Spatial ability of slow learners based on Hubert Maier theory

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Abstract. Slow learners are children who have low learning achievement (under the average of normal children) in one or all of the academic field, but they are not classified as a mentally retarded children. Spatial ability developed according to age and level of knowledge possessed, both from the neighborhood and formal education. Analyzing the spatial ability of students is important for teachers, as an effort to improve the quality of learning for slow learners. Especially on the implementation of inclusion school which is developing in Indonesia. This research used a qualitative method and involved slow learner students as the subject. Based on the data analysis it was found the spatial ability of slow learners, there were: spatial perception, students were able to describe the other shape of object when its position changed; spatial visualisation, students were able to describe the materials that construct an object; mental rotation, students can not describe the object being rotated; spatial relation, students can not describe the relations of same objects; spatial orientation, students were able to describe object from the others perspective.

1. Introduction

The concept of children with special need has a broader meaning and spectrum compared to the concept of exceptional children [1]. Slow learners are one of the children with a special need who are doing poorly in school, yet are not eligible for special education. Slow learners are categorized as stupid students (borderline mentally retarded). The characteristics of slow learners are slower to catch on to whatever being taught if it involves symbolic, abstract or conceptual subject matter [2].

A slow learner is one of the children with a special need who is very possible to learn by using the curriculum imposed on normal children. Curriculum in inclusive schools requires some modifications based on the slow learners learning needs. To make some modifications to learning in inclusive schools, especially in geometry learning process, it is important for teachers to know the spatial ability of slow learner. Learning geometry gives many benefits to students. It strengthens the development of deductive thinking and reasoning, and it also provides an opportunity to improve visualization and spatial ability.

Spatial ability has an important role in supporting the development of student’s ability in mathematics, students with good spatial ability have better mathematics learning achievement than their peers who have low spatial abilities [3]. There are several definitions of spatial thinking, but it is
not easy to define it [4]. This study refers to the definition of spatial thinking by NRC states "Spatial thinking is a collection of cognitive skills. The skills consist of declarative and perceptual forms of knowledge and some cognitive operations that can be used to transform, combine, or otherwise, operate on this knowledge. The key to spatial thinking is a constructive amalgam of three elements: concepts of space, tools of representation, and processes of reasoning" [5]. Elements of spatial ability based on Hubert Maier theory are spatial perception, visualization, mental rotation, spatial relation, and spatial orientation. The first element, spatial perception require the location the horizontal or the vertical in spite of distracting information. The second element, so-called visualization, comprises the ability to visualize a configuration in which there is movement or displacement among (internal) parts of the configuration. The third element, mental rotation involves the ability to rapidly and accurately rotate a 2D or 3D figure. The fourth element, spatial relation means the ability to comprehend the spatial configuration of objects or parts of an object and their relation to each other. The last element, spatial orientation require a person's orientation in any particular spatial situation, and spatial orientation is the ability to orient oneself physically or mentally in space [6].

Spatial ability is a human qualification which is relevant to a high degree of our lives. Several studies and metaanalysis showed that in school, spatial skills could be used in many mathematical tasks. Obviously spatial abilities are used in a wider range than just for solving geometrical exercises, e.g., Chemistry, biology, and physical education success based on spatial abilities. As well as in school we also profit from a well developed spatial ability in professional life [7].

In mathematics, there are so many topics such as algebra, logic, calculus, and geometry [8]. The correlation between spatial ability tests involving visualization and spatial orientation with mathematics showed that there was a high correlation between spatial abilities and mathematical scores when it compared to verbal and reasoning tests [6]. Spatial ability had a positive correlation with high-level mathematical concepts, but less related to the acquisition of low-level mathematical concepts such as counting [8].

Many studies about spatial ability have done in math, but most studies were conducted for seeing spatial ability of normal students. Whereas, the study only concerned in spatial ability from many theories of psychology [9]. This study aimed to compare mathematics skills and psychology concept of slow learners students in junior high school, to know spatial ability of slow learners based on Hubert Maier’s space theory and to analyze factors which influence spatial ability of slow learners.

2. Methods
This research was conducted at one of the first secondary school in Surakarta which carried out inclusive studies. The subjects in this research were four slow learner students in Modern Islamic Junior High School Surakarta who were selected by using purposive sampling.

This qualitative study consisted of four procedures. Firstly, researchers did an observation of learning process by documentation and interviews how teacher do mathematics learning in inclusive school and made predictions of the importance of research. Secondly, collected data by using task-based interview based on Hubert Maier theory. Thirdly, analyzed the data by reducing and presenting data. Fourthly, made conclusions.
3. Result and Discussion

Task-based interviews were conducted on slow-learner students who attended regular school lessons. The discussion was based on each aspect of spatial ability on Hubert Maier's theory.

The first aspect was spatial perceptions; slow learners were able to describe other forms of an object geometry that changed its position according to the rules of change as well. Slow learners were able to mention four correct answers of water surface position from five presented problem. For every problem that was answered correctly, slow learners were able to explain the exact reasons. One problem that was answered incorrectly was in Figure 1. Slow learners chose option B. The reason for choosing option B was when the position was changed; all objects on the surface of the water would be changed. However, based on the assessment guidelines, if slow learners answered more than three questions correctly then it was said that they have a good spatial perception.

In the object column, there is given a picture of water in a glass which is placed a boat toy. Which one the correct answer of pole position of the boat?

|   | A | B | C | D | E |
|---|---|---|---|---|---|
|   | ![Image of water in a glass with boat](image1.png) | ![Image of water in a glass with boat](image2.png) | ![Image of water in a glass with boat](image3.png) | ![Image of water in a glass with boat](image4.png) | ![Image of water in a glass with boat](image5.png) |

Figure 1. Example of presented problem of spatial perception

The second aspect was visualization; slow learners were able to describe the shapes that construct a geometry object well. Slow learners were able to mention four correct answers of shapes that construct geometry objects from five presented problems. For every problem that was answered correctly, slow learner students were able to explain the exact reasons. One problem that was answered incorrectly was in Figure 2. Slow learners chose option C. The reason for choosing option C was the base of the geometry object is parallelograms shown in the Figure 2, the student were not able to imagine the true object which had presented. However, if slow learners answered more than three questions correctly then it was said that they had a good spatial visualization.

What kind of paper is needed to cover the following wire frames?

|   | A | B | C | D | E |
|---|---|---|---|---|---|
|   | ![Image of wire frame with paper](image6.png) | ![Image of wire frame with paper](image7.png) | ![Image of wire frame with paper](image8.png) | ![Image of wire frame with paper](image9.png) | ![Image of wire frame with paper](image10.png) |

Figure 2. Example of presented problem of spatial visualization
The third aspect was a mental rotation, and slow learners cannot determine which geometry object had been rotated against the certain axis. Slow learners were not able to answer correctly all of five presented problems which were related to the geometry object that changed position due to the rotation. One of the presented problems is in Figure 3. Slow learners said that they could not imagine the object presented. Thus the slow learners have a poor mental rotation.

![Figure 3. Example of presented problem of mental rotation](image)

The fourth aspect was a spatial relation; slow learners cannot describe the relationship between geometry objects which had same characteristics. Slow learners were not able to answer correctly all of five presented problems which were related to geometric objects that had similar characteristics. One of the presented problems was in Figure 4. Slow learners said that all objects in the options were identical to the presented problems. Thus the slow learners had poor spatial relations.

![Figure 4. Example of presented problem of spatial relations](image)

The fifth aspect was the spatial orientation; slow learners were able to determine the object of geometry from another perspective. Slow learners were able to answer correctly three of five presented problems which were related to the object geometry from a different perspective. For every problem that was answered correctly, slow learners were able to explain the exact reasons. Two problems were answered incorrectly are in Figure 5 and Figure 6.
Which image is not the view of the beam image in the object column if it is seen from a different point of view?

| O | A | B | C | D | E |
|---|---|---|---|---|---|
| ![Image](image1.png) | ![Image](image2.png) | ![Image](image3.png) | ![Image](image4.png) | ![Image](image5.png) | ![Image](image6.png) |

**Figure 5.** Example of presented problem of spatial orientation

In Figure 5, slow learners select option C with the reason that in option C there were two squares that juxtaposed, whereas one side of the object requested was a rectangle.

Which image is not a view of the pentagonal perpendicular penth image on the object column if it is viewed from a different point of view?

| O | A | B | C | D | E |
|---|---|---|---|---|---|
| ![Image](image7.png) | ![Image](image8.png) | ![Image](image9.png) | ![Image](image10.png) | ![Image](image11.png) | ![Image](image12.png) |

**Figure 6.** Example of presented problem of spatial orientation

In Figure 6, slow learners selected option B with reason that the base of the pyramid did not appear to have a line. However, if slow learners answered more than three questions correctly, it was said that they had a good spatial orientation.

The spatial ability of the slow learners was influenced by internal and external factors [2]. The internal factors were seen from the characteristics of a slow learner, mentions the characteristics of slow learner were limited cognitive capacity, poor memory, distraction and lack of concentration, and inability to express ideas [11]. Inability to express ideas, whereas, in problem-solving of geometry as in Figure 3, students were asked to imagine and determine the object of geometry which was rotated against a certain axis, slow learners were able to imagine the object but cannot show the idea of the shadow to answer the problem correctly. Slow learner had low concentration ability, as in Figure 4, slow learners assumed that all presented objects were identical, but if it was observed with high concentration, the object was different.

The external factors were based on residential environments and formal education. The family had an important role in the development of children's abilities, one of the abilities was spatial ability. The family had a role in increasing the slow learner motivation in solving the problem because the characteristics of slow learners were slower to catch on whatever being taught if it involves symbolic, abstract or conceptual, and subject matter [10]. Learners education, action, and commitment, was used to accommodate the learning needs of the slow learner, and it could be regarded as one form of support for the paradigm of inclusive education in schools.

4. **Conclusion**
The spatial ability of slow learners based on Hubert Maier's theory showed good results on aspects of spatial perception, visualization, and spatial orientation. The results were poorly indicated in the mental aspects of rotation and spatial relationships. Teachers as educators need to develop the design of learning with various approaches as a means of mediating slow learners difficulties in learning process.

Characteristics of slow learners in learning and coordination become the basis for the development of learning process. Education for slow learner should be implemented in public schools with adjustment of learning method. The inclusion model is an implication in the handling of learning for slow learners.

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