The role of scaffolding in model eliciting activities (MEAs)

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**Abstract**. Model Eliciting Activities (MEAs) is a learning approach that is based on realistic problems. Students are required to make models from real situations, document the modelling process, ensure the model is made suitable for the problems given, and ensure that the model can be used again to solve similar problems. Then the obstacles that occur in MEAs learning are caused by problems related to mathematical modelling, so assistance in the form of scaffolding is needed to overcome these obstacles. There are three characteristics in scaffolding, namely: contingency, fading, and transfer of responsibility. In this literature review, it is found that in providing scaffolding on MEAs learning, it is necessary to pay attention to the following: the form of support provided is adaptive support with continuous evaluation paying attention to short-term and long-term developments, it is suggested that the support provided does not refer to specific topics so that there are cognitive efforts as well as metacognitive from students, the role of the teacher is more asking questions than answering questions, the assistance provided combines several forms of scaffolding in one lesson, the teacher is not in a hurry to provide guidance and appropriate questions.

1. Introduction

Mathematics is the queen of knowledge or the servant of all sciences, where other knowledge such as science, technology, economics, and even astronomy rely on the mathematics to develop it [1]. In the mathematics education community to teaching emphasizes the importance of involving the real world in learning mathematics [2]. Moreover, Model Eliciting Activities (MEAs) is a learning approach that uses real problems as one of the things that must be present in learning. The goal of MEAs learning is to reveal students' thinking processes, as a simulation of real-world applications, and to identify student abilities that were not measured by standardized tests [3]. Besides, MEAs need to be developed and applied in schools because MEAs is a learning approach that is following the demands of learning that exist in the 21st century by promoting innovation and creative activities [4]. So that with MEAs learning it is expected to be able to equip students with the ability to face the real world and also be able to compete internationally. One of the problems in learning mathematics in Indonesia today is related to the low PISA score. The framework in the PISA test is also related to recognizing functions that can be performed by real-world mathematics [5].

There are six principles in MEAs learning: model construction, reality principle, self-assessment principle, construct documentation principle, construct shareability and reusability principle, and effective prototype principle [6]. With these six principles, learning with MEAs is required to make models from real situations, document the modeling process, ensure the model is made suitable for a given problem, and ensure that the model can be used again to solve similar problems. Based on this, it can also be identified that learning with MEAs intersects with mathematical modeling where mathematical modeling is defined as a process of identifying real problems, formulating them into mathematical models, and interpreting mathematical solutions as solutions to real problems [7]–[9].

In applying a learning approach that is non-routine applied, it is certainly not easy. Teachers need to understand what the process means, how students look, and how this learning can be developed in students [10]. There will be obstacles when learning with MEAs, some of the teachers having difficulty connecting MEAs learning and the school curriculum, learning mathematics with MEAs takes much time, and other obstacles related to mathematical modeling [11]. With these obstacles, the teacher needs to implement a strategy that can reduce existing barriers, one of which is scaffolding [12]. Another reason MEAs can be combined with scaffolding is that the MEAs approach can be based on Vygotsky's theory, wherein MEAs learning students are formed to learn in groups, the teacher provides direction and encouragement and supports students at the beginning of learning [13]. Thus, in implementing MEAs learning, it should also be equipped with scaffolding that will be provided.

Scaffolding consists of adults who "control" elements of a task that are initially outside the student's capacity, thus allowing him to concentrate and only solve those elements within his range of competence [14]. It is related to the term Zone of Proximal Development (ZPD) developed by Vygotsky, namely the distance between what students can achieve and their abilities and knowledge assistance from teachers and friends [15]. There are several characteristics of scaffolding, namely : (1) Contingency, the support provided is adjusted to the level of student performance. (2) Fading, the provision of support provided is decreasing. (3) Transfer of responsibility, the process of transferring performance responsibility to students along with fading and contingency:[16]. These three characteristics further strengthen that the provision of assistance is temporary and fades away, and after arriving at ZPD, students take full responsibility for this.

Based on the above background, it is necessary to study more about previous research related to scaffolding that teachers can give to students to reduce difficulties and obstacles. Of course, in providing support, it is necessary to consider that this assistance does not change the principles and essence of learning itself. Every lesson is different, so there are different ways of assisting.

1. Experimental Method

This article is the result of a literature review. It aims to obtain a written summary of a book journal or proceeding that describes the state of previous research related to the Model-Eliciting Activities and the role that scaffolding can play in this learning. The steps in reviewing the literature are as follows: Identify, locate literature, Critically evaluate and select the literature, Organize the literature, write a literature review [17]. In identifying, the keywords used are "Model Eliciting Activities," "Scaffolding," "Mathematical Modeling." Furthermore, the researchers sorted articles in journals, educational books, or national and international proceedings, were available in full text, and were published in the 2000-2020 range. After that, the researcher evaluates critically the articles that will be used as reference material in making notes. Then the researcher developed it to obtain a conclusion in the form of a description of the role of scaffolding in learning Model-Eliciting Activities.

1. Result and Discussion

The MEAs approach is a learning approach based on realistic problems, multiple processes, working in small groups, self-directed learning and self-assessment, and presents a model to help students build problem solving and make students apply the understanding of the mathematical concepts they have learned [6], [18]. In addition, MEAs are also understood as a learning approach rooted in mathematical modeling [19], [20]. Products generated in the model-eliciting activities involve conceptual tools that can be shared, manipulated, modified, and reused to build, describe, explain, predict, or control a mathematically significant system [21]. Thus it can be seen how learning with MEAs is closely related to mathematical modeling activities. The following is the relationship between the MEAs learning steps and the mathematical modeling process.

**Tabel 1.** The relationship between the MEAs learning steps and the mathematical modeling process

|  |  |
| --- | --- |
| Steps in learning MEAs [22] | Mathematical Modeling Process [23] |
| The teacher reads a problem sheet that develops the student's context | Understanding |
| Students answer readiness questions that are based on problems | Simplifying/Structuring |
| The teacher reads the problem formulation with the students and ensures that each group understands what is being asked |
| Students solve the problem | Mathematization – working Mathematically-Interpreting |
| Students recheck the solutions obtained and revise them if necessary | Validating |
| Students present their models in front of the class. | Exposing |

Based on the table above, in the first step, the teacher reads out the problem sheet. The goal is to introduce students to the context of the problem given, and this is in mathematical modeling including the understanding process, which is understanding the problems presented. Then the next step students answer questions about readiness based on problems. And then, together with teacher and students, formulate an understanding of the problem and about what is asked where by answering the questions and drawing an outline of the problem will make students start sorting and compiling relevant information, it is a simplifying/structuring process. Then students solve problems where solving problems in MEAs learning starts from transforming from real problems to mathematical problems and then working with mathematical concepts and interpreting them as solutions to real problems. After that, the next stage is to check back on the MEAs, and it is clear that it is in accordance with the validating stage in mathematical modeling. The last step is to present the model obtained in front of the class, and it is in accordance with the exposing stage in mathematical modeling, namely sharing the solutions they get.

Then the obstacles in implementing MEAs some teachers having difficulty connecting MEAs learning and the school curriculum. It is because mathematical modeling problems focus on practical situations that usually use various mathematical topics as useful tools to solve them so that in their application, sometimes MEAs cannot be fixed by order of material in the curriculum [24]. The next obstacle is learning mathematics with MEAs, which takes much of time. It is also related to the complexity of the material needed to solve the problem where the students' prior knowledge is not sufficient to solve the problem, and teachers who are not used to working with mathematical modeling will "over facilitate" so that the time more is needed [25]. Another obstacle is the constraint associated with mathematical modeling. Where this obstacle is related to the modeling problem-solving procedure, suppose review some previous research, the problems that often arise are students having difficulty sorting out relevant information, errors in using operations or concepts that are under the context of the problem, difficulties in algebraic, arithmetic, or measurement processes, another problem is that students' answers do not make sense and are unrealistic [26], [27].

Then to overcome obstacles in learning mathematics in general, several ways can be done in providing supports, namely: (1) Feeding back, which involves providing information about student performance to the students themselves. (2) hints, giving instructions or suggestions by the teacher and deliberately not giving all solutions or detailed instructions. (3) Instructing, which is telling students what to do or explaining how something should be done and why. (4) Explaining, providing more detailed information or clarification by the teacher. (5) Modeling, the demonstration or process of offering behavior to imitate. (6) Questioning, which is asking questions to students who need linguistic and cognitive active answers [16].

Then when referring to Anghileri, scaffolding is based on three levels [28]. At level 1, the form of scaffolding that is given does not involve direct interaction between teachers and students. The form of scaffolding is used with environmental provisions such as peer collaboration, structured tasks, or self-correcting tasks. At level 2, the form of scaffolding is explaining, reviewing and structuring. Scaffolding involves interaction between teachers and students. Reviewing can be done in several ways such as, getting students to look, touch and verbalize what they see and think; getting students to explain and justify interpreting students' actions and talk; using prompting and probing questions and parallel modeling. Then, restructuring the form of support is in the form of interactions provision of meaningful contexts to abstract situations, simplifying the problem by constraining and limiting the degrees of freedom, rephrasing students' talk and negotiating meanings. At level 3, the form of scaffolding is the development of conceptual thoughts by focusing on making connections and generating conceptual discourse.

With the various strategies for providing supports, it is necessary to be careful in providing support. That will be provided especially for mathematical modeling problems because usually, teachers who do not have sufficient experience with mathematical modeling tasks will "overly facilitate" and provide constant intervention to help students progress with assignments [25]*.* With the many ways that can be provided to support students, of course, to find out the form of supports that is in accordance with the modeling task, it is necessary to review previous research. The following are some of the results of research regarding the form of scaffolding in mathematical modeling assignments.

**Tabel 2.** Types of scaffolding provided on mathematical modeling

|  |  |
| --- | --- |
| Author | Type of Scaffolding |
| [29] Stender et al (2015) | Questions, feedback |
| [30] Tropper et al (2015) | Modeling (worked example), feedback, hint |
| [31] Schukajlow et al (2015) | “Solution Plan” (Instruction, reducing complexity) |
| [32] Ramadhani et al (2015) | Questions, reviewing, pengenalan konteks, instructing |
| [33] Sari and Valentino (2016) | Explaining, restructuring, reviewing |
| [34] Ulu (2017) | Restructure, guiding students to understand that the results they get are not appropriate (explaining), Asking students to do validation (reviewing). |
| [35] Abadi et al (2017) | Explainig, Reviewing, Structuring |
| [36] Hasan (2019) | Reviewing (Ask students to read and understand questions, ask directional questions, have students analyze to prepare a backup answer plan correctly, interpret the irrelevant information identified to create a solution plan). |

Based on the results of the review of the articles above, it can be described how the scaffolding given to mathematical modeling is diverse. It is possible to combine various forms of assistance in solving mathematical modeling problems. If the scaffolding only relies on the interaction between teachers and students, the teacher cannot flexibly activate skills to support students adaptively so that Tropper et al. suggested that the use of demonstrations or modeling is more useful in supporting students. However, individual support from teachers to students while students process the material is also important. So that a form of support that combines demonstration or modeling with other methods such as questions, feedback, hints are recommended [30]. Then in providing supports, the form of assistance provided should be adaptive support [29], [30]. Where to provide an adaptive form of scaffolding, teacher intervention is evaluated continuously by considering short-term and long-term developments, and teachers must consider aspects of individual differences when intervening [29], this is in accordance with the characteristics of scaffolding, namely contingency and fading.

Another form of support that can be provided is strategic prompts. It needs to be paid attention to equipped strategic prompts because the form of support should not be in the form of a topic-specific. It is done so that there are student cognitive efforts to identify the right topic and choose the appropriate plan [31]. In addition to involving cognitive supports, it is also necessary to involve metacognitive, and this can be done by providing feedback related to the content faced by students [29]. It related to MEAs learning because the success of MEAs is supported by the teacher's role as a metacognitive coach who asks more questions than answers questions [6]. Where this is also one of the principles of self-assessment so that this role will make students evaluate or even revise the tasks they are doing.

Furthermore, based on students' difficulties in solving modeling problems, several forms of assistance can be analyzed. At the stage of understanding the problem, the assistance provided is in the form of a probing question to see students' understanding of the problem given then after knowing how the teacher's understanding leads to a prompting question. In the mathematizing step, the assistance provided is in the form of a prompting question by asking a simple form of the written mathematical model. At the working mathematically stage, the researcher asked students to re-examine the answers that were still inaccurate (looking and verbalizing). Then, at the validating / interpreting stage, the researcher gives a prompting question to ask the information in the task but is not used to answer questions [32].

Referring to the last four studies given scaffolding tends to be questioned, explaining, reviewing, and structuring [32]–[36]. When connected to the scaffolding level, it is at level 2, meaning that the provision of assistance for mathematical modeling tasks requires direct interaction between teachers and students. However, the interaction used is only as a trigger to make students construct their understanding. Besides, the form of scaffolding at level 2 also makes it possible to activate student metacognitively. However, what needs to be remembered in providing scaffolding at level 2 is that the teacher must provide appropriate guidance and questions to help students make mathematical models of the problems given so that the potential of students can develop more optimally [37].

Based on the results and discussion above, MEAs learning involves complex modeling problems. The scaffolding that needs to be prepared is also elaborate, in providing scaffolding assistance prepared by the teacher based on previous diagnoses [38]. With a diagnosis of what students know and need, it will be easier for the teacher to map the appropriate learning sequence. Besides that, the teacher is also well-ordered in providing supports because everything has been prepared. The diagnosis process can be done by adding one stage at the beginning of the MEAs lesson, where the teacher asks some questions to find out to what extent students have mastered the basic concepts of the material to be taught [13]. In this way, the role of scaffolding that is prepared can strengthen the teacher's framework in MEAs.

1. Conclusion

Model Eliciting Activities (MEAs) is a learning approach that has roots in mathematical modeling, where MEAs can be based on Vygotsky's theory, which is also related to scaffolding. The role of scaffolding in MEAs can be used to strengthen the teacher's framework in the model eliciting process. The scaffolding that is given in mathematical modeling tends to be level 2, namely by explanation, reviewing, and structuring. Then in providing scaffolding to MEAs, it is recommended to pay attention to several things, namely: the support provided is adaptive support with continuous evaluation paying attention to short-term and long-term developments, it is recommended that the support provided does not refer to specific topics so that there are cognitive and metacognitive efforts from students, the role of the teacher is more asking questions than answering questions, the assistance provided combines several forms of scafoolding in one lesson, and the teacher is not in a hurry to provide appropriate guidance and questions.

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