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Hypothetical Learning Trajectory for Classification of Animals and Sets by Using the STEM Approach

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Abstract: STEM approach is an approach to teaching science, technology, engineering, and mathematics in an integrated manner. The aim of this study was to describe the design of teaching and learning process to teach animal classification in science and set in mathematics using the STEM approach. The type of research used in this study was the Gravemeijer and Cobb models which consist of three phases. The research subjects in this study were 34 students of class VII D of SMPN 1 Yogyakarta. The instrument used in this study is the hypothetical learning trajectory. In the design made by the researcher, there were observations by students about animal characteristics and animal placement in the GembiraLoka zoo. From this observation process, the researcher facilitated students to understand how the process of classifying animals in science, and how to make a set, determine the terms of membership of a set, and write down the membership of a set.

Keywords: STEM approach, integrative, and collaboration.

Introduction

The character of modern society that lives in the 21st century is rational, open, forward-thinking, creative, independent, appreciating time and innovating. Their lives are also influenced by the rapid development of technology and communication. To be able to play a role in shaping the character of society in the 21st century, schools, especially teachers are required to be able to present learning that is able to foster these skills. In the 1990s the United States National Science Foundation held a renewal movement in the education sector and the theme raised was Science Technology Energetic Mathematics (STEM) and from this movement the term STEM first emerged. This movement is a movement that seeks to make updates in the learning process related to the four fields, so that the growth of the workforce of the STEM fields can be increased (Firman, 2015). In addition, this movement also intends to open the horizons of Americans so that they are literate with STEM. If this goal is successfully achieved, then the result in US global competitiveness in science and technology innovation can increase. According to the National STEM Education Center, STEM education does not only mean strengthening the praxis of education in STEM fields separately but developing an educational approach that integrates these four fields by focusing on the educational processes that occur in the classroom in solving real problems found in everyday life and professional life (Firman, 2015). In other words, they began to be invited to learn to integrate their knowledge in the four fields to solve problems they encountered in everyday life. According to Bybee (2010), within the framework of primary and secondary education, STEM education aims to develop STEM literate students with the following characteristics: (1) using scientific steps in identifying and solving problems, (2) understanding the characteristics of each STEM disciplinary component so that it can use all four components in an integrated manner, (3) realizing how the roles of each discipline in STEM form a material environment, intellectual and cultural, and (4) willing to study STEM related issues.

According to Reeve STEM education is an interdisciplinary approach to learning where in the learning process occurs students use science, technology, engineering, and mathematics to solve problems, so that they can be well connected with the world of work, and the world global (Firman, 2015). Therefore, STEM-based learning can be used as a solution that can provide opportunities for students to foster an attitude of cooperation and integrate abilities and knowledge in these four fields. Moore et al. explains that STEM is an approach and effort in combining several or all four STEM subjects into one lesson that is based on relationships between subjects and real-world problems



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(Firman, 2015). Sanders explained that STEM is an approach that explores two or more STEM subjects and one or more subjects in school (Sanders, 2009).

One of the problems faced by students in our school is that students have not been able to integrate the material obtained separately when solving a problem, for example when students are asked to design the location of animal cages in a zoo if animals will be placed at the zoo it is known. Students have not been able to integrate the knowledge they have acquired about animal classification in Science subjects, and the set in Mathematics. Therefore, in this study, we try to design learning activities that can integrate set material on Mathematics subjects and Classifications of Living Beings on science subjects, so that the knowledge formed by students can be integrative with each other.

Hypothetical learning trajectory (HLT) is a hypothesis or prediction of how students' thinking and understanding develop in learning activities (Wijaya, 2009). According to Gravenmeijer (2004), there are three main components in HLT, namely (1) learning objectives, (2) learning activities and devices / media used in the learning process, and (3) the conjecture of the learning process, which contains the initial understanding students and student strategies that emerge and develop when learning activities are carried out in class (Gravemeijer, 2004). In this study, researchers will design a hypothetical learning trajectory (HLT) that uses the STEM approach to teach animal classification in science and the set of mathematics lessons in class VII D at SMPN 1 Yogyakarta in an integrated manner. The researcher chose the two materials because according to the researchers both materials were interconnected and could be taught in an integrated manner.

Research Method

The type of research used in this study is the Cobb and Gravemeijer model design research which consists of three stages, namely (1) making a design plan; consists of (a) determining learning objectives, (b) determining the starting point of learning, and (c) determining the learning model to be used; (2) testing the design design, and (3) conducting a retrospective analysis (Van den Akker, Gravemeijer, McKenney, & Nieveen, 2006). The results presented by researchers in this paper are only limited to stage one of three stages. The things presented by new researchers are limited to how the HLT design is to teach animal classification and assemblies using the STEM approach.

The subjects in this study were students of class VII D of SMP 1 Yogyakarta. The data collection method that will be used in this study is making field notes, observing, giving written tests, and conducting interviews. The research instruments used in this study were HLT, test sheets, and interview guideline sheets. The stages of data analysis used in this study are the stages of data analysis in qualitative research, namely (1) reducing data, (2) presenting data, and (3) making conclusions and verifying conclusions (Miles & Huberman, 1994).

Discussion

The learning objectives of HLT made by researchers are: (1) students can classify animals found based on the characteristics of the animal, (2) students can explain the characteristics of animals in a classification, (3) students can identify whether an animal enters a particular class or not, (4) students can define the meaning of a set, and (5) students can represent membership of a set.

HLT designed by researchers was conducted into two major stages detailed follows:

In the first stage, students were told to photograph five animals that live around their houses. They were asked to write down the characteristics of the five animals based on observations made. Then, the students were made to work in groups of three. Each group later was asked to share their observation results and showed pictures of the animals observed. In the next the task, each group was to identify animals that have similar characteristics. Then students were asked to look for some learning resources available about (1) how the animals they observed breed, (2) how the animal respiration systems are like, and (3) what the animals' digestive systems look like. When the information had been obtained, students were asked to make classifications of animals based on their breeding methods, respiratory and digestive systems. Following their discussion on the classifications, each group was asked to make a poster containing their findings based on the leading questions. Each group were also given the opportunity to add their explanations to the pictures. After that, each group was asked to present the

results of their work during Natural Science class and teacher. Each group was reminded to present different classifications.

Using the results of the group presentations, the Math teacher asked to answer questions, such as: why can animal A, for example a cat, be grouped into groups of animals that breed by giving birth? Give examples of other animals that belong to the group of animals that breed. The Math teacher, then, invited students to draw conclusions about the meaning of the set. To help students draw conclusions about the meaning of the set, the teacher associated the question with the process that happened before, for example about cats that are included in the group of animals that give birth. The teacher asked why cats are included in the set of animals that give birth. From this process, students were expected to make conclusions that the set refers to a collection of objects that have the same characteristics or features. Then, students worked together to add more animals which bear the same characteristics presented during Natural Science class. Then, the students were made to convert all the data they used into graphs. Some were expected to use images or tables. The teacher asked the groups to present the results of their discussion. The teacher ensured that the Math/set poster displayed presented a different representation of the membership of the sets. The procedure was followed with students making conclusions on how to present a set.

Still working in the group, students were given a piece of paper containing the names of sets of numbers, for example a set of integers ranging from - 5 to 4, the set of natural numbers between 12 to 21, or the set of even numbers located between 12 to 15. The groups were tasked to express the statements in different ways. Then, the groups were asked to present the results of their discussion on a poster. The teacher ensured that the poster displayed presented a different representation of the membership of the set. The first stage ended with students concluded about how to present a set.

The second stage began by making students work in groups 3 – 4 students and were told to visit Gembiraloka zoo on a particular day accompanied both Natural Science and Math teachers. During their visit to the zoo, each group was tasked to do the followings: (1) take photos of 15 different animals, (2) record the classifications of the animals while touring in the built-in gardens ranging from the types of food to the living habitats of the animal, and (3) make a video containing reportage two different types of animals in 15 minutes duration. Following their visit to the zoo, students were asked to upload the reportage videos to You Tube channel. Then, other students were asked to watch reportage videos made by other groups. After watching the videos, students were asked to make important notes about the animals described from each video for students to make important notes about things that they felt not right from the reportage their friends made. In the same group, each student was asked to present the notes he had made after watching the video. At the end, each group was asked to summarize the notes from their member and wrote them on the poster. After that, students were invited to discuss the notes that appeared the most especially about things that are not right.

Following that, the teaming-teachers selected thirty photos which were sent by students. These selected photos were returned to the groups, thus each group had thirty photo compilation which they must cut out. The teacher asked the groups to make different classifications to present the results of their discussion. Using a new working sheet from their teachers, the group pasted the photos on the new sheet under a certain classification. In the posters, students were also asked to explain how the classification was made along with the membership requirements for each classification.

Then, the groups continued working by designing a mini zoo containing animals within the collections. After finishing the mini zoo, students were asked to make a video presentation explaining how they built the mini zoo, why they built it, and what difficulties they experienced when making the zoo. After the video was finished, each group was asked to upload it on you tube. Students must watch the videos and rated the content of the video. The most liked videos will be entitled for some presents from the two teachers. A written test, finally, was given to measure their achievement of their learning objective(s).

Conclusion

The context of the exploration of animals that live around the home environment of students can be raised as a context for learning animal classification, understanding sets, and how to represent the set. Another context that can be used to achieve this goal is the context of visiting zoos and discussion activities related to visits to zoos. To see the achievement of the objectives and the implementation of this HLT, researchers need to conduct a trial to the field.

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