



Development of Mathematics Teachings Based on Apos Theory: Construction of Understanding the Concept of Student

Received:08-11-2020 ; Revised: 11-02-2020; Accepted:13-04-2021

Kamid*)

Universitas Jambi, Jambi

E-mail: kamid.math@unja.ac.id

Nizlel Huda

Universitas Jambi, Jambi

E-mail: nizlelhuda@unja.ac.id

Rohati

Universitas Jambi, Jambi

E-mail: rohati@unja.ac.id

Sufri

Universitas Jambi, Jambi

E-mail: sufri@unja.ac.id

Dewi Iriani

Universitas Jambi, Jambi

E-mail: dewiiriani@unja.ac.id

*) Corresponding Author

Abstract: This research is an ADDIE-based research and development. Data on the development process were collected using tools validated by material experts, design experts, student response questionnaires and teacher responses. The results of the implementation of the use of textbooks are seen from the student activity sheets and student learning outcomes, in this study using participants from class VIII students of MTs YPI Kuala Enok totaling 28 students with a random sampling technique. The results of this development research are: (1) SMP / MTs mathematics textbooks based on the APOS theory on straight line equation material are declared suitable for use in learning activities based on the validation results of material experts and design experts. Based on the results of student and teacher responses to textbooks, they are ranked very well. (2) The effectiveness of using SMP/MTs mathematics textbooks based on the APOS (Action, Process, Object, Schema) theory of straight line equation material seen from the student activity sheet can be concluded that in the process of learning student activities. In addition, on the basis of the results of all students, the criteria for completeness were achieved, an average score of 85. Thus, from the results of this analysis, it can be concluded that textbooks based on the APOS theory are effective in constructing an understanding of the concept of straight line equations.

Abstrak: Penelitian ini merupakan penelitian dan pengembangan berbasis ADDIE. Data proses pengembangan dikumpulkan dengan menggunakan alat yang divalidasi oleh ahli materi, ahli desain, angket respon siswa dan respon guru. Hasil penerapan penggunaan buku ajar dilihat dari lembar aktivitas siswa dan hasil belajar siswa, dalam penelitian ini menggunakan partisipan dari siswa kelas VIII MTs YPI Kuala Enok yang berjumlah 28 siswa dengan teknik random sampling. Hasil penelitian pengembangan ini adalah: (1) Buku ajar matematika SMP/MTs berbasis teori APOS pada materi persamaan garis lurus dinyatakan layak digunakan dalam kegiatan pembelajaran berdasarkan hasil validasi ahli materi dan ahli desain. Berdasarkan hasil respon siswa dan guru terhadap buku teks, mereka mendapat peringkat sangat baik. (2) Keefektifan penggunaan buku teks matematika SMP/MTs berdasarkan teori

APOS (Action, Process, Object, Schema) materi persamaan garis lurus dilihat dari lembar kegiatan siswa dapat disimpulkan bahwa dalam proses pembelajaran aktivitas siswa. Selain itu, berdasarkan hasil seluruh siswa, kriteria ketuntasan tercapai, skor rata-rata 85. Dengan demikian, dari hasil analisis ini dapat disimpulkan bahwa buku teks berbasis teori APOS efektif dalam membangun memahami konsep persamaan garis lurus.

Keywords: *APOS Theory; Mathematics; Students*

INTRODUCTION

The development of human civilization cannot be separated from the fundamental sciences as the basis of logic thinking. Mathematics as a fundamental science has taught humans to identify and explain the phenomena that occur around them (Syaiful et al., 2019). According to Arslan, Canli and Sabo (2012) argue that mathematics can be considered as powerful topic for attaining mental discipline. The subject matter concept in mathematics is one of the most important components of the learning objectives of mathematics.

However, there are by the student several factors that cannot be mastered the standard realization of mathematical concepts (Nari, 2011; Yunita, 2014). One of the mathematical concepts that has a pretty low level of realization is the concept of straight-line equations. In the role of growing comprehension of the concept of straight-line equations, one of the most potential teaching materials is books. Books in the school environment are still very limited and there is a lack of student interest in getting books from other sources (Asrial et al, 2019; Maison et al, 2020; Syahril et al, 2002). With its limitations, students expect the development of books in accordance with their characteristics so that students are more motivated and easier to explore the concept of straight line equations that are abstract.

Fajri and Taufiqurrahman (2017) concluded in their study results that textbooks contribute about 75% of the apprenticeship completion rate. In the

learning and learning process, school books play a very important role. Textbooks are the component of learning that most affects what really happens in the learning process (Nodelman, 2001; Montag., Jones, & Smith, 2015). The teaching materials developed by the Ministry of National Education, of course, still need to be corrected and developed by teachers so that the teacher's habit of presenting material from one source can be avoided.

Designing a manual can aim to motivate teachers to try to develop thoughts and conceptions that are tailored to their respective models of thought and creativity. So it is not only students who are expected to think creatively and freely explore knowledge, but each teacher also has a contribution to develop as much knowledge as possible from the problems faced in their respective learning environments. Collecting information from various reading books and immediately concocting in such a way that it is in accordance with the teacher's thinking and mindset, as long as what the teacher designs does not violate the standard of writing books or in accordance with the existing curriculum is one of supporting learning and increasing the potential for creativity and innovation for teachers. In accordance with the demands of increasing their profession, teachers are currently expected to practice researching, developing and studying material concepts that are being taught and being able to adjust their thinking patterns to achieve standards and even be able to add new, broader thoughts that are

possible (Asrial et al, 2019; Syahrial et al., 2019).

There are many models and theories including Theory Bruner, Theory Gestalt, and RME, which can allow the development of manuals, one of which is the APOS theory. Because APOS theory is a theory about how mathematical concepts are studied (Dubinsky and McDonald, 2001; Dubinsky et al., 2005; Arnon et al., 2014). According to (Herawaty et al., 2020) the application of APOS theory is intended to help build students' understanding of different mathematical concepts. This theory constructs mental constructions that are detailed and adapted to the manner in which mathematical concepts are learned. APOS theory also assumes that one's mathematical knowledge is the result of construction with others and the result of that person's mental constructions in understanding mathematical ideas (Maharaj, 2010; Salgado, 2015; Rofiki et al, 2020). APOS theory focuses on models that allow the formation of one's thinking to form learning concepts and use this model in designing teaching materials or evaluating student success and activities in dealing with mathematical problems (Paraguez & Oktac, 2010; Maharaj, 2013).

APOS theory, which is a theory of how a mathematical concept is learned, aims to help build students' understanding of various mathematical concepts and is considered capable of improving understanding of the concept of straight line equations:

1. How to develop a manual of SMP/MTs mathematics based on APOS theory to build an understanding of the concept of straight line equations?
2. How is the effectiveness of SMP/MT mathematical textbooks based on APOS theory to construct an understanding of the concept of straight-line equations?

METHOD

The type of development research used to produce a textbook development product is a research development (Research and Development). Research and design and development is a systematic study of the design, development and evaluation process based on empirical data that produces products for learning and not for learning either in the form of equipment or capital (Richey and Klein, 2007). This textbook development research model uses ADDIE (Branch, 2009). The ADDIE model consists of five steps, namely: Analysis, Analysis is a systematic process of setting goals, identifying problems and determining priorities for action, which is analyzed in this study including the analysis of learning problems; Analysis of learning objectives; and student analysis, Design, The design phase in developing this APOS theory-based book includes several stages, namely, book specifications; Making the structure of the material (content) , Development, At this stage it is the process of developing a textbook or applying a design that has been planned.

Development steps include (1) designing and making textbooks for predetermined learning objectives (2) Study and assessment of the feasibility of textbooks stated by the validation of a team of media experts and material experts (3) After the suggestions of the expert team have been considered good, small and large group trials were conducted to determine the advantages and disadvantages of textbooks before field trials, Implementation which uses 28 students of class VIII MTs YPI Kuala Enok obtained based on random sampling techniques and Evaluation. The instruments used included questionnaires, observation sheets and tests. The data analysis used in this study used descriptive statistics, with the help of the SPSS 21 application.

RESULTS AND DISCUSSION

This research is make an development research that aims to effective textbooks based on the APOS theory to construct an understanding of the concept of straight line equations in class VIII SMP/MTs. This textbook development research model uses ADDIE (Branch, 2009).

Expert Validation

APOS theory-based mathematics textbooks that have been developed are validated by experts. This textbook validation was validated by two experts. The feasibility of textbooks validated by material experts is the feasibility of content aspects, freedom / communication aspects, presentation feasibility aspects and learning aspects in terms of material. Meanwhile, the feasibility of textbooks that are validated by design experts is aspects of book cover fun, content aspects, freedom / communication aspects, presentation feasibility aspects and learning aspects in terms of design.

a. Material The First Expert Validation

In stage I validation, material experts suggest that (1) Textbooks are adjusted to competency standards, basic competencies and learning objectives and are equipped with more real examples in everyday life. (2) Several symbol need to revised. (3) Chart should be added

Furthermore, the researcher made revisions (1) Adjusted the material with CS, BC and learning objectives and added several examples that involved everyday life. (2) Correcting the writing of symbols that are not correct. (3) Adding a chart, namely (Remember!) Which is previously known knowledge which is important to recall and use in learning the concept of straight line equations. (Horizon) which is knowledge in everyday life or an overview of material applications related to the concept of straight line equations. Which is the knowledge that is being learned, needs

to be noted and remembered because this knowledge is useful in learning the next straight line equation concept.

In the material expert validation stage II, there are several responses as follows: The suitability of the material presented with CS, BC and the learning objectives are appropriate, the material presented is in accordance with the mathematical concept is appropriate, it is enough to generate interest in reading, the concept conveyed includes action, proces , objects and schemes are complete, strongly accommodate student learning difficulties, contains cognitive, affective and psychological aspects, reflects a good textbook, manuals for using books are adequate, language is in accordance with the thinking level of SMP/MTs students, very communicative and easy understood, the use of terms and symbols is correct, the presentation of material is logical, consistent, the feasibility of presentation, the learning topic is clear, the text structure is systematic and easy to be understand, the learning objectives are clear, examples and test questions are in accordance with the learning competence and books provide opportunities for giving feedback.

Astra (2015) states that the development of good teaching materials, based on material aspects, must be in accordance with the curriculum, learning objectives, truth according to the knowledge taught and in accordance with the development of student co-workers. There are three principles that guide the development of teaching materials, namely the principle of relevance, the principle of consistency and the principle of sufficiency (Danielsson & Wiberg, 2006). Generating interest in reading, explaining instructional objectives, providing opportunities for students to practice, accommodating student learning difficulties, the mechanism for collecting feedback is part of the characteristics of textbooks (Martono & Nurhayati, 2014;

Lee, Jin & Robertson, 2014; Haryanto, Asrial & Ernawati, 2020).

From some of the opinions above, it can be concluded that textbooks can function as good teaching materials and contain several characteristics of making textbooks. Furthermore, after validation of stage II material experts, the textbook is considered worthy of being tested.

b. Design Expert Validation

In stage I validation, design experts suggest (1) Revise the cover because there is an unclear appearance. (2) There is still a language style that is less communicative and less precise. (3) The left, right, top and bottom borders are still not appropriate. (4) There is an error in writing, punctuation marks. (5) Instructions for using the book are still complicated, there is an unreadable image display. (6) There is an inconsistent image / graphic layout. (7) The preface word should use language that is more communicative to students, complete terms that are not yet in the glossary, improve the presentation of the concept map. (8) Please clarify more about Action and Process activities. (9) There is a less systematic preparation of material and the presentation of reflections is still difficult to understand.

Furthermore, the researcher had made several revisions (1) Improve the appearance of the cover so that it is clearer and legible. (2) Correcting the incompatible EYD writing. (3) Adjusting the left, right, top and bottom borders that still not suitable (4) Correcting errors in writing image punctuation that are still wrong (5) The manual is designed to be more flexible, communicative with curved lines, change the appearance of the pictures contained in the instructions for using books so that they are legible and more clearly visible (6) Rearrange the layout of the pictures/graphics so that they are more consistent (7) Words are conveyed using language that is more communicative and adapted to SMP/MTs

students so that students can read and understand them, adding some terms that are not yet in the glossary, improving the presentation of the concept map with a more flexible design (8) Clarifying each stage of the APOS theory, especially in Action and Process (9) Improving the less systematic preparation of material for example to convey the concept of $y = mx$ and $y = mx + c$ the presentation of the reflection is changed in the form of a box and with questions that are easier to answer understood.

From some of the opinions above, it can be concluded that textbooks can function as good teaching materials and contain several characteristics of making textbooks. Furthermore, after validation of stage II design experts, the textbook is deemed feasible to be implemented in the field.

Product Trial

The data obtained is used to gather information that can be used to improve the product in the next revision.

a. Small group trials

The small group trial consisted of 6 children of SMP N 3 Tanah Merah selected according to the target population whose levels of knowledge were above average, medium and below average. The student's level of ability is measured from the learning outcomes or learning performance of the preceding class. The six students were randomly chosen based on their level of competence. In small group testing, teacher collected data and information about student responses to manuals developed through questionnaires and direct observation during the learning process.

The results of filling out the assessment questionnaire sheet by each student show a clearer picture of the readability of the textbook, the attractiveness of the appearance and design of the textbook, the clarity of the material, the manual for the use of the book and the summary and whether

the textbook can be used at all levels of the student's ability to learn the concept of equations straight line.

Based on the teacher's questionnaire and observations during the learning process, there are suggestions for improvements to sentences that still confuse students, such as those in the example questions page 8 no 2, practice 3 page 21, example questions page 24 no 1. Furthermore, there are still some writings whose copy alphabet.

Paying attention to the results of the student questionnaire, the researchers analysed and revised the textbooks they wrote. In the exercise of question 8 no 2, fix the fault in the explicit word in an implied form, as this affects the way to solve. Exercise 3 page 21 improves the appearance of unclear illustrations and graphs, for example problem 24 no 1 corrects typos in the equivalent form between the problem and the equation that is found on the solution is not the same. Besides, there are still some writings whose characters are vague. Furthermore, from Table 4.4, the data on the results of the recapitulation of the results of small group trials is categorized as very good because the average percentage of student responses reaches a value of 89.56.

b. Large group trials

In this large group test consisted of 22 students MTs YPI Kuala Enok who in the learning activities were divided into 5 hydrogen groups based on the students' daily math test scores in the previous material. The results of filling out the assessment questionnaire sheet by each student show a clearer picture of the readability of the textbook, the attractiveness of the appearance and design of the textbook, the clarity of the material, the manual for the use of the book and the summary and whether the textbook can be used at all levels of the student's ability to learn the concept of equations straight line.

Based on the teacher's questionnaire and observation during the learning process, there is a need for improvement to the example question item 8 no 1, exercise 2 no 1, exercise 4 no 2 and the two lines material that coincide with page 22 is still confusing, exercise 1 no 1b results in the form of fractions that cannot simplified so that it is more difficult to work with, the material intersects perpendicularly, page 24, there is a mismatch between the image and the writing of the intercept (x, y) due to typos, the material for the equation of the line $y = mx + c$ page 27 should use a gradient that is not a fraction so that it is easy to understand .

By paying attention to the results of the questionnaire filled out by the students, the researchers conducted an analysis and revision of the textbooks that the researcher developed. Improvements to the example problem item 8 no 1 alternative problem solving are more simplified, exercise 2 no 1 reduces practice questions because it takes a long time if all the questions have to be done, exercise 4 no 2 can fix the problem because it is still considered confusing and in the material the two lines coincide, page 22 between the description of the image and the material is adjusted because there is a typo, exercise 1 no 1b results in the form of a fraction that cannot be simplified so that it is more difficult to work out a giant question to make it easier to work with, the material intersects perpendicularly page 24 matches the image and the writing of the intersection point (x, y) because of a typo, on the graph of page 26 there was a typo in writing the line equation which was corrected by the material for the line equation $y = mx + c$ p. 27 was replaced using a gradient that was not fractioned to make it easier to understand. Furthermore, from Table 4.5, the data on the results of the recapitulation of the results of large group trials is categorized as very good because the average percentage of student responses reaches a value of 89.39. This shows that the textbooks developed have

very good quality as a teaching tool and can be used in field trials.

The results of the teacher's questionnaire responses showed that the average percentage obtained was 91.5% with a very good interpretation so it was feasible to be used as teaching material. This proves that the APOS theory-based mathematics textbook that is presented as a whole, both cover, material, language, practice questions, presentation, coverage is good and can generate interest in reading, providing opportunities to practice and accommodate student learning difficulties.

From the teacher's response, the material delivered is relevant / relevant to Basic Competence (BC) and the learning objectives get a score of 100%, test questions are in accordance with the material taught, test questions and competency tests are in accordance with BC and learning objectives get a score of 90%, from the response Student test questions in accordance with the learning objectives and the material taught obtained a value of 87.3%, the material presented was in accordance with the learning objectives of 93.6 which means that the material and questions presented were in accordance with the learning objectives and explained instructional objectives.

In line with the opinion (Branch, 2009) which states that the determination of the material and assignments presented must be in line with the learning objectives. students with the material presented in an orderly and structured textbook from easy to difficult get a score of 88.2. In line with the opinion (Richey & Klein, 2007) that material organizing is how to order the material to be delivered in a logical and orderly manner, so that there can be clear links between one topic and another during the meeting. For the process of achieving instructional goals, books are expected to provide opportunities for students to be directly involved in achieving learning objectives. This can be seen in the teacher's response that the

resources and materials presented are in accordance with the learning objectives and students are directly involved in the process of achieving learning objectives obtaining a value of 90 and student responses Students are directly involved in the process of achieving learning objectives obtaining a score of 98.2. In line with the opinion (Richet Klein, 2007) in learning, students not only observe, but must live, be directly involved and be responsible for the process and results. Thus, this textbook is also designed to be flexible, easy to read and understand, and adapted to the students' cognitive abilities. It can be seen from the teacher's response that the language writing style is effective (language that reaches the intended target) and efficient (language that follows standardized rules / EYD) scores 80%, student responses state that textbooks can be understood and are in accordance with the level of student ability to obtain value 87.3.

Implementation

The field trial sample was carried out in class VIIIb with a total of 28 students. The purpose of this implementation was to find out whether the parallel book that was developed was effectively used in the learning process. To assess the effectiveness of textbooks it can be seen from the activities shown by students during the learning process and student learning outcomes after the learning process takes place.

a. Student activities in the learning process

Overall, students' positive activities are very good during the learning process using APOS-based textbooks. To demonstrate effective learning, there are several indicators (Richey & Klein, 2007), including good material organisation, effective communication, mastery and enthusiasm for learning materials, positive attitudes. Good learning result in terms of effective communication between teachers and

students, it can be seen from the point that students pay attention to what the teacher says with a score of 100; students ask things that are not understood and respond to teacher questions at the time of perception with a score of 86.7, students communicate ideas clearly with a percentage of 73.3; students are involved in learning by asking questions with a score of 80.0; students are involved in answering questions during the learning process with a score of 96.7 and there are interactions between students and students or between students and teachers with a percentage of 100. Through the learning process, communication between students and teachers, between students and students went smoothly. This can occur in the learning process when the teacher communicates the learning goals, guidance and questions from the students who pay attention and respond well. When a concept or explanation is misunderstood by students asking questions. To explore knowledge related to concepts learned by students, to express ideas to one another and to respond to ideas among students.

In terms of student enthusiasm during the learning process, it can be seen from the points that students communicate ideas with other students using various ways to achieve goals with a score of 73.3 and students enthusiastically learn using the Apos Theory textbook during the learning process with a score of 90.0; Students continue to carry out assignments even though the results are not clear 80.0; students are right in completing assignments and trying to be on time with a score of 86.7. During the learning process, students are enthusiastic about sharing ideas and enthusiastic about studying manuals, depending on how to learn the concept of straight-line equations. When given assignments and exercises, students try to finish them immediately and when the time runs out but their work has not been completed, how many students are still working outside the lesson and deliver it to

the teacher immediately after they finish. Thus, with different levels of ability, students still have the opportunity to keep practicing and finish their homework.

In terms of the positive attitude of students during the learning process, it can be seen that the points of students completing each task according to the predetermined time with a score of 80.0; students achieve group goals with a score of 80.0; students value and listen to questions and responses from other students with a score of 73.3 students are orderly and active during the learning process 80.0 and students conclude today's learning objectives with a score of 80.0. Learning using the Apos Theory manual results in positive responses from students. This can be seen by the majority of students performing their homework on time, attempting to achieve group goals together, mutual respect, responding to and responding to teachers and students. Throughout the learning process, most students were ordered and active. To reflect on each lesson learned, students complete and summarize the material.

Based on the recap of student learning activity sheets using APOS theoretical textbooks developed by researchers, it can improve student learning activities with an average percentage of 84.0. Positive student activity continues to expand with each meeting. In general, textbooks may be concluded to be effective in the learning process.

b. Student learning outcomes

To learn about student learning outcomes, the researchers ran tests on student learning outcomes. The purpose of the test is to determine learning performance for the skills students have developed in certain areas (Branch, 2009). Because the test is some kind of instrument used to take measurements. Thus, it can be said that indicators of effective learning can be observed from good student learning results.

The test questions were answered with an average of 85.03 with the highest score of 94 and the lowest score of 76. It is therefore possible to conclude that all students have reached the KKM established by the school. Based on the test results, it can be concluded that all students mastered the learning material according to the pre-determined performance standard. In agreement with (Richey & Client, 2007) that indicators of student learning success can be seen as those students mastering the given material.

In addition to analyzing the results of the tests, the researchers also analyzed the results of the construction to understand the concept of straight-line equations using manuals based on the APOS theory. The results of the problem-solving analysis indicate that all students have taken concrete action. The actions taken can be in the form of basic knowledge about understanding the questions, reading, investigating, understanding what is known from the questions, what is being asked or what is the meaning and purpose of the questions. After students are able to carry out the action stage, students then carry out the completion process, or carry out the object stage in the form of a graphic, or straight line equating concept. From the students' overall problem solving. It may be concluded that the concept of straight-line equations echoed in the minds of students, but with different levels of ability. This difference translates into the extent to which students can use the concepts they have understood to resolve existing problems. Using the discussion of the questions, students also resolve the questions in different ways, but with the same goals and objectives.

With respect to translating the goals and objectives of the questions, not all students experienced errors. The second is in terms of the lack of understanding of the previous concept in terms of the lack of mastery of the basics of the concept of algebraic form operation which is indicated by errors in

changing the form of equations and operating numbers. Understanding this earlier concept is the most common problem of solving, especially in the functioning of integers and algebraic forms. Third, the difficulty of using the concept is indicated by mistakes in capturing the formula. Mistakes in the use of this concept are often shown in the resolution of problem number 4 because some students still hesitate to distinguish slopes from parallel or perpendicular lines. The next problem is the capability of the algorithm (step-by-step procedure, step-by-step calculation). There are different solutions for the problems, but basically the same steps. By solving straight equations which the researcher develops, it allows students to solve with different steps, but with a contest on the same result. However, some students failed to ask the questions because they forgot the concept. Moreover, some students are not very prudent.

Product review

The purpose of this development research is to develop APOS theory manuals to build straight equations and to test the effectiveness of manuals developed in the field. The development process of this handbook begins with the analysis of learning problems, learning objectives and student analysis. Then the researcher develops manuals based on the theory of APOS. Teaching books that have been designed are validated by a team of material experts and design experts to get suggestions for improvements and opinions for the improvement of textbooks that are being developed. Once validated, the manual attempts to determine if it is suitable for use in the classroom learning process. To determine the efficacy of the manuals, the researchers implemented the books that had been developed during field trials. The following Figures 1 and 2 provide examples of APOS-based manuals.

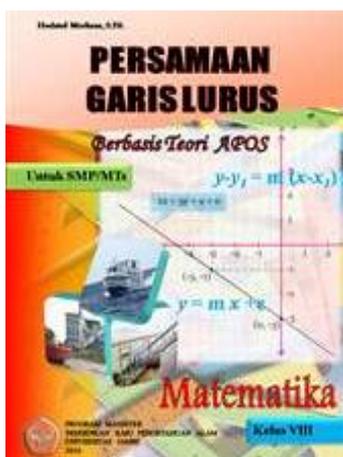


Figure 1. Book Cover Based APOS

In the content section, consists of sub-topics of discussion, content material, graphics, illustration images, 4 mental stages of the APOS theory (Action, Process, Objects and Schemes), Example questions and discussion, practice questions, notes (important knowledge what is being learned that must be really noted and remembered), remember (previously known knowledge that is recalled).

Parraguez & Oktac (2002) argues that textbooks are written material in the form of sheets of paper bound and covered with a presentation of knowledge that is systematically compiled by the author. The mathematical textbook based on the APOS theory developed by the researcher is compiled on the basis of the characteristics of the textbook as presented by (Meyer, Crummey, & Greer, 1988; Penney et al, 2003). By considering books to be used effectively in the learning process. Thus, this book uses indicators of effective learning (Mikk & Luik, 2003; Fischer, Ernst & Mason, 2017).

Textbooks continue to be regarded as the most important educational material (Nicol & Crespo, 2006; Mukunda & Khojasteh, 2011; Shin, Eslami & Chen, 2011). However, until now, textbooks used in schools are still in the form of textbooks designed for general use which are bought on

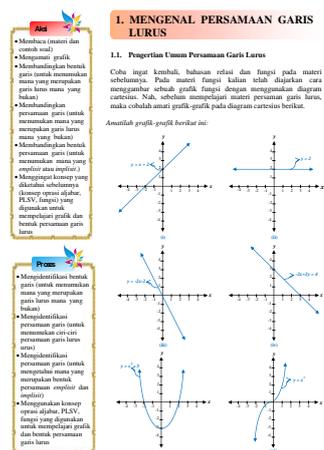


Figure 2. Content section

the market or in bookstores. The book that the researchers develop is based on the APOS theory, because the APOS theory is a theory of how a concept is learned. As stated (Arnon et al., 2014) that the APOS theory is basically a model to describe how mathematical concepts can be learned, which is a framework used to explain how individuals mentally construct their knowledge of mathematical concepts.

The advantages and disadvantages of the book being developed

The book developed has advantages, namely: according to the opinion of the teacher and students the design of the appearance of this book is attractive, this book presents how students master the concept of straight line equations with the APOS theory. The concept that is conveyed is clear and adequate, this book also includes graphic forms of straight line equations which are not included in other books, this book uses illustrations that are around the environment where this book was developed.

The weakness of this book, according to the teacher, is that this book is still designed in the KTSP curriculum, while currently the K-13 curriculum is starting to develop so that further book development is needed. To use this book in the teaching process requires a lot of time and this book

still a little bit connects concepts in everyday life so that it is hoped that there will be further developments that are more flexible and involve more of the concept of straight line equations in everyday life.

CONCLUSION

The resulting book was validated by a team of experts after it was feasible to try it out in a small group to determine the readability of the book and then a large group trial to find out student responses when used in classroom learning. Depending on the answers from students and their peers, the textbooks developed can be used in the learning process. Recommendations from researchers that this APOS theory-based mathematics textbook can be used to construct the concept of line equations at the SMP/MTs level because it has been tested with good results. The results of this study can be used as a preliminary agreement on whether the development manual is appropriate for collaboration with all models, methods and approaches in learning mathematics. Further research is needed to develop this manual, since it is always designed using the KTSP program.

REFERENCES

- Arslan, H., Canli, M., & Sabo, H. M. (2012). A research of the effect of attitude, achievement, and gender on mathematic education. *Acta Didactica Napocensia*, 5(1), 45-52.
- Arnon, I., Cottrill, J., Dubinsky, Ed., Oktac, A., Fuentes, S. R., Trigueros, M. Dan Willer, K., 2014. *APOS Theory A Framework arnafor Research and Currculum Development in Mathematics Education*. Now Yok: Spinger Heidelberg Dordrecht. London.
- Astra, I. M., Nasbey, H., & Nugraha, A. (2015). Development of an android application in the form of a simulation lab as learning media for senior high school students. *Eurasia Journal of Mathematics, Science and Technology Education*, 11(5), 1081-1088.
- Asrial., Syahrial., Kurniawan, D. A., Perdana, R., Nugroho, P. (2019). Supporting Technologi 4.0: Ethnoconstructivist Multimedia for Elementary Schools. *International Journal of Online and Biomedical Engineering (iJOE)*. 15(9), 4-15
- Asrial., Syahrial., Kurniawan, D. A., Subandiyo, M., Amalina, N. (2019). Exploring obstacles in language learning among prospective primary school teacher. *International Journal of Evaluation and Research in Education (IJERE)*, 8(2), 249-254
- Branch, R. M. (2009). *Instructional design: The ADDIE approach* (Vol. 722). Springer Science & Business Media
- Danielsson, K., & Wiberg, C. (2006). Participatory design of learning media: Designing educational computer games with and for teenagers. *Interactive Technology and Smart Education*.
- Dubinsky, E., & McDonald, M. A. (2001). APOS: A constructivist theory of learning in undergraduate mathematics education research. In *The teaching and learning of mathematics at university level* (pp. 275-282). Springer, Dordrecht.,
- Dubinsky, E., Weller, K., Mcdonald, M. A., & Brown, A. (2005). Some historical issues and paradoxes regarding the concept of infinity: An APOS-based analysis: Part 1. *Educational studies in mathematics*, 58(3), 335-359.
- Fajri, K., & Taufiqurrahman, T. (2017). Pengembangan Buku Ajar Menggunakan Model 4D dalam Peningkatan Keberhasilan Pembelajaran Pendidikan Agama Islam. *Jurnal Pendidikan Islam Indonesia*, 2(1), 1-15.

- Fischer, L., Ernst, D., & Mason, S. L. (2017). Rating the quality of open textbooks: How reviewer and text characteristics predict ratings. *International Review of Research in Open and Distributed Learning*, 18(4), 142-154.
- Haryanto., Asrial., Ernawati, M. D. W. (2020). E-Worksheet for science processing skills using kvisoft flipbook. *international journal of online and biomedical engineering*, 16(3), 46-59
- Herawaty, D., Widada, W., Handayani, S., Febrianti, R., & Anggoro, A. F. (2020). Students' obstacles in understanding the properties of the closed sets in terms of the APOS theory. *JPhCS*, 1470(1), 012068
- Lee, J., Lin, L., & Robertson, T. (2012). The impact of media multitasking on learning. *Learning, Media and Technology*, 37(1), 94-104.
- Maison., Darmaji., Astalini., Kurniawan, D. A., Sumaryanti., Perdana, R. (2020). Supporting Assessment in Education: E-Assessment Interest in Physics. *Universal Journal of Education Research*, 8(1) 89-97
- Maharaj, A. (2013). An APOS analysis of natural science students' understanding of derivatives. *South African Journal of Education*, 33(1).
- Maharaj, A. (2010). An APOS analysis of students' understanding of the concept of a limit of a function. *Pythagoras*, 2010(71), 41-52.
- Martono, K. T., & Nurhayati, O. D. (2014). Implementation of android based mobile Learning application as a flexible learning Media. *International Journal of Computer Science Issues (IJCSI)*, 11(3), 168.
- Meyer, L. A., Crummey, L., & Greer, E. A. (1988). Elementary science textbooks: Their contents, text characteristics, and comprehensibility. *Journal of Research in Science Teaching*, 25(6), 435-463.
- Mikk, J., & Luik, P. (2003). Characteristics of multimedia textbooks that affect post- test scores. *Journal of Computer Assisted Learning*, 19(4), 528-537.
- Montag, J. L., Jones, M. N., & Smith, L. B. (2015). The words children hear: Picture books and the statistics for language learning. *Psychological Science*, 26(9), 1489-1496.
- Mukundan, J., & Khojasteh, L. (2011). Modal auxiliary verbs in prescribed Malaysian English textbooks. *English Language Teaching*, 4(1), 79-89.
- Nari, N. (2011). Kemampuan Pemahaman Konsep Matematika dengan menerapkan Pendekatan Pembelajaran Kontekstual melalui Model Pembelajaran Kooperatif Think–Pair–Share berempat dan Kemunculan Komponen Pembelajaran Kontekstual. *Ta'dib*, 14(1), 26-35.
- Nicol, C. C., & Crespo, S. M. (2006). Learning to teach with mathematics textbooks: How preservice teachers interpret and use curriculum materials. *Educational studies in mathematics*, 62(3), 331-355.
- Nodelman, P. (2001). A is for... what? The function of alphabet books. *Journal of Early Childhood Literacy*, 1(3), 235-253.
- Parraguez, M., & Oktaç, A. (2010). Construction of the vector space concept from the viewpoint of APOS theory. *Linear algebra and its applications*, 432(8), 2112-2124.
- Penney, K., Norris, S. P., Phillips, L. M., & Clark, G. (2003). The anatomy of junior high school science textbooks: An analysis of textual characteristics and a comparison to media reports of science. *Canadian Journal of Science, Mathematics and Technology Education*, 3(4), 415-436.
- Richey, R. C., & Klein, J. D. (2007). Design and development research. *Mahwah, NJ*.
- Rofiki, I., Anam, A. C., Sari, P. E., Irawan, W. H., & Santia, I. (2020). Students'

- Mental Construction in Cube and Cuboid Concepts Based on Mathematical Ability Differences. *Al-Jabar: Jurnal Pendidikan Matematika*, 11(1), 133-144.
- Salgado, H., & Trigueros, M. (2015). Teaching eigenvalues and eigenvectors using models and APOS Theory. *The Journal of Mathematical Behavior*, 39, 100-120.
- Shin, J., Eslami, Z. R., & Chen, W. C. (2011). Presentation of local and international culture in current international English-language teaching textbooks. *Language, Culture and Curriculum*, 24(3), 253-268.
- Syaiful., Kamid., Muslim., Huda, N. (2019). Investigate the relationship of creative thinking skills and junior high school students motivation. *Humanities & Social Science Reviews*, 8(2), 159-167
- Yunita, A. (2014). Pengaruh Metode Stratagem Melalui Pembelajaran Kooperatif Terhadap Pemahaman Konsep Matematis Siswa Kelas Viii Smp Negeri 20 Padang. *Ta'dib*, 17(1), 25-36.