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Developing Concept Construction Based Abstract Algebra Textbook to Improve Students' Understanding

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abstract

Developing Concept Construction Based Abstract Algebra Textbook to Improve Students' Understanding. The purpose of this study is to develop and produce a concept construction based abstract algebra textbook to improve students' understanding. The development method used in this study was 3D method, they are define, design and develop. It refered to Tiagrajan's 4D method. Based on the data analysis results, the level of textbook's validity produced was achieving valid criteria without revision, but the results of students' learning tests showed 92,7% students reached the criteria of understanding objects so the textbook could be said effective. Therefore, based on the results, it could be concluded that the textbook could improve students' understanding and it was suitable to be used as abstract algebra's learning book in the learning process.

Keywords:
APOS Theory; Concept Construction; Textbooks of Abstract Algebra and Understanding

INTRODUCTION

Mathematics is one of lesson in Indonesia that gives positive contribution to the intelligence and enlightment of Indonesian development. Accprding to Bell (Nazihah, 2017)) Mathematics teachers have to have wide and deep understanding of university level mathematics to have good learning process in high school level. So the teacher candidates in Mathematics Edication Study Program in STKIP PGRI Pasuruan must have deep understanding of mathematics system in Abstract Algebra lecture.

The understanding of set, relation, function and the properties of integer had learnt in Basic Mathematics and Number Theory are the basic materials to study Abstract Algebra. These basic materials become the first key for students to understand the concepts of Abstract Algebra better than other materials. But in fact, Abstract Algebra is not an easy subject. It is shown from students' score, 20 from 29 students in 2017B class got 61 or C category.

Students' activities in the Abstract Algebra learning process are paying attention on the concepts explained, taking notes and doing some exercises. When lecturer explains the materials, students look passive and no discussion take place. Students only wait for lecturer's explaination about a concept. Based on students' interview result, the students' passive activity happened because no textbook or literature neede about Abstract Algebra, so students only wait for lecturer's expalaination. To prevent this phenomenon, the researcher develops Abstract Algebra textbook which is appropriate with students' thinking level so it can improve students' understanding.

LITERATURE REVIEW

Concept construction used in this research was taken from APOS theory according to (Dubinsky & McDonald, 2002) that an individual mathematical knowledge is her or his tendency to respond to perceived mathematical problem situations by constructing mental actions, processes, and objects and organizing them in schemas to make sense of the situations and solve the problems. In reference to these mental constructions we call it APOS theory.

An arranged transformation firstly formed an action (Aydin & Mutlu, 2013). Mental construction in this level need specific teaching and one need to have step by step transformation explicitly. Dubinsky & Wilson (2013) stated that process comes after a regular action and one has chance to think about action. Then, one can construct an internal mental construction called process which he can think like doing an action without external stimulation. So, process is a mental construction happened internally when someone has done action level frequently. Parraguez & Oktaç (2010)stated that when someone need to transform the process, he could reach object step. Schema is an individu total understanding about a concept. In this level someone can differ which the phenomenon is or not (Dubinsky & McDonald, 2002).In APOS theory, action was internalized into a process then process was aparted into object, object was connected with other knowledge to form a schema. Tall also explained that a schema can be aparted into an object (Tall, 2008).

The understanding is an ability to comprehend a concept (Sudjana, 2005:50). In other hand, understanding is able to comprehend a concept with their own language, can be able to connect the previous part into the next part, can differ the example and predict the written example, can predict the consequence or widen the perception in time, dimension, cases or problems (Sudjana, 2009:24). Arnawa (2009)stated that a person comprehend's level about a concept was connected with his thinking of mental construction. From the expalanation we can know that the understanding level in this research divided into four, they are : (1) action understanding, (2) process understanding, (3) object understanding, and (4)schema understanding.

METHODS

a. Research Design

This research aimed to develop a concept construction textbook and the material given hoped to be appropriate with students' thinking level in Mathematics Education Study Program of STKIP PGRI Pasuruan. So the researcher conducted a Research and Development research. As stated by Plomp (2010:13) that as stated educational design research is the systematic study of designing, developing and evaluating educational interventions (such as programs, teaching learning strategies and materials, products and systems) as solutions for complex problems in educational practice, ehich also aimes at advancing our knowledge about the characteristics of these interventions and the processes of designing and developing them.

Research design has 3 methods called 3D they are define, design and develop, it refers to Tiagrajan 4D method. There are 5 steps in define, they are (1) begin-finish analysis, it is analyzing the relevant theory to get the learning method description which is appropriate with students, (2)students' need analysis, (3) concept analysis, it is identifying, specifying and arranging relevant systematical concept will be taught according to begin-finish analysis result, (4) task analysis and (5) learning goal formulation. Design step is designing learning devices and instruments to get prototype called draft-I. Furthermore develop step produce draft-II from validating and trial.

b. Data Processing

In validating step, the validator gave suggestion to complete draft-I. There are two steps in validating, they are construct validating and content validating. The validator suggestion revised draft-I and produced draft-II. Draft-II was tried out in the class. The try out results revised draft-II and produced draft-III. There were two validators, one from STKIP PGRI Pasuruan and the other from Universitas Trunojoyo Madura. The trial location was in STKIP PGRI Pasuruan. The trial subject was the 41 students of Abstract Algebra class in 2018 generation. The trial has the researcher as the lecturer. The research object was the learning and teaching process conducted with the use of the textbook.

The instruments used in this research was validation sheet and test. There were two kinds of validation sheets, they were textbook validation sheet and test validation sheet. The aspects scored were four, they were textbook content, textbook structure, textbook characteristics and language. Test used to measure students'

understanding after learning using the textbook. Test was taken from the exercises given from the developing textbook about action level test, process level test, object level test and schema level test.

The analysis technique to measure the valisity used Nengah Parta's analysis technique (2009). The average score measured from the average of each aspects takenfrom this formula :

$$V_i = \frac{\sum_{j=1}^{n} I_{ji}}{n}$$

Note:

V_i : average score from all subject validation
I_ji : validator data score to-j of to-i indicator
n : whole validator.

Table 1 the validity Criteria of Instruments and Devices of Learning.

Interval	Validity Criteria
$3 \leq \overline{V_i} \leq 4$	Valid
$2 \leq V_i < 3$	Valid enough
$1 \leq \overline{V_i} < 2$	Invalid

Adapted from Nengah Parta (2009)

The technique analysis of textbook effectivity got from students' answers' test. The test given and categorized based on APOS Theory of understanding. Then it was analyzed using this formula::

$$P_{pmk} = \frac{S_{pmk}}{n} \times 100\%$$

Note :

P_pmk : students' percentage that reached object and schema criteria
S_pmk : tudents' amount that reached object or chema criteri
n : students' amounts
The textbook is called effective whenP_pmk reached 75% or more.

RESULT AND DISCUSSION

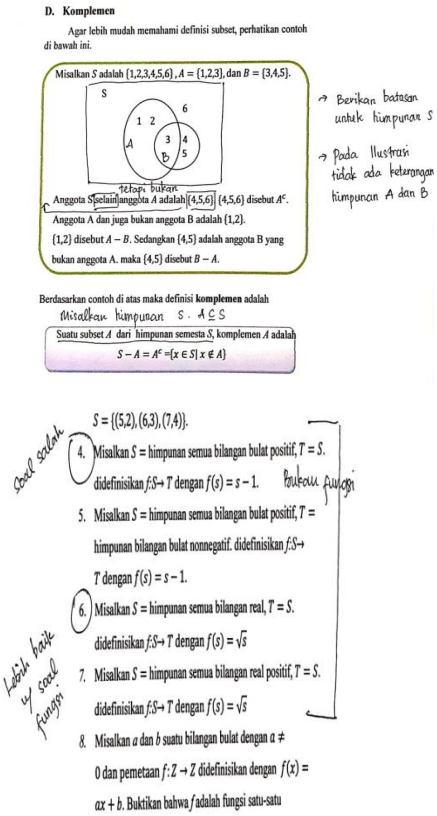
a. Result

The product of this research is a textbook about abstract algebra to reach some criteria they are ; concept construction based, it was formulated by APOS theory, its validity and its effectiveness. Here is the validation results after being analyzed by the validators :

Table 2 The Results of Textbook Validity by Validators

Criteria	Valdity Level	Validity Criteria
Textbook content	3.8	Valid
Textbook structure	3.7	Valid
APOS theory caharacteristics	3.8	Valid
Language	3.4	Valid

Based on validation sheets analysis, the average of validity level is 3.67 it is called valid. The results of all aspect validity shown valid. It shows that the developing textbook is proper to be given as abstract algebra materials, but it still need some revisions as the two validators suggested. The validators suggestions are (1) the material and the exercises still did not appropriate, (2) there was a mistake in function chapter, it was about the definition of the concept, (3) the language needed to be revised, (4) the mistake in group operation test. Here are the picture of validators' suggestion.



D. Komplemen

Agar lebih mudah memahami definisi subset, perhatikan contoh di bawah ini.

Misalkan S adalah $\{1,2,3,4,5,6\}$, $A = \{1,2,3\}$, dan $B = \{3,4,5\}$.

→ Berikan batasan untuk himpunan S

→ Pada ilustrasi tidak ada keterangan himpunan A dan B

Anggota S selain anggota A adalah {4,5,6} {4,5,6} disebut A^c.

Anggota A dan juga bukan anggota B adalah {1,2}.

{1,2} disebut $A - B$. Sedangkan {4,5} adalah anggota B yang bukan anggota A. maka {4,5} disebut $B - A$.

Berdasarkan contoh di atas maka definisi **komplemen** adalah

Misalkan himpunan S. $A \subseteq S$

Suatu subset A dari himpunan semesta S, komplemen A adalah

$S - A = A^c = \{x \in S | x \notin A\}$

$S = \{(5,2),(6,3),(7,4)\}$.

4. Misalkan S = himpunan semua bilangan bulat positif, $T = S$. didefinisikan $f: S \to T$ dengan $f(s) = s - 1$.
5. Misalkan S = himpunan semua bilangan bulat positif, T = himpunan bilangan bulat nonnegatif. didefinisikan $f: S \to T$ dengan $f(s) = s - 1$.
6. Misalkan S = himpunan semua bilangan real, $T = S$. didefinisikan $f: S \to T$ dengan $f(s) = \sqrt{s}$
7. Misalkan S = himpunan semua bilangan real positif, $T = S$. didefinisikan $f: S \to T$ dengan $f(s) = \sqrt{s}$
8. Misalkan a dan b suatu bilangan bulat dengan $a \neq 0$ dan pemetaan $f: Z \to Z$ didefinisikan dengan $f(x) = ax + b$. Buktikan bahwa f adalah fungsi satu-satu

Soal soalan

Pasangan fungsi

Lebih baik by soal fungsi

Furthermore textbook trial was done for chapter 2 and 3 about function and group chapter. Chapter 3 was tried out for 4 meetings,the first meeting was talking about fungstion, the second meeting was explaining about one by one function, then the third meeting talked about onto fungction, and the fourth meeting held to have understanding test of chapter 2. Chapter 3 was tried out in three meetings, the first meeting explained about group, the second meeting talked about subgroup and the third meeting was held to have understanding test or exercise of chapter 3. Here is the exercise results for each meeting and test in chapter 2.

Table 3 Chapter 2 Trial Results

exercise	N	S_{pmk}	P_{pmk}	Description
1	39	29	74,3 %	29 students reached object understanding level 7 students reached schema understanding level
2	38	20	52,6 %	20 students reached object understanding level 1 student reached schema understanding level
3	37	25	68%	25 students reached object understanding level 5 students reached schema understanding level
Chapter 2 test	39	27	70%	27 students reached object understanding level 7 students reached schema understanding level

Table 4 Chapter 3 Trial Results

exercise	N	S_{pmk}	P_{pmk}	Description
1	39	32	82%	29 students reached object understanding level 7 students reached schema understanding level
2	41	32	78%	20 students reached object understanding level 1 student reached schema understanding level

exercise	*N*	S_{pmk}	P_{pmk}	Description
Chapter 3 test	41	38	92,7 %	25 students reached object understanding level 5 students reached schema understanding level

Based on the test results analysisi in function and group material, the percentage in object and schema understanding leve has reached more than 75%. It can be concluded that the textbook has filled the criteria which are valid and effective. In conclusion the textbook of abstract algebra in concept construction based can improve students' understanding and appropriate to be used in the teaching learning process for the next generation.

b. Discussion

The ministry of Higher education (2009) stated that text book is a handbook in a lecture written or elaborated by the expert and fill the textbook's principle and published officially. The abstract algebra textbook development purpose in this research is to supply an appropriate textbook for students based on their thinking structure. The textbook is formulated based on concept construction characteristics in line with APOS theory. This textbook contains of 5 chapters, they are set, function, group, cycle group and homorphsm group. Each chapter is given based on students' thinking level in action level, process level, object level and schema level.

In every beginning of chapter, example are shown to give the beginning concept and what the previous materials are. Beside that the example given are concrete and instructions are also given. It is in line with the action step definition. In the step of process, exercises are given to come and face action step but the exercises do not have instruction like in process step. In object level, the materials and exercises given in the form of abstract substances and in set chapter, the material given is builder notation set. In schema step, the exercises given are different with action, process and object steps. Students are demanded to use the concepts of definition or theorema given that has been proved to have new pronouncement.

CONCLUSION AND RECOMMENDATIONS

a. Conclusion

The textbook was developed to fulfill the characteristics of concept construction based on APOS theory, which was in action, process, object and schema steps. Based on the data analysis results by the two validators, the textbook had fulfilled valid criteria in 3.67 validity level. It was shown that the textbook has reached the four validity criteria. After validating step, the book was developed and tried out to 40 students in abstract algebra class in 2018 generation. The test results shown that 75% students could reach object and schema understanding level. Students who reached object understanding level were more than students who reached schema understanding level. It meant students were still have difficulties in proving the abstract algebra's pronouncement.

Finally it could be concluded that this textbook has been appropriate to be develop and used for the handbook of abstract algebra. It can be used for the teaching and learning process in class or can be used for autonomous learning tool.

The developing textbook in this research has some strength they are : (1) improving students' understanding in abstract algebra's lecture based on appropriate curriculum in STKIP PGRI Pasuruan, (2) the material given is appropriate to students' thinking level. Beside that, this textbook has some weaknesses too, they are : (1) it has not improve the students' ability to prove abstract algebra pronouncement, (2) the research subject is limited in STKIP PGRI Pasuruan students only, so it can be different if it is applied in other university.

b. Recommendations

Based on the research results, so the researcher recommends some suggestions, they are : (1) this textbook is hoped to be used in abstract algebra's lecture, (2) it is suggested to have this textbook trial in other university, (3) the textbook is hoped to be able to help students to improve their proving ability.

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