The teachers ability and response concerning Spatial Orientation

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Abstract. This paper examined the profile of secondary school mathematics teachers about spatial orientation. Participants in this study were 20 secondary school teachers who participated in a mathematics learning workshop related to designing a floor plan. Usually, the teacher conducts weekly or monthly meetings through the group of mathematics teachers in Banda Aceh, Indonesia. The teachers were given a spatial orientation test before and after the workshop, four of them were interviewed. The data obtained were analysed descriptively. The results showed that there is an increase in the teacher spatial orientation ability score after the workshop. The findings also reported some teachers had difficulty in solving the spatial orientation problems because they were not familiar with determining the direction. In addition, most teachers agreed that spatial test is necessary for the students despite their concern about the time constraint. Thus, we suggest utilizing technology to overcome such an issue.

1. Introduction

Spatial thinking is paramount for scientific ideas, such as in representing and manipulating information in learning and problem-solving [1,2], creating and reading maps, planning routes, designing floor plans, and art creation [3]. Also, it is necessary to solve various tasks related to engineering, design, physics and mathematics [2,4]. Students who are good at solving spatial-related problems are likely to have a high mathematics performance [5]. Previous studies reported that high-ability visuospatial working memory correlates to strong abilities concerning numbers [6] and mathematics performance in general [7].

In relation to spatial thinking, the ability to maintain a sense of direction and location while moving into the environment is a fundamental cognitive function. The spatial ability benefits the ability of the use of space [2] or related to the skills in representing, transforming, generating and recalling symbolic non-linguistic information [8]. Further, spatial navigation is defined as the process of utilizing “multiple cue sources such as path integration, magnetic cues, landmarks, and beacons to determine the route to a goal and then travel that route” [9]. Spatial navigation skill can be trained using representation, such as maps and diagrams.

Spatial ability was defined as “the ability to formulate mental images and to manipulate these images in the mind” [10]. Spatial ability is influenced by three major factors, including spatial visualisation, spatial orientation, and mental rotation/spatial relations. Spatial visualisation is the
ability to comprehend imaginary movements in a 3D or the ability to manipulate objects in imagination; spatial orientation is the awareness of whether one object is to the right or left, higher or lower or nearer of farther than another; and mental rotation/spatial relations is the ability to rotate a spatial object as a whole fast mentally and correctly [11]. Students have difficulties in solving spatial problems [12], including in Indonesia [13].

Spatial training is necessary for teachers to ensure that they can equip their students with spatial ability. However, Indonesian mathematics curriculum does not focus on spatial, as indicated in the kompetensi dasar (basic competence) and kompetensi inti (basic competence) in the curriculum 2013 [14]. Thus, high school mathematics textbooks consisted of limited spatial problems in. The absence of spatial problems in textbooks may lead to teachers being hesitant in including this topic in their classroom. Moreover, textbooks highly influence teachers teaching because they guide teachers in decision-making in choosing teaching materials and strategies [15,16].

Some studies related to spatial ability have been previously conducted, such as [5,9]. However, studies related to the spatial ability of teachers in Indonesia, in particular, Aceh, are limited. Therefore, this study investigated the teachers' pre-and post-training spatial ability as well as examined their responses concerning the spatial problems administered. Specifically, this study addressed the following research question: 1) How is the improvement of the teacher's spatial orientation ability after the workshop?, and 2) How are the teachers' response towards the use of the figure in spatial orientation tests?.

2. Method
Participants of this study were 20 secondary school teachers who participated in a mathematics learning workshop related to designing a floor plan. The teachers were given a spatial orientation test before and after the workshop. The pre-test consisted of eight questions adopted from Hegarty [17]. The post-test questions were also adapted from Hegarty [17], with some modification by placing many objects on the house plan. The figure for house plan used in the post-test was taken from one of the teachers' work during the workshop. Figure 1a is the example of the pre-test question, and Figure 1b is the example of the post-test question.

Figure 1. Pictures used as a basis for questions in the tests and questionnaire.
To assess the teachers’ responses concerning the spatial orientation ability test, an open questionnaire consisting of three questions was administered to the teachers. The questions included: 1) Are the spatial tests difficult for you? 2) Which figure [between Figure 1a and Figure 1b] do you find more interesting? Explain!; and 3) Do spatial tests need to be given to students?. Furthermore, the researchers conducted an informal interview with the two teachers who got the low post-test score. The data were then analysed descriptively.

3. Results and discussions

3.1. Improvement of the teachers’ spatial orientation ability
In this subsection, teachers’ tests results are presented to examine the improvement in their spatial orientation skills before and after the intervention (the workshop). Figure 2 presents teachers’ spatial orientation test scores in the pre-test and post-test.

![Figure 2](image)

**Figure 2. Teachers’ pre-test and post-test score**

The maximum score for the pre-test and post-test was 8, and the teachers’ mean score for pre-test and post-test were 5.2 and 6.4 respectively. Figure 2 showed that only 9 out of 20 participants had above average pre-test scores. Concerning the post-test scores, more than half of the participants (55%) had above-average scores. Furthermore, looking at the scores improvement of each participant, 17 participants had an increasing grade, while the other three had steady scores. Based on the descriptions, then it can be concluded that the teachers have improved their spatial orientation ability after the intervention.

Both in the pre-test and post-test, the participants had to answer eight questions related to the spatial orientation. Using the picture in Figure 1 (Figure 1a for pre-test and Figure 1b for post-test), the participants should draw the position of some places/rooms if they were in a certain place/room. Figure 3 presents an example of post-test questions. Based on the informal interview with some teachers who had a low score, it was found that their low score due to their unfamiliarity with such questions. They were not familiar with problems where they should visualise objects based on the observer point of view.
Imagine you are standing at the clothesline and facing the bed. Point (through the picture) to the table.

**Figure 3.** Example of post-test question.

3.2. Teachers’ responses concerning the spatial orientation ability test

Teachers' responses to the questionnaire are as follows.

3.2.1. Teachers’ responses to the difficulty of the questions. Regarding the first question, most of the teachers (12) stated that the tests were easy. One of the reasons was because it was interesting as it related to daily life. The other teacher said that the tests were not difficult if they had already understood about a compass and only needs accuracy to solve the test problem. On the other hand, the other four teachers said that the tests were difficult if they did not understand the prerequisite concepts about the line, angle and wind direction.

One teacher said that at first it was difficult for her to solve the spatial orientation test because she has to imagine the position of objects from different point of views. Furthermore, she had to think about the angle. However, after joining the workshop conducted by the researchers, she became more familiar with the type of test, and she found it become easier to solve.

3.2.2. Teachers' responses to the figures on the tests. The open questionnaire revealed that 12 teachers were more interested in Figure 1a. They stated Figure 1a was more interesting, clearer, often found in everyday life, and easier to understand. Other six teachers who were more interested in Figure 1b reasoned that the picture was more specific, more interesting and more directed. However, two teachers said that the two pictures were equally interesting. Figure 1a was suitable for the pre-test, and Figure 1b was suitable for the post-test after they learned about the spatial orientation. Considering that the teachers’ reasons, the researchers argued that both type of figures should be used in the spatial orientation test, in order to accommodate all preferences of the students.

Teachers’ responses to the importance of the spatial orientation test. Some teachers argued that they could not give the tests to their students because it is time-consuming. They have already preoccupied with the demands of the Indonesian curriculum as regulated in Permendikbud 2016, and the curriculum does not focus on the spatial ability [14]. This is in line with the statement by Whiteley, Sinclair, and Davis [18] who also claimed that despite the important role of spatial reasoning for human action and thinking, it is not necessarily identified or supported in schooling. However, almost all teachers (15) agreed that spatial orientation test is necessary for students to increase students’ reasoning related to direction and distance of places. This is in line with Diezmann [19] stated that spatial skills are important, along with the rapid change of the modern world.

Considering the overall reasons for the teachers, the researchers argued that students' spatial orientation ability is important to be tested and trained, and we should overcome the obstacles concerning time constraint. One way is to embed the spatial training with the learning, for example, Cohen [20] suggested the ability could be trained using interactive animation and virtual solids in geometry learning.
4. Conclusions
To sum up, this study found that teachers' spatial ability was improved after the intervention (the workshop), as indicated by the differences between pre-test and post-test. Some teachers reported having a low score in the test due to their unfamiliarity with the problems presented. Initially, the teacher found that the problem was quite challenging, however, after the workshop, they were more confident in addressing similar questions. Overall, teachers agreed that spatial test is necessary for teacher found that the problem was quite challenging, however, after the workshop, they were more confident in addressing similar questions. Overall, teachers agreed that spatial test is necessary for the issue related to time constraint. Thus, we recommend the integration of technology in teaching and learning to overcome the issue related to time constraint.

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