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Investigating students' spatial ability in the context of cultural differences

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Abstrak: Kultur dipercaya menjadi salah satu faktor yang mempengaruhi pembelajaran matematika. Hal tersebut mendukung berkembangnya ide pendidikan matematika responsif kultur. Penelitian kualitatif ini bertujuan menginvestigasi kemampuan spasial siswa dan kemungkinan keterkaitan perbedaan kultur (pola asuh) dengan kemampuan spasial siswa. Data penelitian diperoleh melalui angket, tes kemampuan awal, tes kemampuan spasial, dan wawancara. Penelitian dimulai dengan identifikasi kultur siswa yang berasal dari dua desa berbeda, yaitu desa Lalar Liang (LL) dan Labu Lalar (LB), melalui angket dan pemberian tes awal untuk klasifikasi kemampuan siswa. Selanjutnya, enam siswa dipilih sebagai subjek dari dua kultur berdasarkan kelompok tinggi, sedang dan rendah untuk diberikan tes penalaran spasial. Pada tahap terakhir, subyek terpilih diwawancarai untuk mengidentifikasi kemungkinan hubungan kultur dengan kemampuan spasial. Hasil tes siswa dianalisis sesuai dengan indikator kemampuan spasial dan dikaitkan dengan pola asuh siswa dari dua desa tersebut. Hasil penelitian menunjukkan bahwa siswa yang berasal dari desa LL lebih mampu memahami dimensi bangun dari berbagai sisi dan perubahan bentuk benda setelah dirotasi, dibandingkan pada siswa yang berasal dari LB. Hasil wawancara mengindikasikan adanya pengaruh pola asuh terhadap pola pikir siswa dalam menyelesaikan masalah matematika. Tetapi, hal ini perlu dibuktikan melalui kajian yang lebih mendalam secara empiris.

Kata kunci: *Kemampuan spasial, Perbedaan budaya, Pola asuh, Pembelajaran matematika*

Abstract: Culture is believed to be one of the factors that influence mathematical learning. It supports the idea of culturally responsive mathematics education. This qualitative study aimed to investigate students' spatial abilities and the possible linkages of cultural differences (parenting) with the abilities. Data were collected through questionnaires, initial ability tests, spatial ability tests, and interviews. The study began with the identification of the students' culture from two different rural areas, namely Lalar Liang (LL) and Labu Lalar (LB), using a questionnaire, and a preliminary test was administered for the classification of students' mathematical abilities. Furthermore, six students were selected as subjects from the two cultures based on the high, medium, and low groups to be given a spatial reasoning test. In the last stage, the selected subjects were interviewed to identify the possible relationship between their culture and spatial ability. The students' answers were analyzed according to the indicators of spatial ability and linked to the culture of students from the two areas. The findings show that students from LL have a better understanding of the dimensions of objects from various sides and the changes of the object shapes after rotating than from LB. The results of the interview indicated that there was a possible relation of parenting on students' thought patterns in solving mathematics problems. However, this needs to be proven by further empirical studies.

Keywords: *Spatial abilities, Cultural differences, Parenting, Mathematical learning*

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A. Introduction

Culture can be defined as beliefs, values, attitudes, customs, social relations, arts, and literature that define an ethnic group (d'Entremont, 2015). In the context of education, Gea (2011) explains that cultural socialization influences public perception about education. In fact, student culture is believed to be one of the factors that influence mathematics learning (Greer et al., 2009). Malloy and Malloy (1998) also explicate that children receive the first mathematics learning in the home culture, which then extends to the community. After that, their culture will represent the various cultures in the community. When children start school, they adapt to the school culture and fields of knowledge.

Culture influences individual behaviors (Aponno, 2017) and plays a vital role in the development of individual understanding, including mathematics learning (Muslimahayati & Wardani, 2019). Cultural factors form a social environment reflected in the patterns of parenting towards children and children's interactions with the surrounding environment (Gea, 2011). Some experts (Brooks, 2006; Santrock, 2007; Kozleski et al., 2008) argue that parenting can be influenced by culture, ethnicity, and socioeconomic status, as well as the social institutions in which children are raised. Several studies (e.g., Li et al., 2019; Kurniawan & Wutsqa, 2014) unravel the influence of parental involvement on academic performance, which has an impact on students' cognitive abilities. Other findings (Tsui, 2005; Colomeischi & Colomeischi, 2015) also show how parental involvement has positively affected students' attitudes and mathematical achievement.

The role of culture in (mathematics) education and multi-cultural classrooms support the development of culturally responsive mathematics education. Empirically, the implementation of culture supports the effectiveness of learning mathematics. Prior studies (McLeod, Lobel, & Cox, 1996; Vezzali et al., 2016; Bouncken, Brem, & Kraus, 2016) found that classes have students with two different cultural backgrounds (bicultural) are more creative than homogeneous classes. In addition, the performance of bicultural students was more innovative at work.

Several studies link culture and mathematics learning (e.g., Kusaeri, Pardi, & Quddus, 2019; Susanti et al., 2020). The studies found that mathematics learning associated with local culture supported students' understanding of mathematical concepts even though the cultural products were just used as the learning media. Also, other research (Aguirre & Zavala, 2013; Quintos, Civil, & Bratton, 2019) examined the relationship between parenting styles and students' academic abilities, especially mathematics. Parents are seen as intellectual resources whose experiences and ideas support their children learn mathematics (Civil, 2002).

In mathematics, spatial abilities have a vital role in supporting students' achievement, especially in geometry and students' creativity in solving various mathematical problems as well (Tam, Wong, & Chan, 2019; Tikhomirova, 2017; Gilligan, Flouri, & Farran, 2017). In addition, spatial abilities also encourage students to create different contexts and generalize concepts (Guzel & Sener, 2009). Several studies also claim that there is a close relationship between spatial ability and mathematical reasoning (Ramful, Lowrie, & Logan, 2017). Three aspects of spatial abilities are (1) Spatial Orientation (SO), the ability to mentally determine objects from an egocentric perspective or from one's body view as a reference (observer); (2) Mental Rotation (MR), the ability to construct two or three dimensions shapes quickly and accurately; and (3) Spatial Visualization (SV), the ability to visualize a configuration where there is a movement or displacement in the part of that configuration (Lowrie et al., 2017).

Indonesia is one of the multi-cultural countries. In this context, students who learn mathematics in the schools come from diverse social and cultural backgrounds. By way of example, the school at which this study was situated consists of two main rural areas with two different cultures. The first is Labu Lalar (LB), a maritime rural area where the residents are immigrants from three tribes (Bugis, Bajo, and Sasak). Meanwhile, Lalar Liang (LL), an agrarian society, is inhabited by local people. This study investigated students' spatial abilities from the two rural areas with distinct cultures and a possible relationship between the abilities with cultural differences pertaining to parenting.

B. Methods

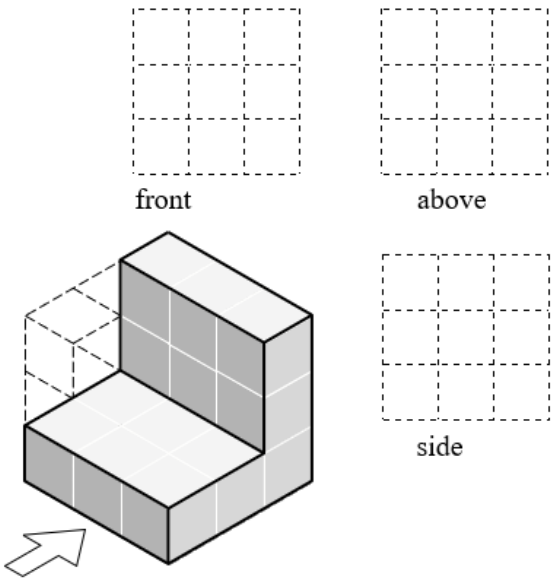
This study involved 81 eighth-grade students from LL and LB. In general, it was carried out in three stages: preparation, implementation, and analysis. In the first stage, we designed the research instruments in the form of tests, questionnaires, and interview guides. In the implementation, the students were given the questionnaire and test 1 (T1). The questionnaire was aimed at identifying the students' social-cultural backgrounds, especially about parenting styles based on the students' point of view; what the students feel and experience. For example, how parents respond when students' grades drop, how they pay enough attention to their children's learning process while at home and at school, and do they provide rewards for the children's achievement. The information from this questionnaire was employed as a starting point in the interviews and a comparison tool to the results of the interview with the selected participants. T1, problems about the area of planes, was used to classify students' mathematical abilities in three groups (low, medium, and high). We intended to contrast students' mathematics abilities as the results of T1 with their spatial abilities.

We purposively chose six participants; LB1 (student with high abilities from LB), LL1 (student with high ability from LL), LB2 (student with medium ability from LB), LL2 (students with medium ability from LL), LB3 (student with low ability from LB), and LL3 (student with low ability from LL). They were given test 2 (T2), a spatial ability test (Figure 1, Figure 2, Figure 3). It comprises three problems referring to the indicators of spatial ability; Spatial Orientation (SO), Mental Rotation (MR), and Spatial Visualization (SV). Each problem is made up of six pictures. The SO test requires students' reasoning. They were asked to describe the shape of a three-dimensional object from various points of view (front, top, and side). The MR test was a multiple choice where students determined the shapes of objects after being rotated according to the direction of rotation. Whereas in the SV test, the students were asked to determine the number of blocks and write the number on the tiles when viewed from the perspective of the upper side. After students worked on the test, a semi-structured interview was administered to further identify and understand the ways their parents educate them at the homes and how it might relate to their spatial abilities.

At the final stage, the students' works on the T2 were reduced by a mean of coding referring to the three aspects of spatial ability (Lowrie et al., 2017). The results of the interviews were verbatim transcribed. The transcripts were also coded to relate to the students' reduced answers in T2. To have a better sight of the data, we presented it in the form of variable-by-variable matrix as one of the explaining methods in qualitative data analysis (Miles, Huberman, & Saldana, 2014). The matrix primarily aims to identify interrelationships between variables. Students' works on the test and selected transcripts were placed in the row and column heading, respectively, in order to detect the possible connections between students' parenting background

with their spatial ability. Using the matrix, conclusions about students' spatial ability and its relation to cultural backgrounds were drawn and verified. In verifying the conclusions, investigator triangulation was carried out (Rothbauer, 2008). The authors were actively involved in data collection and data analysis.

A sample of each test is as follows.



Draw the shapes of the object from three views; front, above, and side!

Figure 1. Number 1 of the spatial orientation test

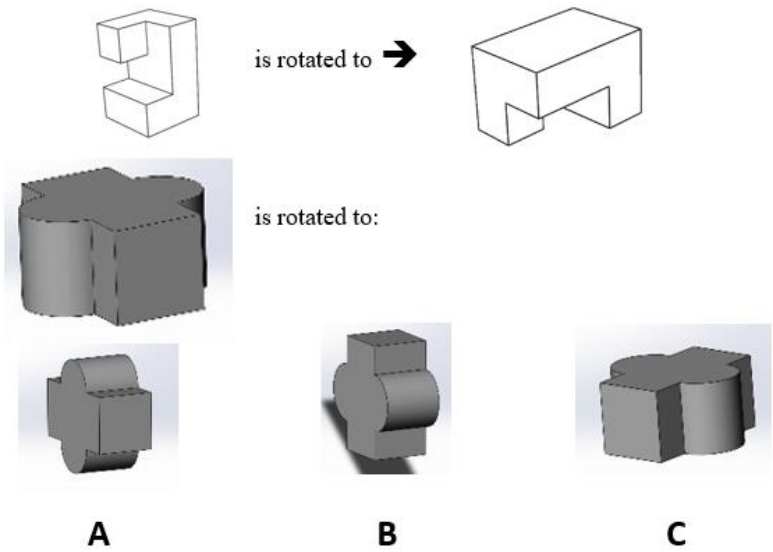
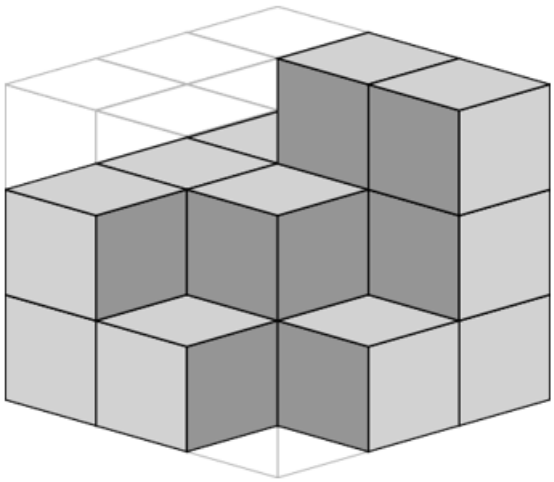


Figure 2. Number 1 of the mental rotation test



How many cubes in the figure above? Locate it on the tile as if you see it from above.

Figure 3. Number 1 of the visual visualization test

C. Findings and Discussion

In this part, we present students' results on each aspect of the spatial ability and excerpts of the interviews. Subsequently, the findings regarding students' spatial abilities and their possible connection to their cultural aspects of parenting will be interpreted and discussed.

Spatial orientation

Table 1 summarizes the results of the spatial orientation test. Some students' answers are also presented (Figure 4, Figure 5). There are differences in the students' results of the SO test from LB and LL, especially those with high and medium mathematics ability. Meanwhile, the students with low ability have a similar result. Overall, students from LL have better spatial orientation than those who come from LB.

Table 1. The summary of students' answers on the SO test

Subjects	No. 1			No. 2			No. 3			No. 4			No. 5			No. 6			The number of correct answers
	D	A	S	D	A	S	D	A	S	D	A	S	D	A	S	D	A	S	
LB1	√	√	√	x	x	x	√	x	x	x	x	√	x	x	x	√	x	x	6
LB2	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	0
LB3	x	x	√	-	-	-	x	x	x	x	x	x	x	x	x	x	x	x	1
LL1	√	√	√	√	√	√	√	√	√	√	x	√	√	x	√	√	√	√	16
LL2	√	√	√	x	x	x	x	x	x	x	x	x	√	x	x	x	x	x	4
LL3	x	x	x	x	x	x	x	√	x	x	x	x	x	x	x	x	x	x	1

(√) the correct answer, (x) the incorrect answer, (-) no answer
(D) front view, (A) top view, (S) side view

Mental rotation

Table 2 shows the summary of students' answers. Overall, in this test, LB students have higher average scores than LL students. The analysis of the students' steps used in answering

the test uncovers that some students from LB answered some of the questions by guessing without any mathematical thinking. They also claimed to be unsure of the answers given. In addition, their way of conveying the steps in answering questions was also less systematic. A different approach by LL students in dealing with the test, they tried understanding the intended rotation and paying deep attention to find the visual shape of the object after rotating it with the help of body gestures. Their steps in answering the test were systematic and correct, for example, rotating 90 degrees to the left.

Table 2. The summary of students' answers on the MR test

Subject	Answers						The number of correct answers
	A	C	B	A	C	B	
LB1	C	C	B	A	C	B	5
LB2	A	A	B	A	C	B	5
LB3	A	C	A	C	C	B	4
LL1	A	B	B	A	C	-	3
LL2	A	C	A	A	C	A	4
LL3	A	B	A	A	C	B	4

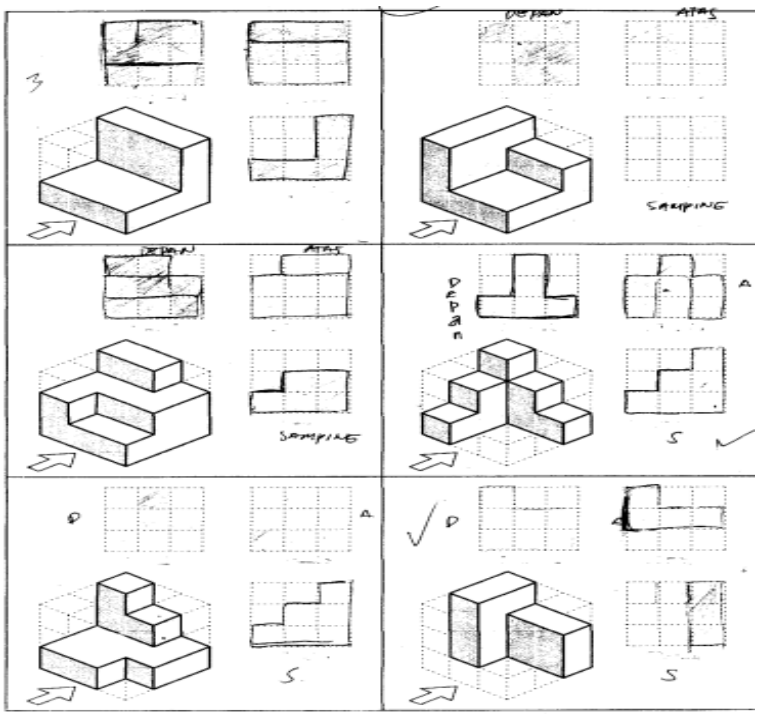


Figure 4. LB1's answer on SO items

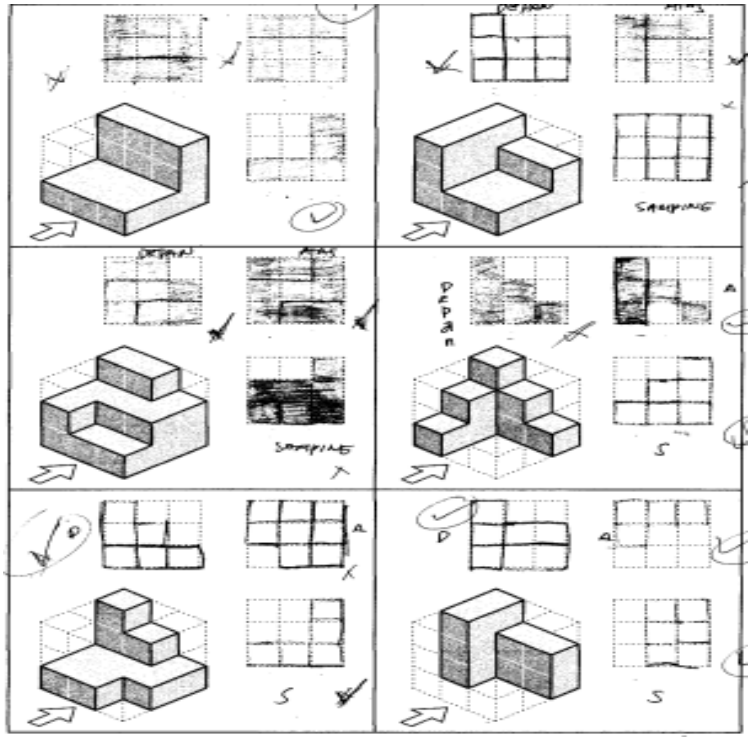


Figure 5. LL1's answer on SO items

Spatial visualization

Table 3 summarizes the results of students' answers for the spatial visualization test. Figure 6 and Figure 7 are presented to show some students' works. Table 3 reveals that only one LB student could answer one question correctly, while the other two had no correct answer. The students from LB Village still had difficulty determining the number of unit cubes (blocks) seen from the above perspective. It is clear that LL students have better SV than LB students.

Table 3. The summary of students' answers on the SV test

Subject	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	The number of correct answers
LB1	x	√	x	x	x	x	1
LB2	x	x	x	x	x	x	0
LB3	x	x	x	x	x	x	0
LL1	√	√	√	√	√	√	6
LL2	√	√	√	√	√	√	6
LL3	√	√	√	√	√	√	6

The interview results found that the parenting of LB students tends to be permissive, which was marked by the lack of parents' roles to support their children. Parents seem to have less control over their children. This is shown in the following excerpts of interviews between the researcher (R) and LB2 and LB3.

R : How do your parents educate you at home?
LB2 : My mother never scolded me. I was never strictly asked to study. My mother only reminded me to study when she saw I had never studied, but there was no need to study.

LB3 : My parents never scolded and reprimanded me even though I did not study. I am also allowed to play as I please.

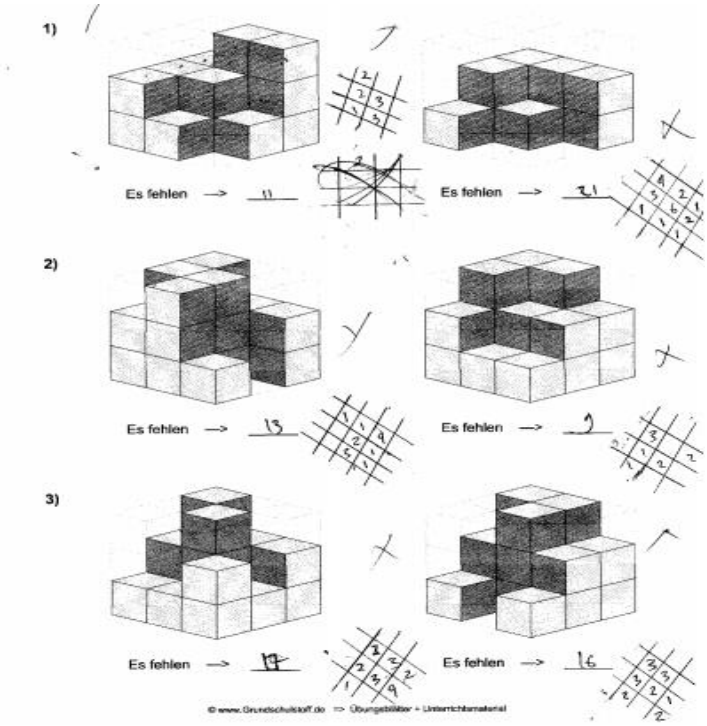


Figure 6. LB2's answer on SV items

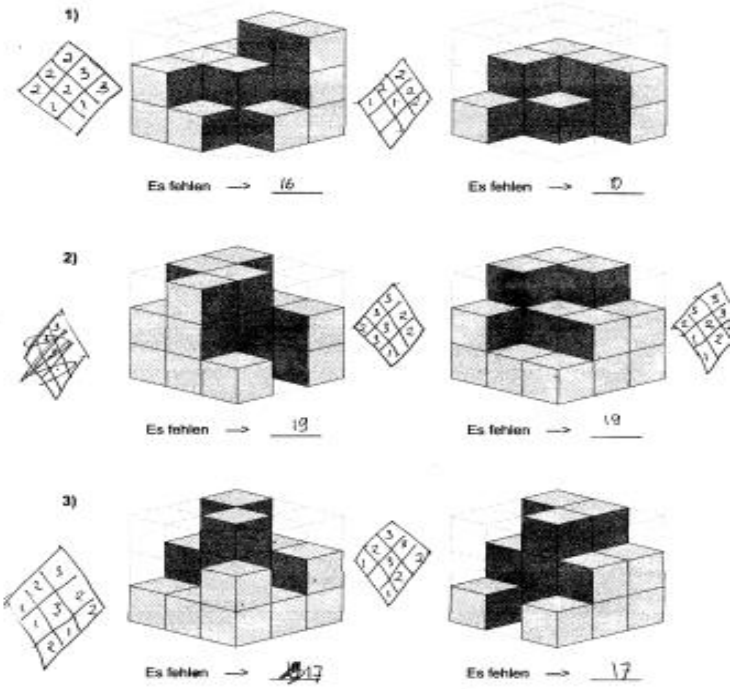


Figure 7. LL2 answer (SV)

In the family, there are not many rules to be followed, which limit children in certain activities, especially in learning. In addition, the parents also tend not to demand high

achievement from their children. This is possible considering their social background as a maritime society with a fishing profession and a highly dependent income on natural conditions. They have a low economic level in supporting children's academic activities. The lack of knowledge and level of education made these parents do not have high expectations for their children. In fact, they never reminded their child to learn, as directly admitted by the students through the following interview.

R : Do your parents always remind you to learn at home?
LB1 : Rarely
LB2 : Never. Everything is handed over to me.
LB3 : Never

The parents from LB have not been involved in helping their children when they have difficulty completing mathematics assignments at home. The students explain that their parents are not good at mathematics. In the end, these students do the assignment themselves or ask their friends to understand the problem and find a solution. This is evident in the following interview.

R : If you have difficulty solving the given math problems, what will your parents do to help you?
LB1 : They can't help. My parents don't understand math.
LB2 : They didn't do anything. I do it myself. Sometimes I ask my friends.
LB3 : My parents never know about my problems at school. Besides, my parents don't understand how to solve it. They do not have a sufficient understanding of mathematics.

This deficiency in parental involvement makes students less focused on learning. If parents continue to not take part, students will feel less confident, embarrassed to ask questions, careless, and tend to give up easily when faced with difficulties. In fact, from the results of the interview, one LB student also tried spending his time studying or doing homework even though it was only at night. If the parents pay a little attention and are actively involved in the children's learning process, it is not impossible for these children to make even better achievements. On the other hand, LL parents are more democratic and authoritative. They are actively involved in controlling children's daily lives and reminding them to learn (as evidenced by the following excerpts of the interviews), so that children's learning patterns are monitored. The LL students are given support and motivation when they encounter difficulties, which results in children being more confident, not shy about asking questions, and not giving up easily to find various problem-solving strategies.

R : Do your parents always remind you to study?
LL1 : My parents often remind me. They also sometimes accompany me when I study.
LL2 : My parents always remind me. Even if I have homework or not, they still ask me to study.
LL3 : My parents keep reminding me to study, but sometimes I am a bit stubborn and lazy to study.
R : If you have difficulty doing math problems, what will your parents do to help you?

LL1 : They buy mobile credit to use in finding answers on the internet. I can also use the credit to call the teacher to ask how to solve it.
LL2 : Sometimes they help me. But, if they can't help, they ask me to ask a friend or teacher.
LL3 : If the parents understand the problems given by the teacher, they will teach me. If not, they ask me to do it myself.

In this case, the parents become good friends with the students. They try understanding their children's learning need, giving advice if they make a mistake, and giving rewards when the child gets an achievement.

R : How do your parents educate you at home?
LL1 : My parents are rarely angry. I often tell them everything that I experience and feel. If I make a mistake, they advise and remind me to be careful in choosing my friends to play with.
LL2 : They do not allow me to play without knowing the time. They really support me in participating in all the positive activities at school. If I get good grades, I get a prize, or sometimes they just give me a compliment.
LL3 : They let me play with certain friends. If I make a mistake, they scold me but never hit me.
R : How do your parents respond when you get poor grades or your performance drops?
LL1 : They ask me the reason why my score drops then I am given the advice to improve it.
LL2 : They are not angry, but they advise me to study harder.
LL3 : My parents scold me and ask me to study hard.

Regarding the strategies used by students in solving the spatial ability test, LL students attempted to visualize all the problems to get the answers they wanted, while some students from LL admitted that they could not imagine and draw the desired answers so that they answer the questions given carelessly.

R : How did you solve the problems?
LB1 : I imagined first and then drew the answer. The multiple-choice problems (related to MR) were easier for me, while the problem of counting the number of cubes (related to RV) was a bit confusing for me.
LL1 : I imagined first and then looked for answers to the questions using my fingers as if I were rotating the picture. After that, I drew the answers I got.
LB2 : I could hardly imagine it. Moreover, drawing it, it's hard.
LL2 : I could just imagine, but I could not draw it. For me, the problem regarding rotation was very difficult, while the easy one was the problem of calculating cubes.
LB3 : I just did it carelessly.
LL3 : I was having a hard time. However, I tried imagining and drawing the result, even though I was still confused.

Based on the results of the spatial ability test, LL students' spatial orientation and spatial visualization are better than LB students. However, in mental rotation ability, LB students show higher achievement. The difficulty LB students found in the SO test is changing the perspective of three-dimensional shapes into two dimensions which are expressed into two-dimensional

images. The images made by LB2 and LB3 do not show an understanding of the perspective shape of the object being displayed. In the SV test, LB students were still inaccurate in predicting the number of tiles. They also had difficulty determining the position of the unit cubes on the tile from the point of view of the object. In contrast to LB students, LL students were able to determine the exact number of cubes and position the tiles from the perspective of the object. Both of these tests (SO and SV tests) require reasoning skills in which students can imagine shapes and draw their shapes again according to different perspectives. In the MR test, LB students could choose 4-5 correct answers from the six questions given, which is better than the results on LL students. After being confirmed through the interviews, LB students had speculative answers, while LL students tended to imagine three-dimensional shapes from various points of view and then re-drew them in two dimensions. However, these results indicate that the students' ability to determine the shape of a three-dimensional object when rotated still encountered many difficulties.

The difference in the achievement of LL and LB students possibly relates to the cultural differences, especially parenting. LL students who get the combination of democratic and authoritarian parenting tend to have better reasoning because of controlled and directed learning activities. In addition, the involvement of parents in assisting or directing children in decision-making and problem-solving strategies when working on the assignments from the teacher is very good. This encourages children to be responsible for their decisions so that children tend to be more careful and afraid to answer speculatively without being based on clear and systematic procedures.

On the other hand, LB students, who have permissive parenting, have difficulty in reasoning due to their less focused learning activities. They are accustomed to making their own decisions due to a lack of parental involvement. Their parents' treatment that does not hesitate to punish their children and their lack of appreciation for children has an impact on children who tend to do things carelessly and tend to be speculative. However, good results of MR test for LB students need teachers’ attention to be able to encourage and support their potential.

Regarding the relationship between the spatial ability test and cultural background (parenting), it is found that LL students who have high parental control over education and students' daily activities, including their learning activities, are able to be careful, thorough, systematic, not easy to give up, and more communicative when having difficulty (dare to ask) in doing spatial ability test questions. In contrast, LB students with permissive parenting background and very minimal parental control over education solve mathematics problems in these characteristics; careless, easily give up when encountering difficulties, and show no effort to use other strategies or ask questions. Even so, the relationship between the two variables is still our conjecture, and further research is needed to prove it empirically.

As a maritime community who lives in the coastal area, the livelihoods as fishermen that are dependent on the natural conditions form a dominant social environment that applies permissive parenting. In addition, motivation for education and involvement in managing their children's daily lives are considered low (Rahman & Yusuf, 2012; Mansyur, Umrah, & Rifal, 2019). If the children misbehave, the parents do not hesitate to give the children physical punishments. However, if children do what their parents want, no award is given because they think it is an obligation for the children to their parents (Wahyuddin, 2014). This makes children

less focused on learning and has an impact on how students solve mathematical problems given by the teachers. Moreover, children tend to give up easily because of a lack of motivation when they have problems that cannot be solved. They also have a fear of asking questions. For example, in this study, LB students who live in the coastal areas have difficulty when faced with spatial reasoning problems. This is reinforced by Wahyuni (2016) in her study that many students living in coastal areas have deficiencies in the aspects of mathematical reasoning and problem-solving. Similar findings were also obtained by Safitri (2018), where there are differences in learning achievement between students who come from coastal and urban areas.

Meanwhile, LL population, which are agrarian communities, lives as farmers, tends to adopt democratic and authoritarian parenting styles. They prioritize parenting with the aim of training children to be more independent, responsible, and they also always try to provide reasons why the rules are set (Maskulin, 2019; Nadia, 2015; Nair et al., 2020). This parenting style is also shown by the existence of parental control in daily activities, which causes children's learning activities to be more disciplined. The role of parents who are always there and accompanying children when they face problems causes children to be more confident, not easily give up, not ashamed to ask questions, and this has an impact on the ability of children to find ways to solve problems with various strategies. Oktarini, Suarjana, and Arini (2019) argued that parental involvement affects children's self-confidence and mathematics learning outcomes. Likewise, Park et al. (2010) emphasize that children with authoritarian parenting will be easy to obey, achievement-oriented, and self-control. Kordi and Baharudin (2010) found that children with authoritative parenting have higher achievement in school.

D. Conclusion

This study found the differences in students' spatial abilities from two different cultures (in this case, the parenting styles) who live in rural areas. LB students with permissive parenting backgrounds have lower spatial abilities when compared to LL students with democratic-authoritarian parenting. This is possibly affected by the ways the parents educate the students. However, these results still need to be further studied, which involve more students and sources of data. The findings of this study can be used as starting points for teachers in designing instructions that acknowledge the students' cultural backgrounds. The students with different backgrounds in the mathematics classroom are equipped with different experiences in their cultural context, which might support or hinder the teaching and learning of mathematics.

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