



Development of Diagnostic Test to Measure Learning Loss of High School Students in Trigonometry

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Abstract

Learning loss is when a student loses academic knowledge and skills due to certain situations and conditions, such as pandemics, long school holidays, and other emergencies. An effort can be made to determine the learning loss that occurs in students by using diagnostic tests. However, the availability of questions for diagnostic tests on mathematics, especially trigonometry material, is still limited. This research aims to develop and validate diagnostic test questions to measure high school students' learning loss in the trigonometric function topic. This research uses preliminary research in the development stage with the Plomp model. The stages carried out in this study include self-evaluation and expert review. Document analysis is carried out at the self-evaluation stage by identifying basic competencies and formulating indicators, compiling a learning continuum, formulating attributes, compiling a Q matrix, and constructing questions. Then, three validators tested the validity and feasibility of the questions. The results of the validity test show that the 25 diagnostic questions that have been developed all meet the very valid criteria, with the average score for each item from the three validators being more than 3.20.

Keywords: diagnostic tests; learning loss; trigonometry

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INTRODUCTION

Evaluation is an important aspect that cannot be separated from every educational process. The purpose of evaluation is to prove something and make improvements (Dunn & Mulvenon, 2019; House, 2012). Based on the type of evaluation, it consists of formative evaluation, which functions as an assessment instrument carried out continuously during the learning process. Summative evaluation is a tool to assess student achievement results during the learning process in a certain period. Diagnostic evaluation assesses the causes of student failure in learning lesson material (Csapó & Molnár, 2019; Champagne Quelo et al., 2017; Ketterlin-Geller & Yovanoff, 2019).

However, many students find math boring and hard to understand, especially trigonometry material (Fajri & Nida, 2019; Nurizlan et al., 2022), because the material involves many interconnected concepts. Therefore, when students are faced with questions related to trigonometry, they find it difficult to solve the problem given (Jatisunda, 2019; Laja, 2022; Nurfauziah & Sari, 2018).



On the other hand, the Covid-19 pandemic has also significantly impacted education in Indonesia. One of the impacts experienced was the cessation of learning at school; in other words, students had to take part in online learning. This situation provides new challenges for students, teachers and parents in adapting to the online learning model as an alternative to continuing the education process. Even though online learning has become an important alternative in overcoming the pandemic, there are still challenges that must be overcome (Adedoyin & Soykan, 2023; Hermanto & Srimulyani, 2021), one of which is students' learning loss. Learning loss is a condition where students experience a decrease in understanding, skills and basic mastery of learning material due to the lack of opportunities to participate in learning at school (Gore et al., 2021; Safira & Ifadah, 2021).

According to Donnelly and Patrinos (2022), learning loss is a decline in students' academic knowledge and skills due to learning at home, which lasts for quite a long time. Learning loss can also be interpreted as a decrease in students' interest in learning caused by a lack of interaction with teachers during the learning process (Budi et al., 2021). Learning loss can be caused by various factors such as uneven infrastructure, computer and internet networks, boredom, difficulty understanding the material, and lack of motivation to learn (Sovayunanto, 2022). Learning loss hurts students, especially in learning mathematics, including students having difficulty understanding basic concepts, which results in problems understanding further concepts, decreased student self-confidence, decreased academic achievement, lack of tolerance and cooperation, loss of interest in learning, and low ability of problem-solving (Kusnadi & Sari, 2023; Muskita et al., 2022; Safira & Ifadah, 2021; Widodo & Umar, 2022).

As a result of this problem, teachers need an assessment tool to identify the learning loss experienced by students. A solution that can be offered is to carry out a diagnostic test on trigonometry material to determine the learning loss that occurs in students. A diagnostic test is a test to determine the types of difficulties experienced by students in the learning process (Sriyanti et al., 2019). In this case, a diagnostic test is used to determine student learning loss in learning trigonometry. In addition, this test can also help teachers provide solutions to identified problems. A diagnostic test on student learning loss is an effort that needs to be made by teachers to find out the learning obstacles experienced by students, especially in learning mathematics. However, the availability of questions for diagnostic tests on trigonometry material is still limited, making it an obstacle for teachers who want to improve students' learning loss. Therefore, researchers are interested in developing diagnostic test questions to measure high school students' learning loss in trigonometry material. The research questions in this study are "What are the results of developing and validating diagnostic tests to determine student learning loss in trigonometry material in high school?" and "What are the processes of developing and validating diagnostic tests to determine student learning loss in trigonometry material in high school?"

METHOD

This research uses preliminary research in the development stage with the Plomp model. It aims to analyze the feasibility or usefulness of diagnostic tests on trigonometric function material in learning loss. Tessmer stated that a theory about formative evaluation was carried out to examine the advantages and disadvantages of development designs to increase efficiency and attractiveness (Tessmer, 1993). The research stages carried out in this study include a preliminary research stage and expert review. This limitation indicates that the research results may not fully reflect the effectiveness and efficiency of the diagnostic test being developed because other evaluation stages, such as the one-to-

one evaluation, expert review, small group evaluation, and field test stages have not been carried out. Without involving these stages, potential deficiencies in the implementation and acceptance of tests in the field may not have been fully identified, so the final results of this development may not be optimal.

Firstly, document analysis was carried out at the preliminary research stage by analyzing the independent curriculum and specialization learning materials, especially trigonometry material. Then, learning outcomes used in the curriculum and schools were identified, indicators were formed, and a learning continuum was compiled so that attributes were obtained in accordance with the learning continuum for developing diagnostic questions. After the questions were prepared, expert validation was carried out by validators consisting of one mathematics lecturer and two high school mathematics subject teachers.

Secondly, at the expert validation stage, responses and suggestions from the validator are written on the validation sheet as revision material. The instrument used was a validation questionnaire with a grid adopted from Cayani (2021) as shown in Table 1.

Table 1 Grid of expert validation questionnaires

Content	a. Suitability of attributes or indicators of competency achievement with the material b. The attribute level or learning continuum is formulated appropriately c. Formulation of attributes using operational verbs d. Conformity of question indicators with attributes e. Conformity of questions to indicators
Construct	a. The main questions are formulated briefly, clearly and firmly b. The main questions do not provide clues to the answer key c. The main questions are free from double-negative statements d. There is only one answer key e. Answer choices are homogeneous and logical in terms of material f. Images, graphs, tables, diagrams, or similar are clear and functional g. Answer choices do not say "all the answers above are wrong/right" h. The answer choices in the form of numbers/time are arranged based on the order of the size of the numbers or chronologically i. The options provided are accompanied by an explanation of distractors based on the error level, namely: D0 Most errors D1 Has many errors D2 Misdemeanor D3 Lightest error (few)
Language	a. Using language that conforms to Indonesian rules b. Using communicative language c. Do not use local/taboo language d. Answer choices do not repeat the same words/groups of words unless they are a unified meaning

Validation data from all validators will be processed and calculated to measure the validity and feasibility of several instruments used in this research. Overall, expert validation provides important information regarding the validity, feasibility, and utility of the diagnostic test being developed. The feasibility test is carried out based on the following formula:

$$R = \frac{\sum_{j=1}^m x_j}{m}$$

Notes:

R = Validity of the questions

$\bar{x}_j$ = Average results of the item

m = Number of items

The validation data is then processed and calculated using the following formula with the criteria shown in Table 2.

$$R = \frac{\sum x_i}{m} \times 100\%$$

Notes:

R = Validity of the questions

x_i = Value given by validators

m = Greatest value from each aspect

Table 2 Eligibility criteria (Cayani, 2021)

Eligibility Value %	Criteria
$R > 3.20$	Highly valid
$2.40 < R \leq 3.20$	Valid
$1.60 < R \leq 2.40$	Enough
$0.80 < R \leq 1.60$	Less Valid
$R \leq 0.80$	Invalid

RESULT AND DISCUSSION

This part is the main part of a scientific article. Results and discussions are usually Based on the self-evaluation stage; document analysis was carried out by identifying basic competencies (CP), formulating indicators, compiling a learning continuum, formulating attributes, compiling a Q matrix, and constructing questions. The document analysis process is explained as follows.

Identify Basic Learning Outcome

Identification of basic competencies and indicators is carried out through analysis of the independent curriculum (Kemendikbud, 2023) that is carried out to see the comparison of the 2013 curriculum and the independent curriculum which is currently being implemented in schools, as well as looking at learning achievements in high school mathematics subjects to formulate learning objectives. In the independent curriculum, the intended learning outcomes are that students can determine trigonometric functions and determine graphs of trigonometric functions.

Developing a Learning Continuum

The learning continuum is a material hierarchy arranged from simple to complex. Learning continuum in trigonometric function material is: (1) students can describe trigonometric functions; (2) understand trigonometric ratios; (3) explain trigonometric functions with the unit circle; and (4) explain changes that occur in the function graph. The material hierarchy is explained in Figure 1.

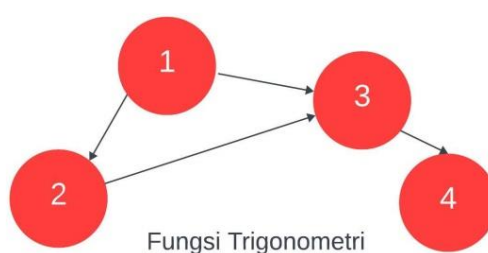


Figure 1 Learning continuum of trigonometry function

Formulating Attributes

Attributes are abilities or competencies that must be possessed so that students can complete an item (Kusaeri, 2012). The formulation of attributes is adjusted to the learning outcomes of the independent curriculum. The attributes that have been prepared in this research are (1) Determining the value of trigonometric functions, (2) Determining trigonometric identities, (3) Determining graphs of trigonometric functions, and (4) Determining trigonometric equations.

Compiling the Q Matrix

The Q matrix represents attribute mastery, abbreviated as A1 for attribute 1, A2 for attribute 2, and so on. The element in the Q matrix will have a value of 1 if the student masters the attributes required in a particular item. Conversely, it is worth zero if the student does not master one of the required attributes (de la Torre et al., 2010). The Q matrix in this study is shown in Table 3.

Table 3 Q matrix

Question	A1	A 2	A3	A 4	Question	A1	A 2	A3	A 4
1	1	0	0	0	14	1	1	1	0
2	1	0	0	0	15	1	1	1	0
3	1	0	0	0	16	1	1	1	0
4	1	0	0	0	17	1	1	1	0
5	1	0	0	0	18	1	1	1	0
6	1	0	0	0	19	1	1	1	1
7	1	1	0	0	20	1	1	1	1
8	1	1	0	0	21	1	1	1	1
9	1	1	0	0	22	1	1	1	1
10	1	1	0	0	23	1	1	1	1
11	1	1	0	0	24	1	1	1	1
12	1	1	0	0	25	1	1	1	1
13	1	1	1	0					

Constructing Questions

The questions were developed with 25 multiple-choice questions and a polytomous model that places levels on each option. The options given consist of five choices, taking into account the level of error, hereinafter called the option level. The option level consists of D0 most errors, D1 most errors, D2 light errors, D3 lightest (few) errors, and D4 answer key. An example of the item can be seen in Figure 2.

If $\cos \theta = \frac{1}{3}$, then the value of $\tan \theta$ is....	
A. $\frac{1}{3}$	D3 / lightest (few) errors
B. $\frac{1}{8}\sqrt{8}$	D0 / Most errors
C. $\frac{1}{3}\sqrt{8}$	D2 / light errors
D. $\frac{3}{8}\sqrt{8}$	D1 / most errors
E. $\sqrt{8}$	Answer key

Figure 2 Example of the item

After the questions are prepared, they are validated (expert validation) by three validators. The comments and suggestions from the three validators are presented in Table 4.

Table 4 Validator suggestions and comments

Validator	Comments/Suggestions
Validator 1	a) Clarify the question indicators b) Question number 6 contains overlapping information (consider it carefully) c) Numbers in the form of fractions with denominators in the form of roots are rationalized
Validator 2	Question indicators are more specific
Validator 3	a) Clarify the question indicators b) Eliminate questions about maximum and minimum values

Based on the data obtained from the validation sheet by three validators, the validity and feasibility of the questions were tested with the results for each question described in Table 5.

Table 5 Results of validity test

Item	Validator I	Validator II	Validator III	Average	Explanation
1	3.72	4.94	4.06	4.24	Highly Valid
2	3.83	5	4.06	4.30	Highly Valid
3	3.83	4.78	4	4.20	Highly Valid
4	4.17	4.67	4.28	4.37	Highly Valid
5	4.17	4.83	4.22	4.41	Highly Valid
6	3.56	4.61	4.06	4.08	Highly Valid
7	3.94	5	4.9	4.61	Highly Valid
8	4.33	4.67	4.61	4.54	Highly Valid
9	4.33	5.94	4.83	5.03	Highly Valid
10	3.39	3.61	4.06	3.69	Highly Valid
11	3.22	3.72	4.06	3.67	Highly Valid
12	3.33	3.72	4.06	3.70	Highly Valid
13	4.56	5	5	4.85	Highly Valid
14	4.28	5	4.94	4.74	Highly Valid
15	4.39	5	5	4.80	Highly Valid
16	4.17	5	5	4.72	Highly Valid
17	4.11	5	5	4.70	Highly Valid
18	4.11	5	5	4.70	Highly Valid
19	4.67	5	5	4.89	Highly Valid
20	4.44	5	4.89	4.78	Highly Valid
21	4.5	5	4.89	4.80	Highly Valid
22	4.06	5	4.94	4.67	Highly Valid
23	4.11	5	4.94	4.68	Highly Valid
24	3.89	4.83	4.83	4.52	Highly Valid
25	3.83	5	4.72	4.52	Highly Valid

Based on Table 5, it can be concluded that the 25 diagnostic items that have been developed all meet the very valid criteria because the average value for each item from the three validators is more than 3.20. Thus, the diagnostic items can be used to carry out readability tests at the next stage with slight revisions based on suggestions from the validator.

Developing an e-learning-based diagnostic test to measure student learning loss in trigonometry is an important step in overcoming the challenges posed by the current

educational landscape and referring to the less-than-optimal learning situation in Indonesia over the last two years. In this research, learning loss describes a student's decline in understanding learning caused by students who are unable to learn the material optimally and do not master learning skills that should be taught at a level appropriate to the student.

Several factors behind the occurrence of learning loss have a negative impact on students, especially in learning mathematics. These negative impacts include students having difficulty understanding basic concepts, which results in difficulty understanding further concepts, decreased student self-confidence, decreased academic achievement, lack of tolerance and cooperation, loss of interest in learning, and low problem-solving abilities (Kusnadi & Sari, 2023; Muskita et al., 2022; Safira & Ifadah, 2021; Widodo & Umar, 2022). As a result of this problem, a tool is needed to identify learning loss experienced by students. One solution that can be offered is to carry out a diagnostic test on trigonometry material as a first step to find out where students experience learning loss.

In this case, diagnostic tests are used to identify student learning loss in learning trigonometry. This test not only identifies student learning problems but also helps teachers find solutions to identified problems. This discussion explores the systematic process undertaken to create and validate the test, following stages of self-evaluation and expert review guided by Tessmer's formative evaluation.

CONCLUSION

Based on the research results and discussions described, the 25 diagnostic questions developed all meet the very valid criteria. Thus, the diagnostic questions can be used to carry out readability tests at the next stage with slight revisions based on suggestions from the validator.

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