[個別論文]

Gender, Age, Ethnicity Differences in Spatial Ability of Myanmar Middle School Students

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Abstract: This study was conducted to investigate the levels of spatial ability of Myanmar middle school students across gender, age, and ethnicity by using a spatial ability test. It considered examining four spatial factors such as spatial perception, spatial orientation, spatial visualization and spatial manipulation. Therefore, the test includes four tasks; Paper Formboard for spatial perception, Figure Rotation for spatial orientation, Paper Folding for spatial visualization and Block Rotation for spatial manipulation. Fourteen hundred students from three different ethnic groups participated in this study. Age range of all participants was 13 to 15 years. Results indicated that spatial perception ability was the best among four factors of spatial ability. Elder students did better in the spatial ability test than younger students did. It was also observed that gender difference emerged depending on the type of spatial tasks. Besides, students' spatial ability levels were different due to the different ethnicity.

Key words: spatial ability, gender difference, age difference, ethnicity

1. Introduction

1.1. Importance of the Spatial Ability for Middle School Students

As a human being, having a flexible ability enables to do jobs conveniently. Spatial ability plays an important role in our daily lives and we use it unconsciously for many common activities, such as using a map to guide us through an unfamiliar city, merging into high-speed traffic, and orienting ourselves in our environment. Lohman (1993) defined spatial ability as an ability to generate, retain, retrieve, and transform well-structured visual images. It involves an integrated use of visual spatial capacities to solve problems and expand creative thinking (Gardner, 1983; Hegarty, 2010).

Since the 2nd world war, the assessment of spatial ability has been used for personnel

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selection because it has been accepted that there is a strong relationship between spatial ability and an individual's achievement (Eliot & Smith, 1983; Tai, Yu, Lai, & Lin, 2003). Gardner (1983) articulates that spatial ability and spatial cognition are the basic building blocks that a child needs in order to develop higher level thinking skills. Nowadays, spatial ability has become an important research topic in psychology and education, especially given recent evidence that links spatial ability to achievements in the science (Small & Morton, 1985), physics (Pallrand & Seeber ,1984), chemistry (Baker & Talley, 1972), biology (Lord, 1985), and mathematics (e.g., Maccoby & Jacklin, 1974). Consequently, spatial ability tests become popular for applying jobs, selection of subjects for professional colleges and universities.

Most of spatial ability tests are figural tests (Vandenberg & Kuse, 1978). Lazear (2004) proposed the practical implementations of Gardner's multiple intelligence theory, in which spatial ability is regarding as spatial intelligence, and he wrote assessments of spatial intelligence for students. He identified the behaviors as criteria in item writing for assessments of students' ability. Hegarty (2010) and Kayhan (2005) strongly recommended the teachers, curriculum developers and researchers to be aware of the importance of spatial ability, to tell the students about the importance of spatial ability, and to prepare concrete activities to develop student's spatial abilities during the elementary and secondary education.

Shea, Lubinski, and Benbow (2001) also recommended that if the students know their levels of spatial ability from their middle school age, it will help them to develop their spatial skills by practicing and to select major subjects at professional colleges and universities. Barke (1993) reported that around the age of 14 years (middle school age) spatial ability develops to a point that students interpret the two-dimensional drawings of cubes, tetrahedrons or octahedrons in a spatial way. Besides, middle school students need to select the subjects for high school level. Therefore, it is better if students can predict their study areas, and adjust their interest and their ability with the particular subject areas.

1.2. Developing a Spatial Ability Test for Myanmar Middle School Students

As mentioned above, nowadays, interest in spatial ability has been increasing in education. However, Myanmar, one of developing countries, had not yet become widely aware of the importance of spatial ability in education (Khaing, Yamada & Ishii, 2011, 2012). Therefore, as a new contribution, Khaing et al. (2011, 2012) developed a spatial ability test in order to investigate the spatial ability of middle school students in Myanmar. Since spatial ability tests are generally figural tests and participants can memorize the test items during the first test administration, the researchers cannot administer the test to the participants twice for getting test-retest reliability. Therefore, they simultaneously developed two equivalent tests which were linked by common items, and then a test information function was used as a replacement for traditional concepts of reliability and standard error of measurement. As a result, two spatial ability tests-

S.A.T (Test Form A and Test Form B) were developed, and their test scores could be placed on the same scale and their estimated reliabilities were high (Khaing et al., 2012).

Generally, spatial ability tests are non-verbal tests. But for only this reason, it cannot be mentioned that spatial ability tests are not biased against gender and ethnic minorities. Therefore, S.A.T tests needed to identify whether the tests had no potentially biased items to all Myanmar students. Therefore, as a next study, the authors analyzed DIF (differential item functioning) items across gender and ethnicity to ensure that no students were unfairly panelized when taking the S.A.T tests. As a result, they could revise the spatial test which has no potentially uniform DIF items.

Consequently, the main purpose of the current study was to investigate the spatial abilities of Myanmar middle school students by using the revised S.A.T test.

1.3. Gender and Age Differences in Spatial Ability

Several researchers have provided reviews of the sex difference literature (e.g., Bergvall, Sorby, & Worthen, 1994; MacIntyre, 1997; Peters, Chisholm, & Laeng, 1994). The differences in the spatial performance of males versus females are frequently acknowledged male superiority (e.g., Eals & Silverman, 1994; Kimura, 1996; Moffat & Hampson, 1996). However, according to Voyer, Voyer and Bryden (1995), it cannot be stated that a male advantage occur in all spatial factors.

Linn and Peterson (1985) conducted a meta-analysis for spatial ability research through 1974 to 1982. According to them, male superiority is the most demonstrative in the tasks of mental rotation or spatial manipulation, with lesser differences evident in spatial orientation and no differences evident in spatial visualization. Especially, the difference in performance was large for only mental rotation. Silverman and Eals (1992) and Masters and Sanders (1993) also tested male and female participants on mental rotation tasks, and they found that males were superior in performance, in agreement with previous findings. However, MacIntyre (1997) did predicting that females tend to have superior spatial abilities for specific tasks. Kimura (1996) noted that superior performance by women on a task of requiring object location memory has challenged the traditional view that men excel on all spatial tasks. Moreover, according to Voyer, Voyer and Bryden (1995), sex difference emerges highly depending on the type of test. Therefore, evidence is still inconsistent regarding the differences in specific spatial abilities between male and female.

Therefore, the first purpose of this study becomes to investigate gender difference in students' spatial abilities in our sample.

In addition to gender difference, several studies of spatial ability have focused on developmental issues (Halpern, 2000). Some of them focus on spatial ability differences at various age levels (Battista, 1990; Salthouse, Babcock, Mitchell, Palmon, & Skovronek, 1990). Others focus on the ages at which different factors of spatial ability seem most apparent (Salthouse &

Mitchell, 1990; Tartre, 1990). Some focus on how spatial ability changes over time (Coleman & Gotch, 1998).

Moreover, sex differences in spatial ability favoring males do exist at pre-pubertal ages (Vederhus & Krekling, 1996), specifically at seven or eight years of age (Glasmer & Turner, 1995). These differences remain constant to age 18 (Johnson & Meade, 1987). However, Orde (1996) also found that spatial ability improves with age in childhood years, but Pak (2001) argued that the spatial ability declines with age in adulthood, agreement with Salthouse, Babcock, Skovronek, Mitchel and Pallmon (1990). According to Salthouse et al., spatial ability seems to reach a plateau at puberty but begins to decline in the late twenties due to the aging effect. David, Lappan and Houang (1988) suggested that seventh grade is an optimal time for the teaching of spatial visualization tasks. However, some studies note that the sex difference does not reliably appear until after puberty and that maturation has an effect on spatial development because late maturation is related to high spatial ability (cited in Nyborg, 1983). Therefore, both gender and age largely affect spatial ability.

As we have introduced in section 1.2, spatial ability tests constructed by Khaing et al. (2012) were composed of four spatial tasks which measure four aspects/ factors of spatial ability. By using these tests, it is hoped that age differences in spatial performance of the students can be examined, and determined whether the results agree with the previous research. Therefore, the second purpose of this study becomes to investigate age differences in students' spatial abilities.

1.4. Ethnicity in Spatial Ability

In literature, childhood experiences, environmental differences and cultural factors play a big part in explaining differences in spatial ability (e.g., Barke & Engida, 2001; Berry, 1971; Engida, 2000; Harris, 1978; Khaing et al., 2012; Sherman,1979). According to the findings of Harris (1978), while evidence for gender or environment (or an interaction of the two) is not conclusive, it is clear that they both play some role in the development of spatial ability. Therefore, the differences that are exhibited among different environmental/ different ethnic groups should also be investigated.

In fact, Myanmar has over 100 ethnic groups, who have different cultures, different environments, different languages and dialects. The largest ethnic minorities are Burma, Shan, Karen, Mon, Rakhine, Chin, Kachin and Kayar. Therefore, the third purpose of the current study becomes to investigate ethnicity differences in students' spatial abilities.

1.5. Purpose of this Study

The main purpose of our research is to investigate the spatial ability of middle school students in Myanmar, and the current study is to investigate the levels of students' four spatial abilities by gender, age, and ethnicity.

2. Method

2.1. Participants

In this study, three different ethnic group students in Myanmar were selected. They were sampled from Kachin State, Rakhine State, and Magway Region. Although their official language is Myanmar language but their typical languages in everyday use are different. Accordingly, their cultures and religions are also different.

Kachin State is one of the seven states of Myanmar. The majority of the population in Kachin State is Kachin. Their language is Kachin and they employ in agriculture. Christianity is the main religion in Kachin State.

Rakhine State also has a diverse ethnic population. The majority is Rakhine and use Rakhine language. Most of people living in Rakhine State are Theravada Buddhists. Rakhine State has also some Muslims, few of Hinduism, and others. Rice is the main crop in this region, occupying around 85% of the total agricultural land.

Magway Region is the largest of Myanmar's seven regions and over 95% of the people in Magway Region are Burma and use Myanmar language. Most of them are Buddhists. The principal product of Magway Region is petroleum.

Then, three townships from the three sub-populations were randomly selected. They were Sittway Township from Rakhine State, Myitkyinar Township from Kachin State and Minhla Township from Magway Region. After that, schools and students were randomly sampled.

The number of students participated in this study is shown in Table 1. Fourteen hundred middle school students (693 males and 707 females) from nine schools participated. According to the situation of the sample schools, the sample sizes of the three ethnic groups were not the same. Myitkyinar (Kachin group) is the largest group. Specifically, 742 students in Myitkyinar, 211 students in Sittway and 447 students in Minhla participated. Concerning the age, 135 (10%) students were 13-years old, 779 (55%) students were 14-years old, and 486 (35%) students were 15-years old.

Table 1. Number of students participated in this study

Ethnic groups	Townships	Schools	Male	Female	Total
Rakhaine	Sittway	3	104	107	211
Kachin	Myitkyinar	3	372	370	742
Burma	Minhla	3	217	230	447
Total		9	693	707	1400

2.2. Instrument

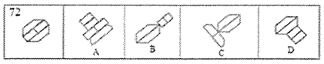
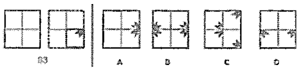
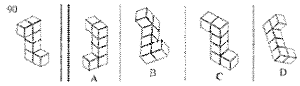
S.A.T tests were composed of four spatial tasks which measure four aspects/ factors of spatial ability. In this study, revised form B test was utilized because it was considered to contain no uniform DIF items.

The four spatial tasks were Paper Formboard (9-items), Figure Rotation (9-items), Paper Folding (7-items) and Block Rotation (5-items). The total items of the test were 30-items. All items were multiple choice-items with four alternative answers. The first task was designed to measure the students' ability to recognize relationship between objects to measure spatial perception, SP. The second task was to examine students' ability of finding one way in space in order to measure spatial orientation, SO. The third one was also to measure the students' processing a visual imagination and ability in manipulating visual patterns to determine spatial visualization, SV. The last task was used to assess students' manipulating images and ability to mentally rotate two or three dimensional figures rapidly and accurately, i.e., spatial manipulation, SM. Block Rotation, the fourth task of the test, is often called mental rotation test. Table 2 describes sample test items of the four spatial tasks.

1. *Paper Formboard.* Each problem has a numbered figure to the left and four lettered figures to the right. Students must find the lettered figure made of exactly the same pieces that are in the numbered figure.
2. *Figure Rotation.* Students have to indicate which of four figures, when mentally turned or rotated, are different from a given figure
3. *Paper Folding.* Students must imagine the folding and unfolding of pieces of paper. In each problem, the figures to the left represent a piece of paper being folded. One of the four figures to the right of the vertical line shows where the holes that are in the paper will be when it is completely unfolded. Students have to decide which one of these figures is correct.
4. *Block Rotation.* Each problem consists of five blocks, and four of them are the same. Students must indicate which block, when mentally turned or rotated, is different from a given block.

Instructions of the test were written in Myanmar Language. Each task takes 2 minutes each to complete.

Table 2. Samples of the Four Tasks

Paper Formboard	
Figure Rotation	
Paper Folding	
Block Rotation	

2.3. Procedure and Scoring

First, the researcher requested to the respective school principals to collect necessary data. After getting permission from these principals, data gathering procedure was conducted in the last week of November, 2011. Before the test administration, participants were provided necessary instructions and explanations to accomplish. They were asked to use only pencils and erasers but not rulers, to answer the test that the teachers instructed, not to read the next task unless the teacher permitted it, to listen to and follow the instructions carefully.

After collecting the necessary data, students' responses were scored. Respondents take 1 if answered correctly and 0 if answered incorrectly. First, descriptive statistics was used to explore the mean and standard deviation, frequency, maximum and minimum scores for students' spatial abilities.

Then, collected data were analyzed by an item response theory (IRT) model. Generally, IRT models show the relationship between the ability (symbolized θ) measured by a test and the item response. Because of the assumption of unidimensionality of a test, principal factor analysis was conducted at first, and the scree plots of eigenvalues were graphed. It was found that the largest eigenvalue of the 30 items is nearly three times larger than the second largest eigenvalue. Therefore, it was concluded that the test possessed the dominance of the first factor, i.e., it had a reasonable unidimensionality. Then, to confirm whether the four spatial tasks of the test loaded on a single general spatial factor, a factor analysis with promax rotation method was performed again. As a result, there were four eigenvalues that are greater than 1.0. Although a major factor loaded for the whole test, four groups of items also loaded on factor 1, factor 2, factor 3, and factor 4. These results were consistent with the previous studies (Khaing et al., 2012).

As a next step, an IRT parameter estimation procedure was carried out with two-parameter logistic model (2PLM), by utilizing **BILOG-MG** (Zimowski, Muraki, Mislevy & Bock, 2003), in which “MG” stands for “multiple group.” In 2PLM, the probability of a correct response depends on the examinee's ability, θ, and the parameters, a and b, that characterize the item. The item parameter a is discrimination parameter and b is difficulty parameter (Hambleton, Swaminathan & Rogers, 1991).

3. Results

3.1. Examining the Spatial Abilities of Students in Each Tasks

According to the descriptive statistics, the range of raw scores of spatial ability was from 3 to 30, mean and standard deviation of the whole test were 18.21 and 5.83, respectively. Figure 1 shows the frequency distribution of raw spatial ability scores.

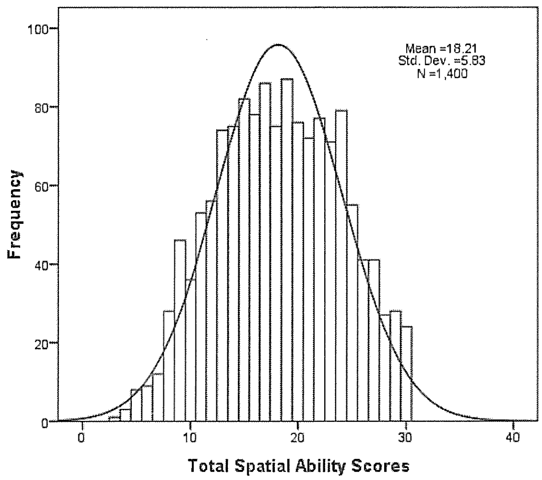


Figure 1. Frequency Distribution of Raw Scores of Spatial Abilities

Table 3 contains the descriptive statistics of four spatial abilities, and figure 2 illustrates the percentage of students who correctly responded all items in each task. The mean scores were 7.02 in spatial perception, 4.73 in spatial orientation, 3.78 in spatial visualization, and 2.69 in spatial manipulation. Looking at Table 3, it can be observed that the difficulty value of the Task 1 was -0.01, and that of Task 2, Task 3 and Task 4 were the same and its value was 0.00. Then, difficulty values of all tasks were nearly 0.00 and difficulty of each task can be considered almost the same. However, we can see that the percentage of students in spatial perception task was 78% and it was the highest value among all tasks. Therefore, it was concluded that the students were able to solve spatial perception items more than other items.

For other spatial tasks, the percentages of students who correctly responded all items were above 50%, and they were nearly the same. So, it was interpreted that the students have moderate level of the spatial ability in the three spatial categories.

Table 3. Descriptive Statistics for Four Tasks of Spatial Ability

Spatial factors	Tasks	No. of items	Total scores given	Mean	SD	% of students who correctly responded	Task difficulty (*b*-values)
Spatial Perception	1. Paper Formboard	9	9	7.02	1.80	78	−0.01
Spatial Orientation	2. Figure Rotation	9	9	4.73	2.67	52.5	0.00
Spatial Visualization	3. Paper Folding	7	7	3.78	1.94	53.9	0.00
Spatial Manipulation	4. Block Rotation	5	5	2.69	1.46	53.7	0.00

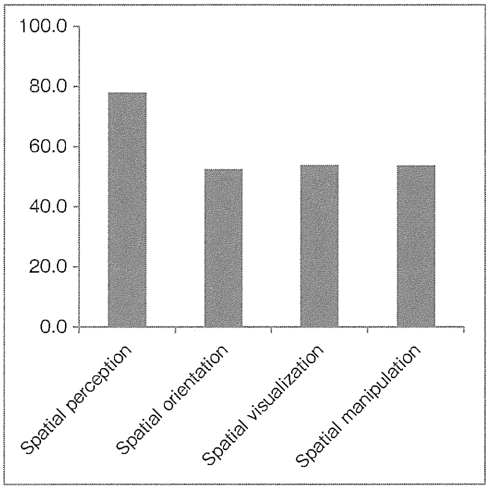


Figure 2. Comparison of Spatial Abilities of Students in the Four Factors

3.2. Examining the Levels of Students' Spatial Ability by Gender

Regarding with the gender effect, a mean comparison of ability scores of male and female was conducted. It was found that the mean scores of spatial ability of male students were 18.27 and those of female students was 18.14. It seems that spatial ability of male students was higher than that of female students, but when it was measured by t-test, there was no significance difference between them.

Concerning the spatial factors, Table 4 describes means and standard deviations of spatial ability in raw scores and ability scores by gender. In IRT analysis, male group's distribution was set as the standard normal distribution (mean=0, SD=1.00). Then ability parameters of the female group were estimated and compared with the male group.

Table 4. Mean Comparison of Spatial Ability Scores by Gender

Spatial factors	Tasks	Raw scores		Ability scores	
		Male	Female	Male	Female
Spatial Perception	1. Paper Formboard	7.14 *1.84*	6.91 *1.75*	0.00 *1.00*	−0.14 *0.93*
Spatia Orientation	2. Figure Rotation	4.80 *2.74*	4.66 *2.59*	0.00 *1.00*	−0.09 *0.84*
Spatial Visualization	3. Paper Folding	3.67 *1.76*	3.88 *2.09*	0.00 *1.00*	0.19 *1.36*
Spatial Manipulation	4. Block Rotation	2.67 *1.46*	2.70 *1.47*	0.00 *1.00*	0.04 *0.97*

Note: The upper is mean, and the lower (Italic) is standard deviation (SD).

As shown in Table 4, mean scores in each task for male and female were different. Specifically, the mean scores of male were higher than that of female in the tasks of spatial perception and spatial orientation, whereas female performed better than male in the tasks of spatial visualization and spatial manipulation. This result was clearly viewed in Figure 3. Therefore, it was interpreted that gender difference emerged depending on the type of spatial tasks.

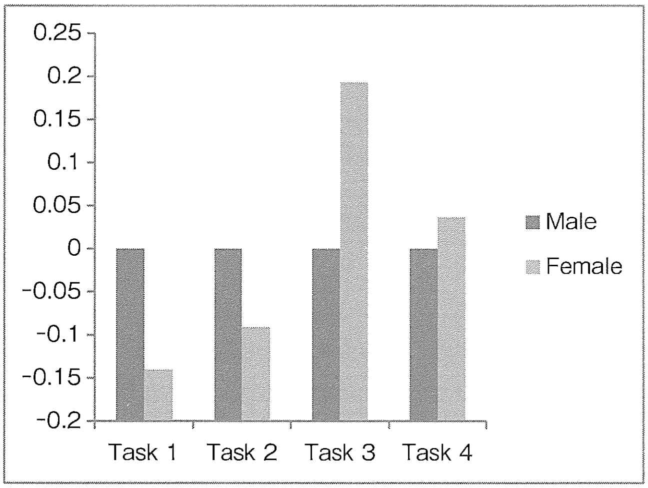


Figure 3. Mean Comparison of Spatial Ability Scores by Gender

Gender differences in spatial ability were examined by independent sample *t*-tests. The result was shown in Table 5. According to the result of t-tests, it was found that there were significant differences between male and female students in the spatial perception and the spatial visualization ($p < .05$). Especially, it was sure that males relatively performed better on tasks of spatial orientation, but females relatively performed better on tasks of spatial manipulation. Therefore, in this step, we could confirm the interpretation that males outperformed females in some but not all of spatial tasks. However, the effect sizes were not very large. We will consider this point later.

Table 5. Result of t-test by Gender for Each Spatial Tasks

Tasks	Gender	N	Mean	SD	*t*	df	*p*	Mean difference
1. Paper Formboard	Male Female	693 707	7.14 6.91	1.84 1.75	2.432	1398	0.015*	0.233
2. Figure Rotation	Male Female	693 707	4.80 4.66	2.74 2.59	0.964	1398	0.335	0.137
3. Paper Folding	Male Female	693 707	3.67 3.88	1.76 2.09	−2.103	1398	0.036*	−0.217
4. Block Rotation	Male Female	693 707	2.67 2.70	1.46 1.47	−0.299	1398	0.765	−0.023
Total	Male Female	693 707	18.27 18.14	5.81 5.85	0.417	1398	0.677	0.130

Note: $^{*}p < 0.05$.

3.3. Examining the Levels of Students' Spatial Ability by Age

To examine the age effect, students were categorized into three groups by their ages; 13-year group, 14-year group, and 15-year group. To compare the ability scores of the three age groups, an IRT analysis was utilized. Similar to gender analysis, the ability score distribution of 13-year group was assumed to be the standard normal distribution. Table 6 describes the means and standard deviations of the ability scores of three age groups.

Table 6. Mean and Standard Deviation of Students' Age Groups

Spatial factors	Tasks	Age groups		
		13	14	15
Spatial Perception	1. Paper Formboard	0.00 *1.00*	0.07 *0.88*	0.20 *0.87*
Spatial Orientation	2. Figure Rotation	0.00 *1.00*	0.23 *1.1*	0.40 *1.13*
Spatial Visualization	3. Paper Folding	0.00 *1.00*	0.17 *1.02*	0.38 *1.01*
Spatial Manipulation	4. Block Rotation	0.00 *1.00*	0.31 *1.35*	0.43 *1.44*

Note: The upper is mean, and the lower (Italic) is standard deviation (SD).

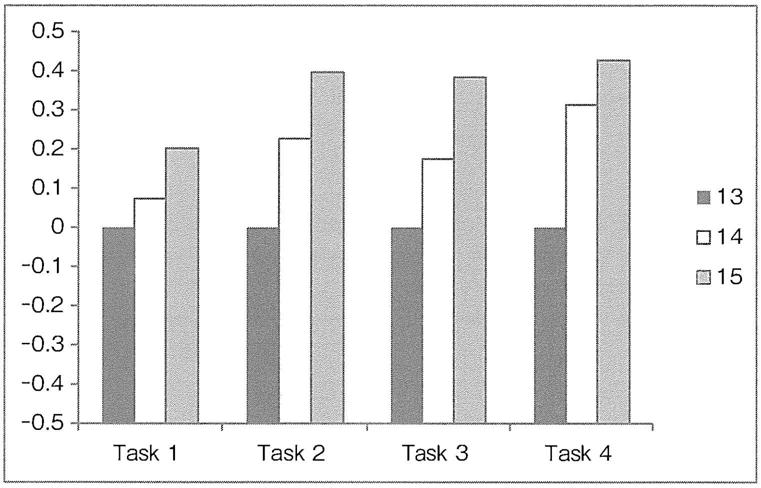


Figure 4.Mean Comparison of Spatial Ability Scores by Age

According to the results, it can be seen that the means of ability scores for three age groups were different in each task. Moreover, it was found that spatial abilities were likely to improve from 13-year group to 15-year group. Figure 4 clearly illustrates this tendency. Thus, it is apparent that the students' age also affects their spatial ability level.

To explore the differences of student spatial ability among the three groups, one-way analysis of variance (ANOVA) was conducted. The ANOVA result showed that there were significant differences among the three groups ($p<.001$). Moreover, when Post-Hoc test was executed by Turkey HSD method, it was found that there was no significant difference between 13-year students and 14-year students but significantly differences between 14-year students and 15 -year students and 13-year students and 15-year students ($p<.01$).

3.4. Examining the Levels of Students' Spatial Ability by Ethnic Groups

As a next step, ethnic group analysis was executed. Descriptive analysis revealed the differences in means and standard deviations of ability scores among ethnic groups (See Table 7 and Figure 5). The ability score distribution of Group-1 was assumed to be the standard normal distribution. The result revealed that the levels of spatial ability of Group-2 were apparently higher than those of other groups. When Group-1 and Group-3 were compared, it was observed that Group-1 students were performed better in Task 1 and Task 2 than Group-3 students but not as well as Group-3 students in Task 3 and Task 4.

Table 7. Mean and Standard Deviation of Students' Ethnic Groups

Spatial factors	Tasks	Ethnic groups		
		Group1	Group2	Group3
Spatial Perception	1. Paper Formboard	0.00 *1.00*	0.83 *0.82*	0.21 *0.82*
Spatial Orientation	2. Figure Rotation	0.00 *1.00*	1.22 *1.41*	0.12 *1.15*
Spatial Visualization	3. Paper Folding	0.00 *1.00*	1.08 *1.03*	−0.15 *0.88*
Spatial Manipulation	4. Block Rotation	0.00 *1.00*	1.54 *1.72*	−0.34 *1.73*

Note: The upper is mean, and the lower (Italic) is standard deviation (SD).

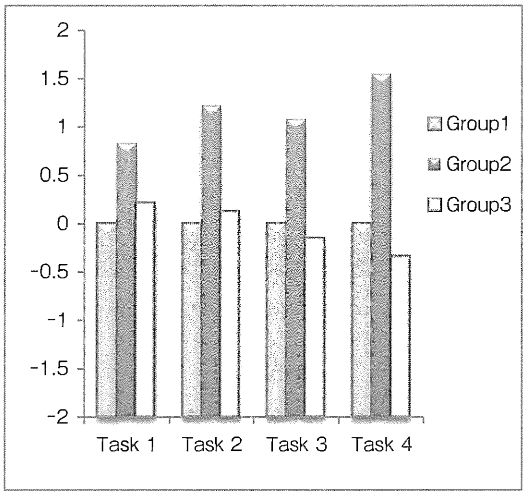


Figure 5. Mean Comparison of Spatial Ability Scores by ethnic groups

So as to consider the significant difference among ethnic groups, one way ANOVA was executed. In line with the result of ANOVA, there were significant differences among groups in all tasks ($p<.001$). Moreover, according to the result of Turkey HSD method, it was found that mean of Group-2 was higher than those of Group-1 and Group-3. There were no significant difference of spatial performance among four tasks within Group-1 and Group-3. In Group-2, students performed the best in spatial manipulation.

3.5. Analyzing Students' Spatial Ability by Gender, Age and Ethnic Groups

Finally, it was studied the overall comparison of spatial abilities by gender, age and ethnic groups. Table 8 reported mean scores and standard deviations of whole spatial ability by gender, age and ethnic group. Figure 6 illustrated the comparison findings of this research.

Table 8. Mean Comparison between the Levels of Students' Spatial Ability

Group	Subgroups	Mean (θ)	SD
Gender	Male	0.26	1.02
	Female	0.23	1.01
Age groups	13	0.00	0.90
	14	0.20	1.01
	15	0.39	1.03
Ethnic groups	Group1	-0.34	0.83
	Group2	0.71	0.93
	Group3	-0.25	0.84

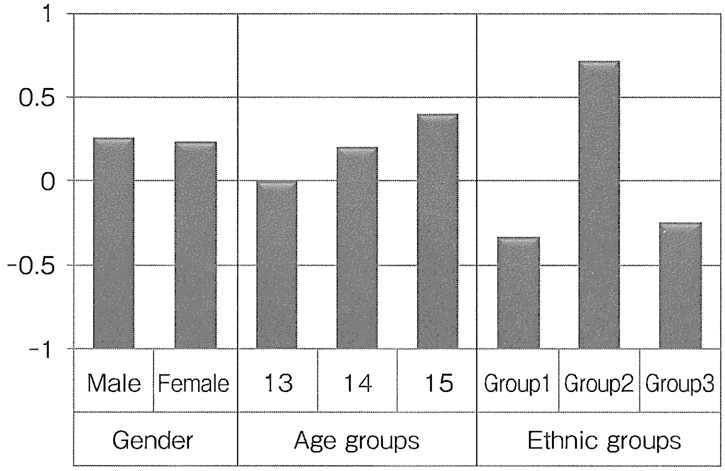


Figure 6. Mean Comparison of Spatial Ability Scores

As shown in Table 8 and Figure 6, spatial ability was slightly different between male and female. Those of three age groups were distinctly different and they improved from the younger group to the elder group. Moreover, there were large differences in three ethnic groups. Therefore, it was concluded that comparing these three factors, ethnicity had the largest effect, age had middle effect, and gender had little effect on spatial ability.

4. Discussion and Further Research

4.1. Concerning the Levels of Spatial Ability of Students in Each Task

As expressed earlier, students' spatial ability was identified in this research by Task 1: Paper Formboard (spatial perception items), Task 2: Figure Rotation (spatial orientation items), Task 3: Paper Folding (spatial visualization items) and Task 4: Block Rotation (spatial manipulation items), respectively.

Our results revealed that students had the highest spatial ability in spatial perception. In other words, Myanmar middle school students in this study had high ability to recognize relationship between objects. This result was consistent with the previous study of Khaing et al. (submitted).

Moreover, Students also performed equally in the areas of orientation, visualization and manipulation. Thus, it would be recognized that each Myanmar middle school student possessed relatively similar levels of spatial abilities in order to keep track of objects or locations in space even after a rotation or movement to a new location, to visualize how separate parts of complex physical system interrelate of the students, and to mentally rotate two or three dimensional figures.

4.2. Concerning the Levels of Students' Spatial Ability by Gender

In literature, there was a general agreement among many researchers that spatial ability of males is higher than that of females (e.g., Caplanet.al. 1985; Kali & Orion, 1996,). Regarding to the findings in this study, there was little gender difference. When studied by four spatial factors, it was found that females relatively performed better than males in the tasks of spatial visualization and spatial manipulation, while the males relatively performed better than the females in the tasks of spatial perception and spatial orientation. Therefore, it was interpreted that males could outperform females in some but not all spatial tasks.

According to the result of t-test, while males performed significantly better than females in the tasks of spatial orientation, females performed obviously better than males in the tasks of spatial manipulation. This result supported the findings that gender difference emerged highly depending on the type of task and a male advantage was not occurred in all spatial factors, followed the previous research (Linn & Peterson, 1985;Voyer et al., 1995).Also, this agreed with the result in MacIntyre (1997) which did predict that females should have superior spatial abilities for specific tasks.

4.3. Concerning the Levels of Students' Spatial Ability by Age

Related to the age effect, it was observed that the means of ability scores of three age groups were different in each task. Thus, it could be concluded that their spatial ability had age affect. Moreover, the mean of ability scores of 13-year students was the lowest and that of 15-year students was the highest. Therefore, spatial abilities were likely to develop from the younger students to the elder students. Here, we considered two reasons for that. One reason was that 15-year students were learning Grade-9 courses. In Grade-9 courses, more lessons were composed with stimuli behind strong development of spatial skills. Therefore, 15-year students could perform better in spatial ability tasks than 14-year students who were learning the Grade-8 courses and 13-year students who were learning Grade-7 courses. This considering suggested that spatial ability had strong relationship with academic subjects and it was a specific talent that contributes to success in mathematics, science, geography, and other subjects.

This result followed with Johnson and Meade (1987).

Another reason was students' cognitive development. It was well documented that spatial ability developed childhood to adulthood. Orde (1996) viewed that spatial ability improved with age in childhood years. McGee (1979) and Weber (1976) stated that pubertal change could explain development of spatial ability in early adolescence. Salthouse et al. (1990) agreed that spatial ability improved a plateau at puberty. In our research, it was observed that spatial ability developed from age of 13 to 15 students who were early adolescents. However, Salthouse et al. insisted that this development began to decline in the late twenties due to the aging effect. Therefore, it would be worth to conduct follow up study after several years passed.

4.4. Concerning the Levels of Students' Spatial Ability by Ethnic Groups

According to the previous research (Bowles, 1998; Boyd & Richerson, 1985), education, experience and environmental factors have been shown to improve spatial ability. In this study, an ethnic group analysis was executed. The result revealed that spatial abilities of Group-2 students were significantly higher than those of other groups. In fact, Group-2 students were from Myitkyinar which is the capital city of Kachin State in Myanmar. Moreover, schools of Group-2 were big and famous for their matriculation exam results in Kachin State. So,Group-2 students may have better socioeconomic status and education of parents than other groups. Therefore, it may be one reason why they had significantly higher spatial ability than those of the other groups.

Another reason may be that their cultural or ethnical differences affected the spatial ability. Typically, Kachin people are more likely to participate in activities such as playing sports, singing traditional songs, and dancing together in peer groups whenever they had a free time. According to the school principals of these schools, Group-2 of Kachin students were used to participating in the activities ranging from sports to art and music to church programs after school programs. Moreover, it was noted that most of Kachin parents actually wished their children to participate both in school programs and after-school programs because they believed all these programs could improve academic achievement of their children. Of course, it was needless to say that the Group-2 students participated enthusiastically in the present survey.

In literature, some researchers believe that musical background (Heitland, 2000a; Robichaux & Guarino, 2000) are potential roots for the development of spatial ability. Baenninger & Newcombe's (1989) meta-analysis found spatial activity participation was more probably to be related to spatial ability for both genders. Activities that have been found to improve spatial ability include creating artwork (Caldera, Culp, O'Brian, Truglio, Alvarez & Huston, 1999), previous geometry instruction, experience, and participation in a certain sports (Sorby, Leopold &Gorska, 1999). Therefore, all of these finding answered the question why spatial abilities of Group-2 students were significantly higher than those of the other groups.

4.5. Further Research

One limitation of this study was sampling data for ethnic groups. Myanmar has seven states and seven regions. The samples of the current study were selected only from Rakhine State, Kachin State, and Magwe Region of Myanmar. Therefore, further researches are necessary for another ethnicity analysis to conduct by using other student groups from other states and regions. Other problem concerning sampling is that data of this study is cross-sectional and not longitudinal. Then, age factor and cohort factor are contaminated. To solve this problem, a longitudinal study should be conducted. Moreover, the current study performed analyses for differences in spatial ability across only gender, age, and ethnicity factors. Thus, a further research is also necessary to examine other potential differences (e.g., respondent's test experience, and participation in a certain sports, creating artwork). We also have to conduct non-uniform DIF analysis.

5. Conclusion

The results of this study highlighted the facts that 1) age and ethnicity affect distinctly spatial ability development, and 2) not only male but also females are likely to be superior spatial abilities for specific tasks. Gender effect on spatial ability was really little. It is expected that the results of this study can provide some insight to know about spatial ability related to gender, age and ethnic factors.

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