

State University of Makassar

**INTERNATIONAL CONFERENCE ON MATHEMATICS,
SCIENCES, TECHNOLOGY, EDUCATION
AND THEIR APPLICATIONS**

*"Recent Research and Issues in
Mathematics, Sciences, Technology, Education
and their Applications"*

**PROCEEDINGS
ICMSTEA 2014**

Makassar, August 20-21, 2014

**ICMSTEA
2014**

**INTERNATIONAL CONFERENCE ON MATHEMATICS, SCIENCES,
TECHNOLOGY, EDUCATION AND THEIR APPLICATIONS
Makassar, August 20-21, 2014**

ISBN: 979-604-151-0

ISBN: 979-604-151-0



Conference Proceeding

INTERNATIONAL CONFERENCE ON MATHEMATICS, SCIENCES, TECHNOLOGY, EDUCATION AND THEIR APPLICATIONS

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**Mathematics and Science Faculty
Makassar State University**

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DESIGNING LEARNING CONTINUUM AS A BASIS FOR CONSTRUCTING DIAGNOSTIC TEST (ITS IMPLEMENTATION FOR ALGEBRA EXPRESSION)

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Abstract

Algebra is well known as one of difficult subjects for most students of the second grade of Junior high schools. At least, there are two reasons namely. *First*, studying algebra requires students to learn Mathematic Language symbol which students are not familiar with especially when learning Arithmetic. *Second*, studying algebra demands students to develop the skill of abstract thinking and problem solving. Given this facts, Algebra creates more difficulty for student to study compared to Arithmetic. The aims of this research are: (i) to formulate learning continuum for algebra expression, (ii) to develop hierarchical concept based on learning continuum. The learning continuum and the hierarchical concept that have been developed are thus utilized to design diagnostic test with the purpose of detecting students' misconception on algebra expression. This research is the type of research and development. Several steps to be undertaken are: (i) to identify the basic competence of the Algebra expression subject, (ii) to formulate the indicators, (iii) to design learning continuum, (iv) to develop hierarchical concept, (v) to construct diagnostic test, (vi) to obtain validation from the experts, and (vii) empirical testing. The findings have shown that (i) there are 136 learning continuum for the algebra expression that have successfully been formulated. All learning continuum are formulated based on the indicators of numerical, fraction, equation and inequality subject, and (ii) there are 4 groups of hierarchical concepts that have been developed based in learning continuum.

Keywords: Algebra, learning continuum, and diagnostic test

1. Introduction

When students are in their VII grade of junior high school, they are introduced to a new subject in mathematic, algebra. This material is the development of arithmetic, part of mathematics that the students have learned in their primary schools. According to Rakes (2010:44-45), students will potentially find it difficult to understand algebra on their initial learning of the subject.

One of the causes of such difficulty is because in learning algebra, the students are required to understand the symbolic language of mathematic. Learning this

mathematic symbol is a new experience for students at the seventh grade of junior high school. It is because the symbols that they have learned previously is arithmetic is to some extent different from algebra symbols. In arithmetic, students learn and manipulate numeric symbols. With these numeric symbols, students can easily imagine how many are being symbolized. In daily life, students also often deal with number. Therefore, it is easy for the students to understand the arithmetic symbols. In algebra; however, the symbols used are not only numeric

ones but also alphabetical or both numeric and alphabetical symbols in combination.

Teachers have used different ways of using algebra symbols in their teaching. This variation in symbolizing makes it more difficult for the students to relate the symbols with their meaning. This results in two folds; students do not understand the meaning of the symbols or they may have limited understanding on the symbols. This later makes the students give inappropriate meanings to the symbols.

Chi (2008:61) did an analysis on students who had difficulty in learning algebra. Chi tried to correlate this difficulty to students understanding on arithmetic. These students were, then, put into three groups. The first groups are those who have no initial knowledge on algebra. Although they have some relevant knowledge on algebra from their previous arithmetic learning, such knowledge is missing. This is because the objects learned in algebra are different from that of arithmetic. In this context, learning algebra is the process of adding a new knowledge. The second groups are students who may have sufficient initial knowledge on the concept of algebra, but this initial knowledge is incomplete. In this sense, learning algebra is considered as the process of filling in the gap between concepts. The third groups are students who have sufficient initial knowledge on arithmetic from their primary education but this knowledge is different from the concepts they are learning in junior high school. This raises the potential of conceptual change on the student understanding. This conceptual change may result in misconception as there is a conflict between the old and new concepts.

Misconception is students' misunderstanding, which then causes systematic error pattern, such as incorrect algorithm or other kind of error.

Misconception is commonly stable and sturdy (Xiaobao Li, 2006:23). Misconception commonly occurs when students fail to relate their new knowledge to their previous knowledge (Russel & O'dwyer, 2009:414). In this case, students incorrectly apply the strategy they use in their previous knowledge construction to solve new problems.

From the description above, it can be concluded that misconception has stable and sturdy structures that influence the ways students understand certain basic concepts. As a result, there should be solution to prevent students from having misconception in algebra. This can be done by identifying types of errors and by investigating the causes of such errors. In this context, diagnosing these two things is deemed significant to conduct.

Test can serve as a good tool to do diagnoses. If the test is in multiple choice forms, types of error can be serving as distractor. Student's selection on distractor signals the student's inability to understand the concept in the distractor. A good distractor can be developed through learning continuum. Learning continuum makes it possible to diagnose which materials that students already understand and which ones that students do not. Learning continuum helps to portray students' mastery on certain material.

2. Research Method

This study is research and development, i.e. it develops a diagnostic test. The development took seven stages (Kusaeri, 2012): (1) identifying the basic competency for algebra, (2) formulating the indicators, (3) formulating learning continuum, (4) constructing the hierarchy of concepts, (5) constructing diagnostic test, (6) expert validation and (7) empirical try out.

The identification of the basic competency was conducted by studying

the Content Standard (Standar Isi) of mathematic for junior high school. The identification was conducted for all algebra competencies for grade seven. The results of this identification become the basis to draft the basic competencies and their indicators.

Indicator is detail and operational break down or explanation of basic competency. Indicator also signals the acquisition of the basic competency as indicator hints changes of measurable behaviors (attitude, knowledge and skills). That is why every basic competency is developed into its indicators. In this study, every basic competency is developed into five indicators at the minimum. These indicators become the basis for the construction of learning continuum.

In constructing learning continuum, the indicators were ordered based on the level of complexity, from the simple to the complex ones. This means that the competency that becomes the prerequisite for competencies is put in the initial level and numbered the smallest while the competency that needs other competencies as prerequisite is put at the upper level. This ordering goes in the same order until the highest level of competency. This ordering develops hierarchy of indicators as learning continuum showing the order of acquisition students must have.

The construction of this concept hierarchy began with mapping several competencies in the learning continuum. Focus of the mapping is on the competencies that have the potential to be assessed though question items. For each of the competencies that is going to be assessed, there is an identification of what competencies students must have as the prerequisite. The prerequisite competencies become the required knowledge. From this stage, the relationship among materials, concepts and competencies was determined; thus, this constructs the hierarchy of concepts.

This hierarchy shows prerequisite direct interdependability among identified concepts. For example, if concept A_1 is the prerequisite for A_2 and A_3 , the assumption is that students will not be able to understand A_2 and A_3 before they understand A_1 .

The construction of question items was done in two series of activities, Delphi technique and focus group discussion (FGD). Delphi technique was applied when every teacher was asked to write question items on question card. The distribution of question card in the process of test construction is to reduce variation of teachers' understanding and to give concrete guidance of what to write. Also, it is expected that question card can improve the validity of the questions from their appropriateness, meaningfulness and usefulness. After all teachers have constructed their questions, the questions were brought into FGD. This was aimed to evaluate the concord among indicators, questions, answer keys and distracters.

Expert validation was intended to improve the quality and concord of the indicators and basic competencies, the order of indicators (from simple to complex), order in the learning continuum, and the hierarchy of concepts. Also become the points of validation are the concord between question and indicator, the suitability of options with attribute and effectiveness, and the appeal of distractor in each question.

The last stage of development is empirical experiment. The experiment was aimed to measure the empirical effectiveness of the distractors. This is because the distractors were developed based on the flow of thought and experiences of the teachers. Therefore, it is important to test whether the flow of thought in every distractor is the same as what most students think.

3. Finding and Discussion

As has been explained in the earlier section, the identification of basic competencies and indicators was conducted through Delphi technique and FGD. Therefore, there are two sets of data: data from Delphi technique and data from FGD. Delphi technique generates some important suggestions related to the improvement of indicator formulation. These include (a) completing the already existing indicators; (b) reordering indicators and (c) changing some indicators with the ones which are more relevant to the basic competencies.

As a description, for example, in basic competency: ‘recognizing algebra and its elements’, there were initially four indicators. After considering some suggestions in FGD, (a) two other indicators were added: (i) explaining the definition of algebra and (ii) explaining factorization form in algebra; (b) the wording in an indicator was improved from ‘writing the algebra form from an expression’ to ‘writing algebra form (mathematic model) of verbal expression/from daily life’; (c) there was also suggestion to change the order of indicators.

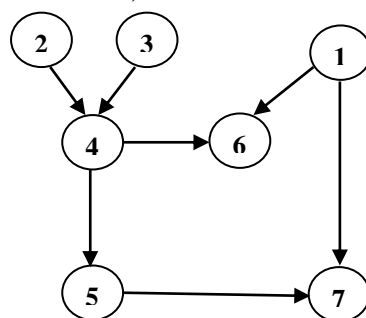
The same things were also done to other basic competencies. As a result, there are many indicators added. This process results in detail, complete and well ordered indicators that make it easier to arrange the learning continuum.

At the stage of constructing learning continuum, all indicators resulted from FGD were directly put and ordered from grade six (VI) to (VIII). However, after

further discussion, there was a suggestion to add several indicators in order to improve the learning continuum. Also, there were still overlaps in the construction of learning continuum. Some indicators also either reoccurred or put in different wording but conveyed the same meaning.

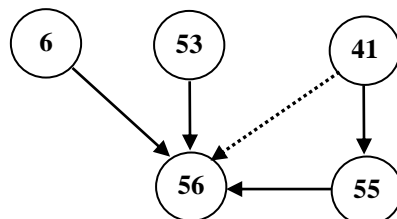
Based on these findings, some improvements were made. For the improvement, inappropriate use of terms is improved (such as the use of ‘and’ to relate two or more sentences while actually ‘or’ should have been used instead). Expressions that shared the same meaning are also deleted. From this activity, 136 learning continuums for algebra are formulated. All these continuums are broken down from indicators for the materials of number, fraction, equation and quadratic inequality. This draft of learning continuum directs and signals the formulation concepts hierarchy.

At the initial stage, the result of indicator identification was ordered in form of diagram. For example, if for a student to simplify algebra form of the same type, he needs to understand (1) arithmetic operation for integer and fraction, (2) definition of variable, (3) definition of coefisien, (4) definition of algebra expression, (5) rate similar and different numbers, (6) addition of rate similar number in algebra expression and (7) subtraction of rate similar number in algebra expression. All these seven indicators were then ordered in the following diagram.



In FGD, it was suggested that to achieve the above competencies, students need to understand the definition of constants. The definition of algebra form does not become prerequisite in understanding rate numbers. Meanwhile, understanding rate numbers not only become the basis for rate number subtraction in algebra expression but also in addition. Considering this, some changes are made which then also changes the diagram of material hierarchy.

There was also inappropriate numbering in the diagram. The top of the diagram should have started with the smallest number going down to the biggest. This means that simpler concept should have been given smaller number. Therefore, the order of concepts is then rearranged to fit with this formulation.



Similar things were also done for other concepts. Therefore, this study results in four groups of concepts hierarchy. These four groups are then used as the basis to construct questions and distractors.

The construction of question items by 8 teachers results in 24 multiple choice items with four answer options consisting one correct answer and three distractors. The answer keys explain the steps to get the answer. Explanation of each distractor is accompanied with explanation of the possible misconception that makes the students trapped to select the distractors.

Two experts gave validation on the development of this diagnostic test, Prof. Dr. Budiyo, M. Sc (a mathematic education expert from Graduate School of Universitas Negeri 11 Maret Surakarta) and Dr. Jamilah Bondan W., M.Si (a mathematic education expert from

There was also an opinion that it was inappropriate to use numbers in diagrams because not all diagrams started with number 1. The number in the diagrams should have been referred to the number in the learning continuum. Based on these suggestion, the number in the diagrams are then changed into (6) distributive characteristics of multiplication toward subtraction; (41) mixed arithmetic operation for integer; (53) rate similar number in algebra expression; (55) arithmetic operation for addition, subtraction, multiplication and division in algebra expression and (56) simplifying algebra expression with rate similar numbers. With these changes, the diagram becomes as follows.

Graduate School of Universitas Negeri Yogyakarta). All instruments developed in this study are validated including the formulation of standard competency, basic competencies and indicator, learning continuum, order of hierarchy of concepts, diagnostic test items and distractor analysis. Therefore, the validation is not limited to the test items only.

The result of expert validation is in written form and the suggestions are grouped into four categories of suggestion related: (a) writing techniques, (b) completeness of the material, (c) order of the material, (d) content. Suggestions on writing techniques include consistency of the terms used, for example the use of mathematic symbol minus (–) or times (×). Related to the completeness of the material, it has to be ensured that there is not material missed, especially material that becomes the prerequisite for other

materials. The order of materials should also be given attention to ensure that the material starts from the simplest to the more complex in order to avoid overlaps. Suggestion on content includes the validity of the test item to assess certain indicator.

The last stage of the study was empirical try out in SMPN 1 Sidoarjo, SMPN 2 Taman Sidoarjo and SMPN 1 Waru Sidoarjo involving 268 students. The interesting findings from this experiment can be classified into 3: (a) several answer options need to be modified, (b) there needs to be changes in some frame of thoughts in the distractor, and (c) it is found that there are certain frame of thoughts that stimulate misconceptions in items and these become the basis to construct the distractors.

It is also found that some distractors developed by the teachers are different from what are thought by the students. This suggests that there should be changes in the logic used in the distractors. With this try out, the logic of the distractors used in this study is expected to be reflecting the misconception held by most of students in studying algebra.

4. Conclusion

Based on the elaboration of the data and discussion above, it can be concluded that (i) 136 *learning continuum* material of algebra from has been well formulated. The entire *learning continuum* is broken down from indicators of numbers, fraction, quadratic equation and inequality and (ii) four (4) groups of concepts hierarchy have been ordered and constructed based on the learning continuum.

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