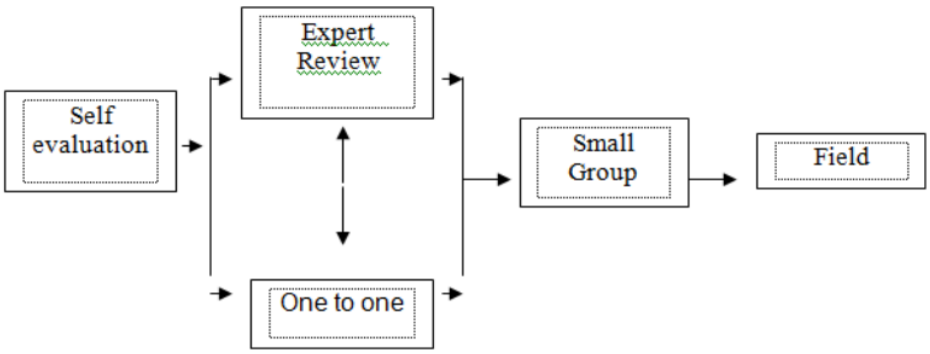

Figure 2. Formative evaluation design flow[8].

Research subjects conducted in class XI high school, one to one trial 3 students in class IPA.VI, small group test 9 students of class IPA.VI and field test 34 students in class IPA.VIII. The results of the score at the expert review stage were analyzed quantitatively as input to revise the Student Worksheet. In addition, the input is to find out the validity of the product being developed. As for the tools used to collect data in the form of questionnaire sheets given to experts. Questionnaire sheets in the form of validation sheets given to experts are made on a Likert scale.

Table 1. Category for each score at the stage *Expert Review*, One to One and Small Group [9].

Answer Category	Score statement
Very suitable	5
Corresponding	4
Quite appropriate	3
Not suitable	2
It is not in accordance with	1

The results of expert recommendations and recommendations were then revised, while the scores provided by the three validators to see the level of accuracy (validity) per content indicator. To analyze the accuracy (validity) the correctd item total correlation coefficient was used and then compared with the r table (person product mmoment level of significance 0.05 and 2 tailets. If the coefficient rn value (number of categories) is greater than the coefficient r table then the object (Student Educator Worksheet products based on mathematical proof) are valid[10].

Questionnaire data analysis is based on the results of the questionnaire given to students. In the one to one and small group stages, it is useful to perfect or revise the Student Worksheet guidelines based on responses from students. Similar to the questionnaire for experts, the questionnaire sheets used were in the form of responses or suggestions and in the form of a checklist.

To find out the consistency of the objects (Student Worksheet Product Based on Mathematical Proofing) the scores of respondents' assessment results on each item were analyzed using the Cronbach Alpha technique. If the Cronbach Alpha value is less than 0.6 then the object in the category is not good (not reliable), if the Cronbach Alpha value is 0.7 acceptable, and if 0.8 or more then the Student Worksheet objects have good reliability. [12]. Meanwhile, to assess the practicality of a product by converting the average score (X) obtained into a qualitative value according to the assessment criteria shown in Table 2.

Table 2. Category practicality value[13].

Percentage (range of scores)%	Category
$x \geq 80$	Very good
$60 \leq x < 79$	Pretty good
$40 \leq x < 59$	Not good
$20 \leq x < 39$	Bad
$x \leq 19$	Very bad

3. Result and Discussion

Evidence for judges can have implications for something that is not in doubt; evidence for statisticians means it occurs with a certain probability; and for scientists, evidence is the result of an empirical experiment[14].Furringhetti and Morselli are specific. In addition, this involves a commitment to a problem-solving approach that is no longer a practical requirement but a requirement. The role of proof is for several years I have asked myself what role of evidence must be played in mathematics education. in mathematics and in particular on what makes evidence acceptable. This topic is discussed long enough in rigorous evidence in mathematics education [15]. The functions of proof [16, 17, 18] consist of:

- Verification (concerned with the truth of the statement)
- Explanation (giving insight into why it's true)
- Systematization (organizing various results into a deductive system of actions, main concepts and theorems)
- Discovery (discovery or discovery of new results)

- Communication (transmission of mathematical knowledge)
- Empirical theory construction
- Exploration the meaning of the definition or consequences of a presumption
- Incorporating well-known facts into the new framework and therefore seeing them from a new perspective

Trigonometry is one of the topics of mathematics that students must understand to develop their mathematical understanding[19]. This is in agreement with who said that for most students in tertiary education, trigonometry is an important part of analysis in reasoning.[20] who focused research on the development of trigonometric learning tools, in her research concluded that the trigonometric learning tools developed were categorized as valid and practical.

3.1 The results of Expert Validation

The results of expert validation carried out on 3 experts to the eligibility of the student worksheets provided through scores for each aspect of the content. language, design, language and aspects of the phases built in the Student Worksheet after being analyzed using the Cronbach's Alpha technique: (1) for the aspect of content whose indicators assess the validity of the Student Worksheets that are developed towards conformity to conformity with competence, competence basis, indicators, objectives, material. Teaching activities, the Syntax in the Student Worksheet is obtained for each indicator 0.9 except the goals and the syntax of the Student Worksheet each 0.923, with a reliability level of 0.918. For aspects of language which are self-indicators of readability, clarity of information, a lack of good language rules and the use of effective and efficient language, respectively 0.750, 0.857, 0.857 and 0.750 with a reliability level of 0.857. For aspects of design, the indicators consist of: Order of presentation, cover design, use of fonts (types and sizes), effective and efficient user and layout, each obtained 0.893, 0.893, 0.893, 1,000, 0.893 and 0.893. Furthermore, for aspects of phases that are developed in the Student Worksheet which includes: factoring equations, converters into sines and cosines, conversion into multiples of small alliances, conversion into the form of the number of fractions, use of the identity of pytagoras, conversion into ordinary fractions and make the conclusions each obtained respectively: 0.914; 0,900; 0.914; 0,900; 0.914; 0,900; and 0.914 with a reliability level of 0.921.

3.2 The Results of the One To One stage, the small group and stage fild tes stage

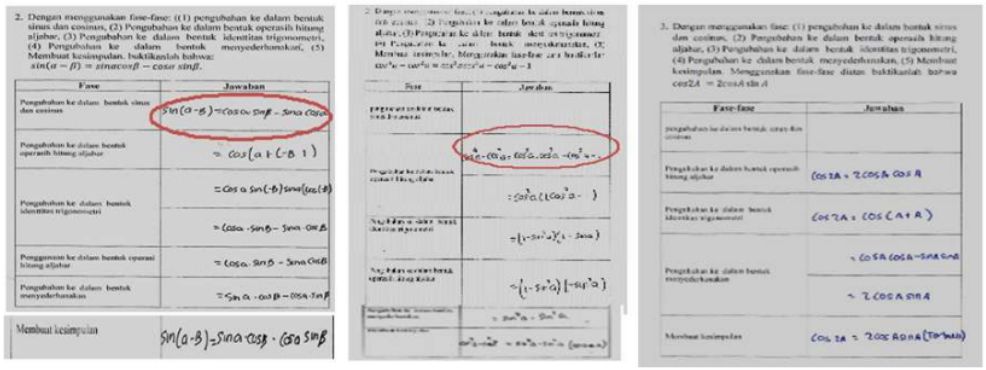

Figure 3. Results of the One To One stage.

These results mean that the developed student worksheet is appropriate and appropriate to use, because it is in accordance with core competencies, basic competencies, indicators, objectives, scenarios of teaching and learning activities and has phases that are measurable and clearly easy to understand by students and can develop student worksheets that have been developed to meet the eligibility as a good student worksheet.

Table 3. The results of practicality analysis in one to one stage for each indicator

Statement	Results
usefulness obtained	0.33
clarity of information	0.33
Motivation	0.367
use of language	0.367
Instructions	0.367
use of fonts	0.367
type and size of	0.367
lay out	0, 33
Illustration	0.33
display design	0.33
Interest	0.33
average total indicator	3.44
with standard deviation	0.17

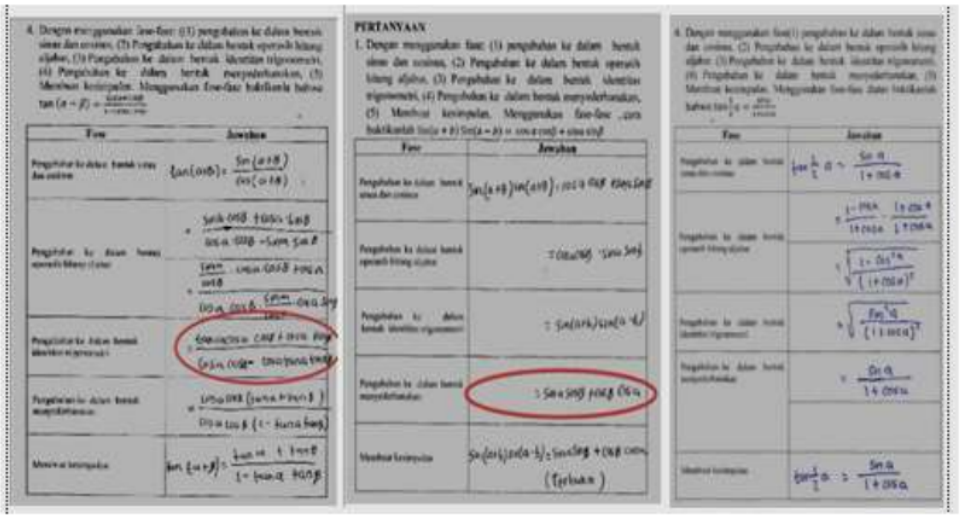

Figure 4. Results of the small group.

After categorizing both small group stages based on practicality criteria, for each indicator in the practicality category at a good level. This gives meaning that the Student Worksheets that are developed can provide benefits for students, Student Worksheets that are developed are clearly easy to understand, can increase student motivation, are arranged and designed using good language, have clear instructions, use types fonts and font sizes, layouts, illustrations, good display designs, in addition to that also the Worksheet Students that are developed can foster and increase interest in learning.

Table 4. The results of practicality analysis at the small group stage for each indicator.

Statement	Results
usefulness obtained	0.36
clarity of information	0.35
Motivation	0.362
use of language	0.361
Instructions	0.367
use of fonts	0.367
type and size of	0.356
lay out	0.367
Illustration	0,377
display design	0,367
Interest	0,357
average total indicator	3,64
with standard deviation	0,117

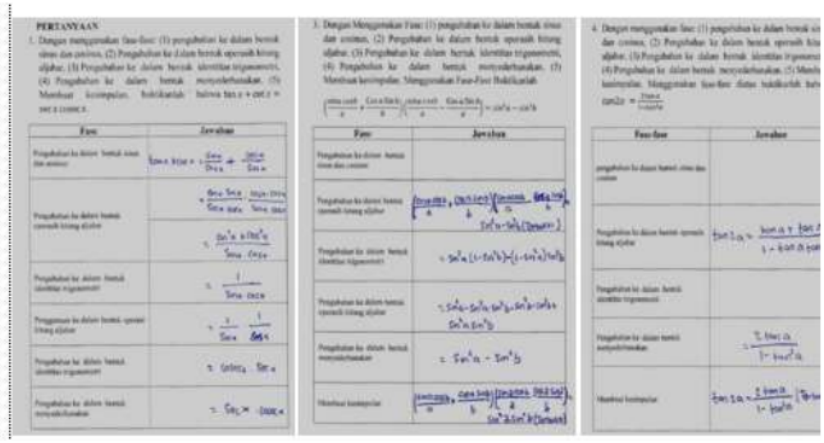

Figure 5. Results of the field test

After categorizing both the fildtes stages based on practicality criteria, for each indicator in the practicality category at a good level. This gives meaning that the Student Worksheets that are developed can provide benefits for students, Student Worksheets that are developed are clearly easy to understand, can increase student motivation, are arranged and designed using good language, have clear instructions, use types fonts and font sizes, layouts, illustrations, good display designs, in addition to that also the Worksheet Students that are developed can foster and increase interest in learning.

Table 5. The results of practicality analysis at the small group stage for each indicator.

Statement	Results
usefulness obtained	0.701
clarity of information	0.639
Motivation	0.676
use of language	0.747
Instructions	0.747
use of fonts	0.765
type and size of	0.772
lay out	0.719
Illustration	0.664
display design	0.684
Interest	0,674
average total indicator	7,72
with standard deviation	0,448

Analysis of the advantages and limitations at the one to one, small group and fild tes stages for each indicator (motivation, interest, attitude, honesty, discipline and cooperation) obtained on average for each indicator 3.42-3.77 (on a scale of 5). This gives meaning that the Worksheets of Students who are developed can increase motivation, foster interest in learning, foster an attitude of confidence can foster an honest attitude, increase discipline and foster cooperation among fellow students.

4. Conclusion

Based on the results of data analysis it can be concluded that the student worksheet developed: 1) it is appropriate and appropriate to use, because it is in accordance with core competencies, basic competencies, indicators, objectives, scenarios of teaching and learning activities and has measurable and clear phases easily understood by students and can develop Student Worksheets that are has been developed to meet the eligibility as a good student worksheet, 2) both the one to one and the small group stages are based on practical criteria for each indicator in the practicality category at a good level, 3) excellence worksheets students can increase motivation, foster interest in learning, foster an attitude of confidence, can foster an honest attitude, increase discipline and foster cooperation among fellow students.

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