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Hypotetical learning trajectory to anticipate mathematics anxiety in algebra learning based on the perspective of didactical situation theory

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Abstract. The objective of this research is to design an alleged teacher learning path or Hypotetical Learning Trajectory (HLT) to anticipate mathematics anxiety of students in learning algebra. HLT loads expected mathematics learning objectives, estimates the level of knowledge and understanding of the students, as well as the selection of mathematical activity in accordance with the learning competencies. This research uses educational design research method. The research steps consist of a preliminary design, experimental and retrospective analysis. Data were gathered from various sources, such as data is written during the research process of test results, documentation, sheet results of students’ work, results of interviews, questionnaires, and video recordings. The subjects of the study were 10 junior high school students. Based on the research identified 2 students at the level of high anxiety, 7 people at medium anxiety level and 1 student at low anxiety level. High anxiety levels about 20%, was approximately 70% and approximately 10% lower. These results can be used as an evaluation and reflection for designing materials that can anticipate mathematics anxiety of students learning algebra concepts.

1. Introduction
Anxiety students towards mathematics is a major obstacle in the study of mathematics. Many factors that cause anxiety in students while studying mathematics. Math anxiety can be caused because the teachers themselves have no concern about mathematics as a result of the practices of learning that is not appropriate, such as less precisely teachers in managing learning, learning methods that are less relevant, not structured instructional materials that support the achievement of competence, as well as learning structure are not well ordered [1].

The use of materials that are not in accordance with the characteristics of students can be a cause of anxiety for students to learn mathematics. To design teaching materials which includes the interaction between teacher-student-matter, the teacher needs to know the trajectory of student learning / learning trajectory. Learning Trajectory is a picture of students’ thinking during the learning process in the form of allegations from a series of learning activities to encourage the development of the students think that mathematics learning objectives in line with expectations [2]. A path has the characteristics of their learning starting point and end point of learning. Anticipation of student responses that may arise in the learning process is designed in the form of hypotetical learning trajectory/HLT. HLT load expected mathematics learning objectives, estimates the level of knowledge and understanding of the students, as well as the selection of mathematical activity in accordance with the learning
competencies. HLT is also a guide that can connect between the theories of learning and teaching practice. Learning theory perspective used in designing this HLT is a didactical situation theory developed by Brousseau.

In planning the study, most teachers did not consider the diversity of the students' response to the situation didactic (a pattern relationship student-matter through the assistance of the dish teacher) developed, so that a series of situations didactic next most likely no longer corresponds to the diversity of the trajectory of learning of each student [3]. In this case, each student has a groove pattern or a certain thought in responding to the grain material. Teachers need to know the path of learning that must pass students in achieving a goal of competence. Cognitive and affective aspects must be integrated into the learning process with balance. That is, the teacher does not only focus on students' cognitive abilities, but also must pay attention to affective aspects that affect learning outcomes. Attention teachers and support the teacher can help students achieve learning competencies.

Planning for teaching math concepts is crucial to overcoming the barriers that may occur [4]. The learning process will go well, if the interaction that exists between the Teacher-Student-material can overcome any barriers to learning that occurs [3]. "Two fundamental aspects in the learning process of mathematics, namely the relationship of the students-material and the teacher-student relationship, it can create a didactic or pedagogical situation is not simple and often happen very complex" [3].

One of the topics of mathematics at junior high school are to master algebra concepts. Algebra is a language of symbols and relationships. Algebra was introduced by Al-Khwarizmi in the 9th century was viewed as a science equation that can be used as a tool to solve everyday problems [5]. In elementary schools, the number is symbolized by the numbers (numbers sense), and in junior high schools, the number symbolized by numbers, letters, or other symbols (symbol sense). Transition of number sense to symbol sense this a transition from arithmetic to algebra. The difference between arithmetic and algebra contained in the use of the letters in the resolution of a problem. Basic arithmetic does not use symbols other than numbers and basic arithmetic operations. In learning algebra, arithmetic good understanding indispensable. Because when students are confronted with things that are abstract, students will find it difficult to understand. Therefore, students must first be given a better understanding on something concrete. So it is with learning algebra, if students are not given an understanding of arithmetic first, then the student will be difficult to understand algebra.

The transition from arithmetic to algebra also requires a lot of adjustments in the pattern of student thinking, even for students who are quite proficient in arithmetic [5]. The transition from arithmetic to think algebra is the most difficult step in the life of mathematics students [6]. Currently, in elementary school arithmetic generally tend to be oriented on the answers and do not focus on the representation of the algebra itself. The transition from arithmetic to algebra is of course quite difficult to pass by junior high school students. The cause of the difficulties students among others, is a matter of interpretation letter. There is a misperception that that letter is seen as an object, not representing numbers, and letters are often thought to symbolize a certain number. This interpretation difficulties often due to the lack of understanding of the conventions in algebra the teacher assumes that students have understood the significance of the agreement itself.

This transition will pose barriers to learning for students in algebra. The obstacles can be epistemological and psychological barriers. Student anxiety is a psychological barrier that is often experienced by students in learning algebra. Based on the above view, algebra would be controlled if algebra is given through a learning experience that is designed in the form of materials or didactic situation that integrates cognitive and affective aspects. It badly needs the involvement of teachers in investigating diverse student's learning potential and its relation to the role of values that form a learning situation. When designing teaching materials, teachers need to be guided by the question 'why' and 'what'. The question 'why' to direct the teachers explore the meaning and benefits of learning the contents of the materials provided to the students for the students' everyday life. Furthermore, the statement 'for what' is more focused on the character of the students as to what would be formed. This question relates to the expression and expectations associated with the existence of student life in society: understanding, feelings and social interaction [7]. Therefore, based on the theoretical study of
the above, teachers need to make educated guesses student learning trajectory / HLT corresponding to the stages of cognitive and psychological development of students.

2. Research Methods
This study uses educational design research method. Steps of design research consisted of a preliminary design, experimental and retrospective analysis. Data were gathered from various sources, such as data is written during the research process of test results, documentation in the form of photographs, sheet results of students’ work, the results of interviews with students and teachers, questionnaires, and video recordings. Step study can be seen from the following diagram:

![Diagram](image-url)

**Figure 1.** Steps of design research

3. Results and Discussion

3.1. Preliminary Design
HLT designed using the model of development that refers to 4D, which is a development that is carried out by 4D patterns, which include (1) Define which set the terms of the manufacture of materials; (2) Design, namely HLT by paying attention to the syllabus, lesson plans, student anxiety aspect, barriers to learning and theory in accordance with the indicators and the perspective of learning theories used; (3) Develop namely writing instruments of learning. HLT has been prepared then communicated with learning expert. HLT then refined based on input from experts to produced the instrument in accordance with the characteristics of a learning model; and (4) Disseminate namely dissemination HLT to conduct testing that has been developed [8]. Theoretical perspective used in
designing this HLT is the theory of didactic situations. According to the theory of didactic situations introduced by Brousseau in 1978, the didactic action of a teacher in the learning process will create a situation that can be the starting point for the process of learning [3].

The implementation stage theory of didactic situations in a design of a didactic situation as follows [9]:

3.1.1. Phase 1. Teachers give problem / situation. In phase 1, the teacher gives a situation / problem to students as a game rules. A common situation is not intended to merely involve joint action between teachers and students as stipulated by the contract didactic, but associated with a given set of material and institutional contexts that affect classroom interaction [7]. Books, worksheets and other media to communicate and representativeness, is an example of setting material. Meanwhile, various habits, such as communication, is an example of the institutional context. Secondly it is in TDS referred to as the milieu namely 'all the things that act to the student or anything where students act against something' [7].

3.1.2. Phase 2. Students in the group performs. The second stage, students undertake action against the situation chosen by the teacher. In this stage, the students together in a group seek to find ways to improve their actions in order to more easily achieve the goal of the game or the completion of a given problem. A didactical situation are provided for students to practice the rules of the game so that students can play in it [7]. Games in this adidactical situation primarily have a goal that is easily recognizable from the student's perspective. Provision apperception situation like this means that teachers give students the chance to explore based on its ability [7]. Brousseau refer to it as the devolution process, the teacher provided more flexibility for Shiva to reveal their knowledge when faced with a situation [7]. Through devolution, teachers and students talk about what is on the need for transformation of the situation 'layman' to the situation of 'community' in which certain people discuss and agree on something, such as a community of mathematicians [7]. Thus, devolution is a ladder or step for connection previous knowledge with knowledge in a learning experience. In the group of students to explore all their knowledge to solve challenges. In this case, the joint action of students in a group can bridge the students to gain new experiences. The situation of action provides a familiar and easy activities that are interpreted from recontextualization knowledge to recognize the shape of the game [7].

3.1.3. Phase 3. Stage formulations situation. At this stage the student jointly working to find ways to improve their actions in order to more easily achieve the goal of a game or complete the problem chosen by the teacher. Students can find formulas, procedures or the rules of the game in accordance with the given didactic contract. At this stage, each student has the same opportunity to have a voice in the group. Social interactions that occur among students is expected to bridge the knowledge among students. The ability of students heterogeneous group into an advantage, because students with high ability is expected to provide assistance to the other student.

3.1.4. Phase 4. Stage validation situations. At that stage, the students were directed to develop consideration to the conclusions they make. In the final stage of this conceptual understanding are aligned in accordance with the discipline of science [7]. Situation validation involves the students to weigh whether these allegations constitute the main purpose of the game to see it in terms of mathematics. In addition, series of reflections made at this late stage is directed back to the game that revealed how best to win the game [7]. The results of the performance of students in a group can be accepted or rejected by the other students. But in their group all students have the same view on the issue is given so they can discuss their strategy. The hypothesis that they agree to become a theorem. In understanding the situation are chosen, students sometimes get the wrong perception theory, validation situations lead them to reconsider their understanding of the concept. At this stage, the teacher's role is very important to anticipate errors students' understanding of a particular theory.
Ignorance or doubt the students in understanding the situation is a cause of anxiety in students. The existence of the validation process of the teacher can ensure that they use the right strategies. In this case the fault is the basic point in the process of constructing new knowledge. At this stage, it is required of teacher competence in explaining the correct concept. Wilson states that have a good understanding and knowledge of mathematics, as well as their confidence in their competence is a basic requirement for a teacher in the teaching of mathematics [10].

HLT alternatives developed in this study are as follows:

![Diagram of Arithemtic to Algebra Transition]

**Figure 2.** HLT is an alternative to learning the concept of algebra

### 3.2. Experiment

This HLT is tested to 10 8th grades junior high school who divided into 3 groups. Group 1 consists of 3 female students with the initials AAL, AUH, and DR, group 2 consisted of 3 female students with the initials of the NAO, NS and WPE, and Group 3 consisted of 4 male student with the initials MPM, MRI, EA and MLA. HLT In the trial, researchers started learning by giving the concept of algebra problems. Students sit in a line with a group already divided. The concept of class atmosphere like the letter U, which aims to facilitate student interaction and atmosphere more comfortable learning environment. Students are given the freedom to explore his thinking in solving a given problem. Group discussions occurred during the trial HLT. Some symptoms of anxiety that may be identified in 10 subjects during the experiment HLT can be seen by the following table:

| Indicator Anxiety | Identify Anxiety |
|-------------------|-----------------|
| 1. Very Cautious  | Students seemed too cautious task by slow and very neat, he seemed afraid to take risks. In addition she has difficulty and not being able to solve mathematical problems that require thinking rather complicated and requires creativity in answering. |
| 2. Solving complex problems with extremely slow. | Students have difficulty in solving math problems. He seemed to have trouble to look at alternatives or develop a plan to solve the problem-solving in sentence form |
| 3. Expectations exceeded the ability of | the student may always expect to do well in math in school, but their ability in mathematics is far from what was expected. |
| 4. Too scared wrong or fail. | Students are afraid to make mistakes in answering the questions. |
Indicator Anxiety | Identify Anxiety
---|---
5. Physical symptoms | Students display physical symptoms such as hair pulling, cold sweats, and often took a deep breath during the course.
6. Avoiding feedback from environment | Students looking dreamy when studying math, maybe he worried about his math work. This way he used to restrain feeling less confident about the results of his mathematical work.
7. Dependency | There are students who always asked and seemed to cling to the teacher and always ask if the answer he was doing correct math, is a hallmark of student dependence.
8. Avoiding feedback from environment | Students show danger and haste to answer or finish the job.
9. Behavior to avoid | There are students who tend to avoid the problem is given, and not do it is an indicator that they experience math anxiety.
10. Less self-respecting | Students' statements such as “I will never get high marks in math” or “I can’t do maths” shows a lack of self-esteem.
11. The behavior of compulsive | behavior is a student compulsive behavior that is not related to the duties and may direct such negative actions of someone who

Anxiety level of students based on observations, questionnaires, and interviews researcher with the research subjects are as follows:

**Table 2. Anxiety Category**

| Initial subject | Number of indicator appears | Category |
|---|---|---|
| AAL | 3 | Low |
| AUH | 9 | Medium |
| DR | 8 | Medium |
| NAO | 6 | Medium |
| NS | 10 | High |
| WPE | 4 | Medium |
| MPM | 4 | Medium |
| MRI | 5 | Medium |
| EA | 7 | Medium |
| MLA | 11 | High |

**Table 3. Percentage of Mathematics Anxiety Level**

| Category | Percentage |
|---|---|
| Low | 10% |
| Medium | 70% |
| High | 20% |

3.3. Retrospective Analysis

HLT in this research is the implementation process of learning that is guided by an instrument in a learning design that can be broken and repaired during the research process runs [11]. In designing learning activities need to be known picture of students’ thinking regarding the material studied. In this study, HLT is used as a guide in the learning process in which the HLT may develop in the time trial and the trial design initial didactic teaching. The goal is to determine the extent of actual learning trajectory and the trajectory of learning that had been predicted earlier.
When teachers understand the pattern of the natural levels in the process of thinking and learning activities are structured in it, then the teacher of teachers has been exploring a child's ability to learn mathematics is appropriate and effective. Activities designed a simple but enjoyable for students. Students are expected to be confident in solving a given problem. They are also expected to discuss with zealous in their small groups. Their neighbors to help each other also gives an understanding when there are friends who do not understand. When asked to present the results of their respective groups, they race to move forward classes. After each group presents the answer, it is expected to do a class discussion to discuss a given problem.

Based on the HLT field trial, identified the student anxiety toward mathematics. There are two students are on a high level, 7 people at moderate levels and 1 student at a low level. Based on the percentage of students' mathematics anxiety levels, it appears that in general the students have high anxiety levels about 20%, was approximately 70% and approximately 10% lower. Students with low anxiety level and being able to move at a high level. This movement can be influenced by students' learning environment and learning situations designed by the teacher. There are three main domains affect math anxiety, the social/motivational domain, Intellectual/domain Educational and psychological / emotional domain [12]. Further findings during the experiment HLT can be used as an evaluation and reflection for designing materials that can anticipate students' mathematics anxiety. The HLT will be revised to be optimal anticipation of mathematics anxiety.

4. Conclusion
The transition process of thinking or thought process of transition from arithmetic to algebra caused difficulties in students. Difficult to understand the concept of algebra cause anxiety in students. Moreover, the interaction between teachers and students often cause anxiety in students. To help students overcome this difficulty, teachers need determines the trajectory of students in algebra in order to design a learning scenario/HLT to achieve the learning competencies that will be achieved. Teachers can provide strategies, methods, or models of appropriate learning so that students do not have difficulty in passing through this transition period. Teachers can help students overcome the difficulties experienced by students by providing the necessary assistance so that students can pass this transition well.

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