

# MATHEMATICS LEARNING SYNTAX MODEL USING OPEN- ENDED PROBLEM SOLVING TO DEVELOP STUDENTS' CREATIVITY

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## MATHEMATICS LEARNING SYNTAX MODEL USING OPEN-ENDED PROBLEM SOLVING TO DEVELOP STUDENTS' CREATIVITY

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### ABSTRACT

The focus of this research was to develop a syntax model for Mathematics learning using open-ended problem solving that can develop students' creativity. The emphasis on creativity development was done since the curriculum and the experts also emphasize it. This can be understood since someone with high creativity can quickly make innovations or new breakthroughs. The design research used in this study followed Plomp's design research (2007), which consisted of: (1) preliminary research phase; (2) prototyping phase; and (3) assessment phase. The syntax model produced in this research has five phases, namely: (1) introduction; (2) concept tracking; (3) open-ended problem presentation; (4) presentation of work; and (5) closing.

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### A. Background

It is important for teachers at schools to emphasize the development of creativity. This can be seen from the standards of the 2013 Curriculum process which contains activity-based learning for elementary and secondary schools and gives enough space for the development of creativity. This is also in line with the wishes of Indonesia's Deputy Minister of Education, who believes that learning should support the students' creativity development. More specifically, Wardhani (2011) recommends that Mathematics learning needs to be triggered by Mathematics problems that require reasoning, trial, non-trivial solution, which triggers the students' curiosity on related mathematical ideas. The emphasis on this kind of learning can be understood since someone with high creativity can quickly create innovations or new breakthroughs.

However, from the result of the study about current Mathematics learning conditions cited in Suastika (2017), it was found that: (1) the learning still tends to be teacher-centered; (2) the students are not trained to solve open-ended problems that allow for many different answers or solutions; (3) the teacher's evaluation is more emphasized on the mastery of materials, while the aspect related to student's mathematical creativity is almost never touched. The results of the study showed that this teaching method had not supported the development of the students' creativity. This is actually in line with Mann's (2006) statement, who said that traditional teaching method involving only demonstrations and exercises using close-ended problems with single answers are less preparing students in Mathematics.

At the same time, an observation result at a junior high school in Kepanjen related to creativity showed that the students' creativity was still less encouraging. To measure the creativity of the students, the researcher gave open-ended problems, and the results are as follows. Out of 33 who answered the problems, there were 8 students who got 3 correct answers, 7 students got 2 correct answers, 12 students got 1 correct answer, and 6 students couldn't answer at all. From the 8 students who got 3 correct answers, 3 students used 2 different and correct ways of completion, while the rest of them (5 students) used the same way of completion. Through a closer examination, it turned out that the answer had no element of novelty. From the 7 students who got 2 correct answers, there were 3 students who used 2 different and correct ways of completion, while the rest of them (4 students) used the same way of completion. Through a closer examination, it turned out that the answer also had no element of novelty.

The result of the study of Mathematic textbooks circulating in the market showed that the problems presented in the books are mostly close-ended questions. The following is the example of a competency test on the books reviewed.

**Uji Kompetensi 7**

Kerjakan soal-soal berikut di buku tugasmu.

- Hitunglah keliling dan luas persegi panjang dengan ukuran sebagai berikut.
  - panjang = 18 cm dan lebar = 12 cm;
  - panjang = 25 cm dan lebar = 16 cm;
  - panjang = 30 cm dan lebar = 15 cm.
- Seorang petani mempunyai sebidang tanah yang luasnya 432 m<sup>2</sup>. Jika tanah tersebut berukuran panjang 24 m, tentukan
  - lebar tanah tersebut,
  - harga tanah seluruhnya apabila akan dijual seharga Rp150.000,00 per m<sup>2</sup>.
- Perhatikan gambar berikut.
- Hitunglah keliling dan luasnya.
- Sebuah persegi panjang berukuran panjang =  $(3x + 4)$  cm dan lebar =  $(x + 6)$  cm. Jika luas persegi panjang 392 cm<sup>2</sup>, tentukan panjang dan lebarnya.
- Keliling suatu persegi panjang adalah 72 cm dan lebarnya 8 cm kurang dari panjangnya. Hitunglah panjang dan lebarnya.
- Halaman rumah berbentuk persegi panjang berukuran panjang 90 meter dan lebar 65 meter. Di sekeliling halaman itu, akan dipasang pagar dengan biaya Rp135.000,00 per meter. Berapakah biaya yang diperlukan untuk pemasangan pagar tersebut?

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Picture 1. The example of questions in a Mathematic textbook for Junior High School students

Picture 1 showed that the problems in Uji Kompetensi 7 (*lit.* Competency Test 7) are all close-ended problems. The presence of such learning resources certainly can not support the development of students' mathematical creativity in the classroom.

Meanwhile, Yuwono (2006) states that in learning Mathematics, the preceding concepts and skills must really have been internalized before stepping on the next concept

and skills. Further, Situmorang (2012) believes that the low mastery of Mathematics concepts will affect the process of mathematical and creative thinking, which will result in the students' low mathematical problem solving process.

Based on the result of the study, it is necessary to design a learning model (especially the syntax model) that has the following characteristics: (1) student-centered learning; (2) learning by emphasizing open-ended problem solving in order to develop students' creativity; and (3) has concept tracking activity that allows the students to understand the concept first before moving on to the problems.

**METHODOLOGY**

This study aims to develop a valid, practical, and effective Mathematics learning product. The development product is an open-ended Mathematics learning model that can develop students' creativity. Therefore, this study is part of research and development (R&D) activity.

This study followed Plomp's design research (2007), which consisted of: (1) preliminary research phase; (2) prototyping phase; and (3) assessment phase. In designing the components of the learning model, the researcher refers to the model components suggested by Joyce and Weil (2009), namely syntax, social system, reaction principle, and support system. To measure the quality of the model that had been made, the researcher used product quality assessment from Neeven (2007). The three qualities measured from this development product are the validity, practicality, and effectiveness of the model that had been created. The focus of this study is the development of a syntax model for Mathematics learning using open-ended problem solving that can develop students' creativity.

**RESULTS AND DISCUSSION**

This open-ended problem solving syntax model is consisted of five phases, as presented in Table 1. This model hereafter will be referred as PMT model (*Indonesian: Pemecahan Masalah Terbuka*).

**Table 1. Syntax Realization**

Phase	Activities	Notes/Goals
1. Preliminary	<ol style="list-style-type: none"> <li>1. The teacher was greeting the students</li> <li>2. The teacher was asking the students to join their groups (group formation was done before conducting the learning activities)</li> <li>3. The teacher was distributing the student books</li> <li>4. The teacher was asking questions related to the prerequisite materials (if the material to be learned required prerequisites)</li> </ol>	<ol style="list-style-type: none"> <li>1. Facilitating the students in learning</li> <li>2. Maintaining material continuity</li> </ol>
2. Concept Tracking	<ol style="list-style-type: none"> <li>1. The students were answering questions for concept tracking in groups</li> <li>2. The students were working on simple open-ended activities in groups</li> </ol>	<ol style="list-style-type: none"> <li>1. Building an understanding of concepts</li> <li>2. Introducing simple open-ended problems</li> </ol>

Phase	Activities	Notes/Goals
	3. The students with the teacher were reflecting on the concept tracking and simple open-ended problem solving that had been done	that were packaged in activities
3. Presentation of Open-Ended Problems	1. The students were working in groups to solve open-ended problems in the student books 2. The students were asking the teacher whenever they found difficulties in the student books	1. Developing the students' creativity through open-ended problem solving
4. Presentation of Works	1. Several designated groups were writing their answers on the board 2. Other groups were asking or giving feedback to their answers 3. The designated groups were giving answers or responding to their friends' questions or feedbacks 4. The students were writing the answers that had been concluded	1. Internalizing the open-ended problem solving that had been conducted
5. Closing	1. The teacher and the students were reflecting on the material discussed 2. The teacher was telling the students about the next tasks for the next meeting 3. The teacher was asking the students do the competency test in the student books individually	1. Getting the core of the material discussed 2. Getting the students' creativity scores

The discussion of the development result of this syntax model was focused on: (a) concept tracking phase; (b) open-ended problem presentation; and (c) presentation of work, while the preliminary and closing phase are not discussed.

### Concept Tracking

The concept tracking phase in the PMT learning model consists of three elements: (1) the student answers the concept tracking questions, (2) the students solve the simple open-ended problems, and (3) simple open-ended problem solving reflection. In learning with the PMT model, teachers do not directly explain the concepts discussed at the meeting, but rather the concept tracking is packaged in the form of questions presented in the student book. Questions are made in such a way that by answering these questions the students will be brought to the concepts covered in the material discussed at the meeting. The PMT model provides an opportunity for the students to trace the concepts discussed at the meeting, so that students are not only becoming recipients of information, but are also actively involved in the learning process. By actively engaging in concept tracking, the students are expected to have a better understanding of concepts. This is consistent with that proposed by NCTM (2000), that mathematical understanding is a very important aspect in the principle of Mathematics learning. Mathematical understanding is more meaningful if it is built by the students themselves.

This study emphasized the importance of concept tracking before the students solve open-ended problems. Armed with the concept in mind, they were expected to be more comfortable to solve the problems. This is in line with Yuwono's (2006) research,

that in learning Mathematics, preceding concepts and skills must be fully internalized before stepping on to the next concepts and skills. Situmorang (2012) states that the low mastery of mathematical concepts will affect the process of mathematical and creative thinking, which will result in the students' low mathematical problem solving process.

Before moving on to the open-ended problem presentation phase, in the concept tracking phase the students were also given simple open-ended problems. This was intended to allow the students to familiarize themselves with open-ended problems and how to solve them, which have more than one answer and different ways of completion. This supports Habibah's (2006) research, that students need to be given simple open-ended problem first so that they have experience on it. Parwati (2006) states that the presentation of open-ended problems that are done gradually from simple to complex forms can foster students' learning motivation to learn the next material. These simple open-ended problems were done in groups, so that the students can share their ideas with their friends and easier for them to solve the problems.

After performing concept tracking and solving simple open-ended problems, the teacher gave reflection in the form of questions that are reminiscent of the process of solving the open-ended problems already done. By doing so, the students were expected to be more familiar in solving open-ended problems with more than one answer or completing in different ways.

**a. Open-Ended Problem Presentation**

Sujadi (2000) believes that Mathematics needs to be more emphasis on the conscious involvement of the learners consciously. Monahan (2002) states that "most people who study creativeness agree that problem solving is essential to creative achievement. Most who truly understand creativeness believe it's virtually impossible to be creative without a problem". Based on these two opinions, it is necessary to provide problems to the students so that they are optimally involved in learning so that their creativity can develop.

In order to develop their creativity, in this research the students were given some open-ended problems to be solved. Learning by giving problems to the students is in line with the PBL model, as Arends (2008) suggests, that the role of the teacher is to present authentic problems, facilitate students' inquiry, and support their learning. This research is also in line with the Siswono's (2009) research, which is orienting the students on the problem solving by providing problems appropriate to their development level. Giving the open-ended problems to develop creativity is in line with Leikin's opinion (in Kontoyianni, 2013), who states that it is necessary to provide tasks that have more than one answer to develop creativity. Hashimoto (1997) believes that it is necessary to provide open-ended problems to develop students' creativity. Sharp (2004) also states that teachers can get learners to behave creatively through: (1) tasks that not only have one correct answer, (2) tolerate "unique" answers, (3) emphasize the process not just the results, (4) encourage learners to: try; self-define unclear information, have their own interpretation related to knowledge/events, (5) give a balance between structured and spontaneous activities.

In this phase the students worked in groups to solve problems. By doing so, it was expected that they can share their ideas among their friends to solve the problems.

**b. Presentation of Work**

The presentation of work was done to reveal how far the students had been able to solve the open-ended problems assigned to them. The teacher appointed several groups

to present their groups' results on the board. These support Siswono's (2009) research, where teachers should help students in planning, establishing groups and presenting their results. Learning by giving opportunities to students to present their works is in line with the PBL model. This can be seen from PBL's fourth learning phase, which is 'developing and presenting the works and exhibits'.

Based on the answers written on the board, other groups compared their own answers with the presenters' ones. This triggered idea sharing among them. Sometimes, both the presenters and other groups have different yet correct ways to answer the problems. That way the students learned additional insight of the material presented, and developed their creativity.

### CONCLUSION

The development of this syntax model followed Plomp's design research. These includes: (1) preliminary research phase, (2) prototyping phase, and (3) assessment phase. The syntax model consisted of five phases, namely: (1) introduction, (2) concept tracking, (3) presentation of open-ended problems, (4) presentation of works, and (5) closing.

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