The Development of Inquiry-Based Teaching Materials for Basic Algebra Courses: Integration with Guided Note-Taking Learning Models

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Abstract: This study induced the students to be more active and able to design discovery activities so that they can communicate the material's concepts well. Students can use their activities to find a solution to problems with inquiry-based learning materials that were supplemented with a guided note-taking model. For this reason, a valid, practical, and effective inquiry-based learning device with a guided note-taking learning model in Basic Algebra courses is required. This study aimed to develop inquiry-based learning tools with a guided note for Basic Algebra courses that are valid, effective, and practical. The development model used in the study was the instructional development institute (IDI). The data sources were three Basic Algebra lecturers, seven small trial students, and 38 students in a large trial class. The validation of the developed learning device involved experts in mathematics, language, educational technology, and peers. The validity values of the developed learning devices were 80.97 and 78.61 with a highly valid category. The practicality value for the module was 90.33 or very practical. The student learning outcomes were improved with a gain score of 0.40 or moderate category. This study produced valid, practical, and effective inquiry-based learning tools with guided note-taking learning models for basic algebra courses.

INTRODUCTION

Mathematics, as it underlies the development of science and technology subjects from kindergarten to university, can be said to be a science that describes the patterns, structure, and integrated relationships, whilst shaping the minds to understand the world (Aufa et al., 2016). As one of the basic sciences, mathematics has an essential role in life (Wardani et al., 2017). Algebra is one of the scientific branches that relate to numbers, letters, and symbols in simplifying and solving mathematical problems. According to David Pimm's discussion, "In a symbol, there is concealment and revelation" (Kereh et al., 2014). For example, x represents a known number and y represents the number to be identified. When Andi has x books and Bob has three more books than Andi, then Bob's book may correspond as y = x + 3. Using algebra, ones can investigate the patterns of rules and numbers.

Algebra draws conclusions by looking at the objects from above so that a model can be found. Some students have difficulty in understanding arithmetic and algebra (Maharaj & Dlomo, 2018). Algebra is a process skill and requires high-level thinking in mathematics, but this condition tends to make students dislike the challenge in increasing their algebraic skills (Kaput, 1995). Nevertheless, elementary algebra is one of the compulsory subjects in mathematical education courses. A university in West Sumatra has the provisions for student-teaching in the practice of the Court. The abstract nature of mathematics, which is also a character of basic algebra, is one of the factors that cause difficulties in learning it (Kereh et al., 2014) and it is a challenging course to be mastered by students who mainly have low math skills (Suhartati, 2012). This phenomenon is apparent, as students who complete their math studies are still classified as inferior in learning mathematics. The low student's mathematical skill achievement in learning objectives is due to the insufficiency of learning devices to assist students and facilitate the process of learning (Yuliani & Saragih, 2015). The lecturers are less skilled in creating new learning devices, so the teaching methods tend to be monotone. There are many reasons why students have problems with math, but their difficulties with basic algebra courses are a significant one. From the students' learning results in basic algebra courses, there are students with a below-average rating. It can see from the recap of the basic algebra course 2012–2013 in Table 1.

Mark	**Basic Algebra**	
	Students	**Percentage**
A	20	35.43 %
B	81	
C	107	62.39 %
D	81	
E	21	
Sum of Students	335	100%

Table 1: The result basic algebra course in a mathematical education study program at a university in West Sumatra, 2012–2013

Table 1 showed that most students do not understand basic algebra courses. According to the experience of the researcher, many factors cause low student learning outcomes. One of them is material delivery. When the materials are taught conventionally by lecturers, the students are paying full attention to them. Consequently, the students tend to be reactive rather than active. This lowers the concentration of students from the beginning to the end of the learning process. Then the students are disinterested in acquiring the information and skills required to complete the task. Conventional delivery ultimately does not lead students to analyze, synthesize, evaluate, or solve problems and the students are not involved in the thinking process by discussion, asking questions, or finding solutions to gain new knowledge. Along with the statement by (Carneiro et al., 2016), such classrooms are frequently teacher-centered, thus the students accept the passive role in the class, rarely getting opportunities to lock in the learning materials to create basic thinking and understanding. Our duty as instructors is limited to planning and delivering "good" lectures, and we have no practical assessment of students' knowledge of the taught materials. In our involvement, this inactivity in learning manifests in the students and they will lose interest in the subject matter gradually.

One way to address the problems is the use of alternative teaching strategies. The adoption of teaching materials that support the learning process and a model of active learning, in which the learners are invited to participate in the learning process mentally and physically; in other words, learning through a method of inquiry. The means of the inquiry learning method is based on the process skills: the students are engaged in learning activities (Indratno & Soepomo, 2016). Some researchers agree to use this method. Lee in Widiastuti et al. (2018) stated that the inquiry-based method provides better opportunities for students to learn, allowing them to improve their learning outcomes. Sanjaya (Rahmi et al., 2018) explained that critical thinking and analytical skills are developed by creating an active learning climate through inquiry-based methods so that students can find answers to problems through a guided investigation by the teacher. The thought process presented in this learning model is similar to the one used by professional scientists to generate new knowledge (Abdi, 2014). Students learn by making connections between scientific facts and existing theories. This method will stimulate students' critical thinking abilities by integrating various information and preparing learning materials that can measure learning performance without the intervention of the lecturer (Neuby, 2010).

Some studies differ from other studies on the model of guided notetaking and inquiry methods integration into learning devices, namely modules and planned lecture activities (SAP or *Satuan Acara Perkuliahan*). According to the substance of the research, guided learning models can improve the students' concentration and learning outcomes. It is evident from the research conducted by Lazarus (Boyle 2001) that the use of guided note-taking techniques can increase the comprehension and concentration of information provided by the teacher. The same is true with the use of inquiry-based methods. The results of the research conducted by Rodríguez et al. (2019) suggested that the stimulation provided by the inquiry process can improve student learning outcomes. Also, students experience increased satisfaction with their learning experiences.

Guided notetaking is implemented by carrying out a particular action; the teacher prepares a concept map to help students create notes when the teacher instructs on the subject matter. Guided note-taking student gives students opportunities to learn actively, respond, and be involved with the discussed content sot that the students will generate comprehensive and accurate notes. By restudying the notes, the students can acquire high scores (Wardani et al., 2017). Teachers use guided note-taking to improve students' recall (Kiewra, 1985). Collingwood and Hughes (Russell et al., 1983) stated that the use of guided notes induces students to concentrate more on adopting the subject materials. Guided note-taking can also make it easier for students to understand the material (Tanamatayarat et al., 2017). The advantage of using the guided note-taking learning method is that students can understand the material presented by the teacher easier, which improves student learning outcomes and increases student activity during the learning process (Puspasari, 2017). Education teachers, who focus on using models that successfully meet the demands of their educational assignments, can create powerful lessons that students can collaborate to solve problems (Marbán & Mulenga, 2019).

Based on the presented problems, the researchers will develop learning tools for SAP and inquiry-based modules with guided note-taking learning models. This model is expected to make students be more active and able to design material concept discovery activities by applying the Instructional Development Institute (IDI) model development steps. According to Komalasari (Maisyaroh et al., 2017), "teaching materials are one manifestation of the preparations made by the teacher before making the learning process." In line with that, Trianto (Maisyaroh et al., 2017) stated that "the teaching materials are a device that is needed and used for managing the learning process." Hence, it can be said that planning the teaching materials is essential to achieve a great learning.

METHOD

This study was a research and development study, conducted at PGRI University in West Sumatra, Indonesia. The duration of the study was eight months, from February to October 2016. The subjects were students who took basic algebra courses in the academic year of 2015–2016. This research consists of three stages, discovery/analysis, development, and evaluation stage (Figure 1).

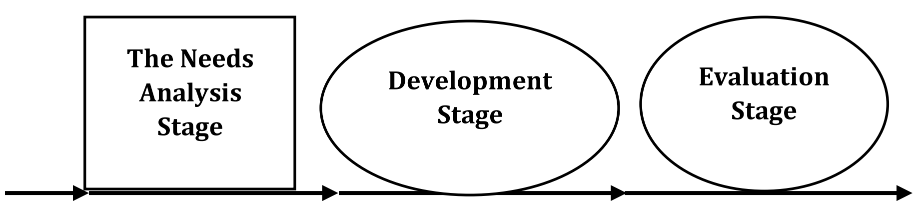

Figure 1: The design of the research

The needs analysis stage was carried out through observation and interview. It was done by analyzing the syllabus and the planned lecture activities to see whether it was teacher-centered or student-centered; analyzing the books on basic algebra to see their contents' conformity with the standards of basic competencies and the competencies that must be achieved by students; reviewing the literature related to the development of learning devices; and interviewing colleagues and students. The interview was about any problems or obstacles encountered in basic algebra courses. The discovery/analysis was used to design and develop products at the development stage.

The development stage was designing a prototype inquiry-based learning device with a Guided Note-Taking learning model based on the discovery/analysis stage results. The designed learning tools were Basic Algebra Modules and its SAP. The creation of this prototype was done through 2 stages, validation test and practicality test. The tested aspects on SAP were identity aspects, formulation of learning goals, selection of learning materials, detailing learning steps and models, and the selected learning resources and assessment. The tested aspects of the module were objective, rational, module content, module characteristics, suitability, module shape, and flexibility. The instruments were validation sheets involving math education experts, educational technology experts, linguists, and lecturers.

The validation results from the validators against all assessed aspects were presented in table form. Next, the average score was calculated using this formula:

$$R = \frac{\sum_{i=1}^{n} V_i}{n} \quad (1)$$

Description:

R = the average assessment from validators,

Vi = the score of the results of the 18th validator assessment,

n = validator number.

Then the obtained average was confirmed with the set criteria. The score ranged from 1 to 5 and the criteria were divided into five levels. The terms were tailored to the aspects in concern. The average range was divided into five interval classes, then the average of all aspects of the module was calculated. To determine the degree of validity of the modules, the following criteria were used:

a. If the average > 3.20 then the module was categorized as very valid.

b. If 2.40 < the average ≤ 3.20 then the module was categorized as valid.

c. If 1.60 < the average ≤ 2.40 then the module was categorized as quite valid.

d. If 0.80 < the average ≤ 1.60 then the module was categorized as less valid.

e. If the average ≤ 0.80, then the module was categorized as invalid.

The practicality tests were done by making observations during the implementation of learning, interviews, and questionnaires. The assessed aspects in SAP and modules were the implementation of learning, ease of use, time, and the equivalence with modules or SAP. The instrument used in this part was a questionnaire.

The practicality of the learning device was described by data frequency analysis techniques with this formula:

$$P = \frac{R}{SM} x100\% \quad (2)$$

Description:
P = Practical value
R = Obtained score
SM = Maximum score

No.	Level of Achievement (%)	Category
1	85 – 100	Very practical
2	75 – 84	Practical
3	60 – 74	Quite practical
4	55 – 59	Less practical
5	0 – 54	Impractical

Table 2: Learning device practicality categories

Based on Table 2, it could be concluded that the device was said to be practical if its practical value was ≥ 75%. This practicality test used a small scale (small group evaluation) involving 7 students. The results of this trial were revised until the product is feasible and practical. The results at this stage were valid and practical modules to use with guided note-taking learning models.

The evaluation stage was carried out to assess whether the developed learning tools are effective in improving the students' learning quality and achievement. The instruments used were pretest and posttest with the indicators of conceptual understanding. The data obtained from the pretest and the posttest were given a score according to the created rubric. The improvement in students' understanding of the mathematical concept was observed through an analysis of normalized gain scores (<g>) compared to the category proposed by Hake (1998) "Normalized gain score i.e., comparison of an actual gain score with the maximum gain score." The actual gain score was the obtained gain score by the student, while the maximum gain score was the highest gain score that the students may get. Thus, the normalized gain score could be expressed by the following formula:

$$\langle g \rangle = \frac{T_1' - T_1}{T_{max} - T_1} \quad (3)$$

$\langle g \rangle$ was the normalized gain score, T_1' is the *posttest* score, T_1 the *pretest* score, and T_{max} was the ideal score. Good learning is achieved if the normalized gain score was more than 0.4. Table 3 shows the categories that can be seen in the results of normalized gain scores.

Percentage	Classification
$\langle g \rangle < 0.3$	Low
$0.3 \leq \langle g \rangle < 0.7$	Medium
$\langle g \rangle \geq 0.7$	High

Table 3: Normalized Gain Criteria

All the calculations were done using Microsoft Excel (Microsoft, USA). Based on effectiveness tests, it was obtained that modules and SAP are effectively used in inquiry-based learning with guided note-taking models. (Elgazzar, 2014) states that products were considered good if they meet the requirements of validity, practicality, and effectiveness.

FINDINGS AND DISCUSSION

The results and discussion contain the development process of inquiry-based learning devices with guided note-taking learning models, the developed products, validity tests, practicality tests, effectiveness tests, and the discussion of the products in improving students' mathematical understanding.

Findings

Need assessment

The analysis of the syllabus and SAP of the basic algebra course showed that the basic competencies have not been able to prepare the students to conduct their experiments, ask questions, search answers on their own, and connect those answers. Basic algebra competencies should provide students with a centralized approach where students are directly involved in asking questions, formulating problems, conducting experiments, collecting, and analyzing data, drawing conclusions, discussing, and communicating the result per the elements of inquiry-based learning. Thus, the students become more active, whilst the role of lecturers is involved in guiding, training, and accustoming students to skilled thinking (minds-on activities).

The stage of inquiry has not been brought up in the reference book. Each presented material has not been able to identify, formulating problems, and describing the discussions between students. Students are not used to making hypotheses, formulate alternative problem-solving, and establish problem-solving when they were provided examples of problems and solutions.

The interviews showed that the lecturers still use the lecturing method, accompanied by the provision of exercises. It is difficult for students to understand and find solutions because of the provided training. The teaching materials were mathematics books of middle and high school level. It was observed that the teaching method did not help the students to understand the material because the questions were not applicable or appropriate. The learning resources used by students were the materials, problem examples, and exercises.

An initial test was provided to measure the student's initial ability in the line and series materials (Figure 2).

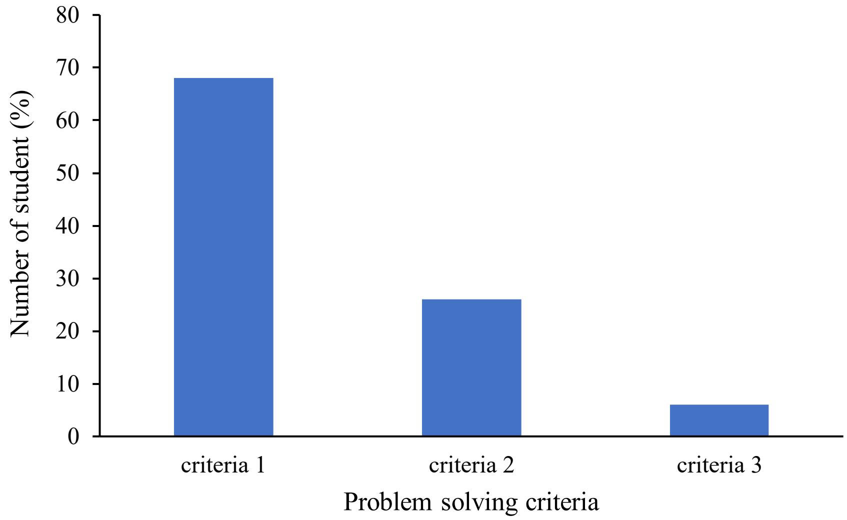

Figure 2: The initial student ability test

Description:

Criterion 1: students can identify problems but have not used any problem-solving approach or strategy
Criterion 2: students can identify the problems correctly, but the used strategy or approach is wrong
Criterion 3: students have done the correct problem solving

Based on the 38 tested students, 68% of students were on criteria 1. Students could identify problems, but they have not used any problem-solving approaches or strategies. As many as 26% of students were on criteria 2. Students could identify problems correctly, but the strategies or approaches were incorrect. Lastly, 6% of students were on criteria 3, who have done the right problem-solving. Most students did not well understand the concept of problem-solving.

Development stage

This stage was drafting the learning device in the form of modules and a guided note-taking learning model for basic algebra courses. Self-evaluation was used to evaluate the modules and SAP. Self-evaluation involved various experts' reviews. Content qualification, presentation, language, and time were evaluated. The results of module validation from expert reviews were in the form of prerequisite materials presented on the module. The results showed that the modules have not directed students to understand the concepts, problem examples, and exercises. Furthermore, the presented materials were not relevant to self-training. SAP validation results from experts were in the form of clarity in lecture scenarios and it was observed that they had not been described in detail and clear. However, all learning devices can be used in large and small trial classes. The results of module validation sheets and SAP can be seen in Table 4.

Components of Assessment	Validator		Sum	Validity Value (%)
	1	2		
Material	27	29	56	80
Presentation	28	30	58	82.9
Language	19	21	40	80
Total				242.9
Average				80.97

Table 4: Validation results of the module sheet

The average value of the validation results was 80.97% with a very valid category. This showed that the developed module can be used in trials. Table 5 showed the SAP validation results based on the experts' reviews.

Components of Assessment	Validator		Sum	Validity Value (%)
	1	2		
The content presented	15	14	29	72.5
Language	12	13	25	83.3
Time	4	4	8	80
Total				235.83
Average				78.61

Table 5: Validation sheet results of SAPs

The average value was 78.61% for the validation results. This showed that the SAP development has been valid in terms of content, language, and time and can be used in trials.

After the validation of the learning device, a small group evaluation was carried out to improve the quality of modules using questionnaires and interviews so that they have a high level of practicality and effectiveness. The trial involved 7 students from the mathematics education study program. Table 6 displayed the results of the questionnaire analysis.

Components of Assessment	Student							Sum	Value
	1	2	3	4	5	6	7		
Ease of Use	51	49	49	51	47	51	45	343	89.09
Time Efficiency	4	5	5	5	5	4	4	32	91.43
Benefits	14	14	14	12	14	14	13	95	90.48
Total									271
Average									90.33

Table 6: Student ratings of the new modules

The results showed that the new modules were very practical, with a score of 90.33%. This showed that the modules have been practical in the aspects of ease of use, time efficiency, and benefits. The practicality of the modules was supported by the interview result with students to get more accurate information about the student's opinions about the modules. The interviews between lecturers and students showed the practicality of the module.

Lecturer : "How easy was the basic algebra module to use, Indah?"
Indah : "The materials, question examples, questions or instructions, and exercises on the modules have been clearly presented to assist me in finding the concept, Ma'am."
Lecturer : "How is the time efficiency in the module, Ika?"
Ika : "The work of problems in modules is very efficient because of the time allotted."
Lecturer : "Is this module beneficial for Tika?"
Tika : "It is rewarding, Ma'am because I can devote more time to do exercises and study alone."

No	Interviewing aspect	Interview Results
1	Easiness of Use	Materials, question examples, inquiries or instructions, and exercises on the module seem to help students to find concepts; The modules were written in a well-written formal Indonesian language.
2	Time efficiency	The students need about 50 minutes to understand the material in the module, and they can understand the content within the available time.
3	Benefits	The learning modules will lead the students to be more active in listening, speaking, and reading. Thus, the students can study independently and devote more time to working on exercises.

Table 7: Student interview results of the module

According to the interviews with students in Table 7, the modules have made it easier to learn in listening, speaking, writing, and reading. According to (Abu-hardan, 2019) through reading, communication can occur. In this case, learning is the process of interaction between students and the presented material in the module. The presented modules were time-efficient so that the students can understand the materials on the module in a short time frame.

Assessment stage

This stage was done with a large class of 38 students using the revised learning devices. The purpose of the test was to see the effectiveness of inquiry-based learning tools with guided note-taking learning models. The results can be found in Table 8.

Student Learning Outcomes	***Average N-Gain***	***Category***
Experiment	0.40	Medium

Table 8: Student interview results of the module

Table 8 showed that the guided note-taking learning models improved the student's learning outcomes. The learning outcome test score was 0.40, or moderate, indicating that the learning outcomes on algebra courses were improved after an inquiry-based learning device with a guided note-taking learning model was used. Figure 3 showed the distribution of test scores about the achievement of learning outcomes after using the modules. The average score of posttest was 82.1 while the average score of pretest was 67.9. The lowest score on the pretest was 31, while the highest score on the posttest was 93.

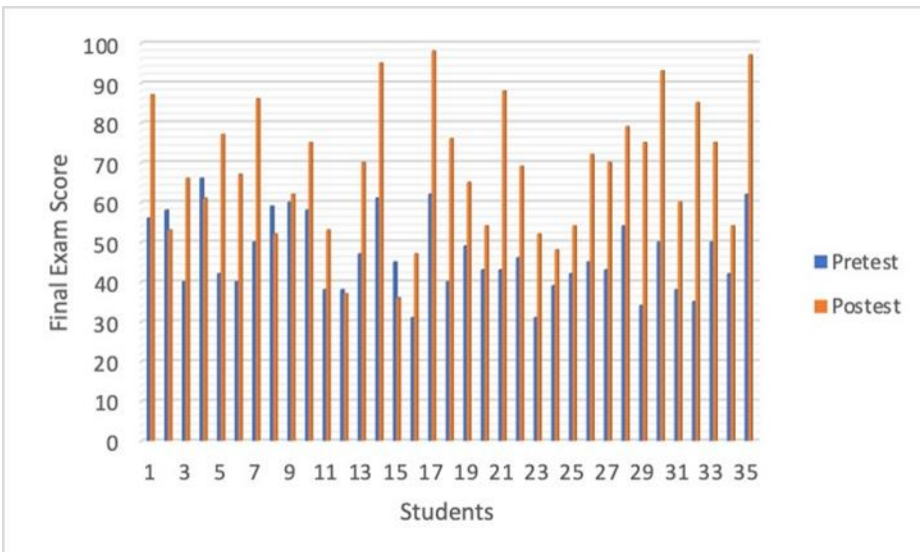

Figure3: Pre-test and post-test score distribution

DISCUSSION

The students have low creative thinking skills and some investigations showed that the learning process has not actively engaged them to solve problems as the teaching materials and devices did not trigger students' interest in learning (Sari et al., 2021). The modules and the learning tools can help students to learn basic algebra more easily (Shofiyah et al., 2021). The modules used in the lecture should engage students to learn on their own. Through this learning device, students can use relevant ways to gather information, use logical analysis (Dharma et al., 2020), and investigate the surrounding phenomena with guidance from the questions, so that they can solve problems using the facts that they find (Risman & Santoso, 2017).

The use of modules can increase students' motivation to learn (Harefa & Silalahi, 2020). Lecturer guides, trains, and educates students through guided notes, taking learning models that are integrated with skilled thinking modules, and mental and physical involvement experience. The learning model can improve students' learning outcomes (Harefa & Silalahi, 2020) and improves verbal and written communication skills through hands-on experience (Schmidt & Kelter, 2017).

The delivery of teaching materials through guided note-taking learning models has received the full attention of students due to the effectiveness of learning devices demonstrated by N-gain scores (Novilia et al., 2016). The effectiveness is shown by the differences in students' critical thinking skills (Irwan et al., 2019). This has an impact on increasing the concentration of students from the beginning to the end of the learning sessions so that they can complete the tasks. This condition causes student responses in analyzing, synthesizing, evaluating, and solving problems. Students are more involved in thinking about new knowledge through the process of discussion, asking, and searching for solutions (Yuhana et al., 2020).

CONCLUSIONS

The inquiry-based learning devices with guided note-taking learning models have been proven to be valid with a score of 80.97 and the SAP had a validity score of 78.61. The inquiry-based learning device was designed with a strong theoretical rationale and its components were internally consistent. The practicality value for the module was 90.33, or very practical, which means that the students, as the module user, considered that the module has met the needs, expectations, and limitations. Students' learning outcomes have been improved with the help of learning devices, indicated by the gain score of 0.40 or categorized as moderate. The learning tools have positive impacts on students.

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