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A Case Study on the Spatial Conceptualization Abilities for Sixth Grade Elementary Students from Urban, Suburban and Remote Schools

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ABSTRACT
The main objective of this study was to investigate and compare the spatial conceptualization performance for sixth grade elementary school students from urban, suburban and remote schools in Taiwan. This study involved 27, 25, and 26 sixth grade students from one remote indigenous school in eastern Taiwan, one suburban indigenous school in northern Taiwan, and one urban Han Chinese school in northern Taiwan, respectively. Spatial ability assessments were carried out on the students to explore the spatial conceptualization abilities and the possible relationship between school children's spatial abilities and urban-rural, ethnic, and cultural diversities. The research tool utilized in this study was a scenario-based spatial ability assessment test, which had been carefully reviewed and pre-tested by experts. Test results revealed that: (1) Sixth grade students from the suburban and remote indigenous school shared no significant difference in their spatial abilities; (2) Sixth grade students from the urban Han Chinese school exhibited significantly better spatial performance than those from the suburban and remote indigenous schools. The spatial conceptualization performance for sixth grade elementary school students from urban, suburban and remote schools in Taiwan is different.
Keywords: spatial ability, urban school, suburban school, remote school

INTRODUCTION

Academic Performance Gaps in Urban-Rural, Ethnic and Cultural Divides

Sociologist Pierre Bourdieu (1979) considers schools an arena that reproduces social class. With a "valuable and legitimate culture" as a tool, schools output mainstream cultural values in order to build up a system of values recognized by the ruling class and the majority. However, "culturally disadvantaged" students often end up achieving poor academic performance due to ethnic and cultural divides (Chen, & Cheng, 2008; Chen, Wang, & Huang, 2013). Chao, & Chao, (2012) found that in junior high schools, Han Chinese senior

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State of the literature

- McGee divided spatial abilities into spatial visualization and spatial orientation. Spatial visualization is an ability to operate, rotate and turn a solid object with the imagination. Spatial orientation is an ability to determine a relative spatial orientation.
- Developing spatial abilities through tactile, visual and other sensory stimulations may enhance students' image understanding of solid objects. Some research has indicated that spatial ability is the basic ability required to acquire all sorts of knowledge.
- Unfairly allocated educational opportunities and resources lead to an academic performance gap between students from urban and suburban areas.

Contribution of this paper to the literature

- The research participants from the urban Han Chinese school exhibited significantly higher spatial abilities than those from the suburban and remote indigenous school in the aspects of "rotation," "mapping," "perspective," "folding," "stacking," "cube counting" and total score.
- In this study, students from the suburban indigenous school exhibited significantly higher test scores than those from the remote indigenous school in the aspects of "rotation," "perspective," "folding," "stacking," "cube counting" and total score. However, students from the suburban indigenous school and the remote indigenous school did not reach a statistically significant difference.
- In conclusion, sixth grade students from an urban Han Chinese school exhibited significantly higher spatial abilities than those from a suburban indigenous school and a remote indigenous school, while sixth grade students from a suburban indigenous school and a remote indigenous school do not show a statistically significant difference.

students delivered significantly better academic results in Chinese language courses than those with indigenous backgrounds. Yang, (1997) stated that the indigenous students score significantly lower than Han Chinese students in math and Chinese language achievement tests.

In addition, owing to population density and flourishing economic activity, there are more educational institutions in urban areas. Educational resources are also more accessible than in suburban and remote areas. Unfairly allocated educational opportunities and resources lead to an academic performance gap between students from urban and suburban areas. (Chen, & Liu, 2008; Li, 2010).

According to recent studies, academic performance discrepancies among Taiwanese students result from urban-rural, ethnic and cultural differences (Chen, 1998; Chen, & Liu, 2008; Chou, 2012; Yang, 1997).

Lee (2003) further indicates that insufficient English teachers, less teaching hours and indifferent parents in remote schools are the reasons students there fall far behind those from urban areas in terms of their English abilities when entering senior high school.

From data in the Taiwan Education Panel Survey (TEPS) in 2001, Tsai (2008) revealed that junior high school students from urban areas exhibit better performance than those from suburban and remote areas with regards to anaylsis, mathematics and digital analysis and general analysis abilities, and students from suburban schools perform better than those from remote schools.

The literature mentioned above suggests urban-rural, ethnic and cultural divides do have an influence on students' academic performance. As a result, this research selected sixth grade elementary school students from three different schools, one urban Han Chinese school, one surburban indigenous school and one remote indigenous school, to investigate the academic gap in students' spatial abilities.

Spatial Ability

McGee (1979) divided spatial abilities into spatial visualization and spatial orientation. Spatial visualization is an ability to operate, rotate and turn a solid object with the imagination. Spatial orientation is an ability to determine a relative spatial orientation.

According to related studies in Taiwan, people with outstanding spatial abilities have better performance in learning, scientific deduction and creative thinking. They are more active in learning new things and highly willing to challenge themselves (Wu, 2001). Developing spatial abilities through tactile, visual and other sensory stimulations may enhance students' image understanding of solid objects (Yang, Yeh, & Tan, 2014). Lin, (1994) further indicates that spatial ability is the basic ability required to acquire all sorts of knowledge.

In light of the findings described above, spatial ability is indeed a key capability for one to learn new things. Referring to McGee's classification, this study prepared and designed scenario-based spatial ability assessments based on six concepts, "rotation," "mapping," "perspective," "folding," "stacking," and "cube counting," for the purpose of understanding the spatial abilities of sixth grade students from urban, suburban and remote areas.

Research Objectives

The research objectives are as follows: 1. Developing the spatial abilities assessments; 2.Understanding the performance of sixth grade students from urban Han Chinese, suburban and remote indigenous schools in spatial ability assessments; 3.Understanding the performance of sixth grade students from suburban and remote indigenous schools in spatial ability assessments.

METHODS

This research is a quantitative research with self-designed questions. Experts have vetted validity and pre-tested the questions in the aspects of "rotation," "mapping," "perspective," "folding," "stacking," and "cube counting" to ensure validity and reliability.

Study Participants

Study objects were 27, 25 and 26 sixth grade students selected from one remote indigenous school in eastern Taiwan, one suburban indigenous school in northern Taiwan, and one urban Han Chinese school in northern Taiwan respectively. The study used purposive sampling method.

(1) the remote indigenous school in eastern Taiwan
This is an indigenous Atayal school, located in the remote Yilan County in Taiwan. This school has six classes and 80 students. It needs to drive about an hour to the nearest city.
(2) the suburban indigenous school in northern Taiwan
This school is located in Taoyuan City. It only needs to drive 15~20 minutes to the nearest city. There are about 35 classes and 880 students. This school is near industrial areas and most parents are the industrial area employees and indigenous people.
(3) the urban Han Chinese school in northern Taiwan
This school is located in the center of Taiwan's capital city, Taipei. This school has 44 classes and 1082 students. Most parents are from the high socio-economic and educated families.

Spatial ability assessments were performed on the students from different areas and of different ethnic groups to understand discrepancies in their spatial abilities.

Spatial Ability Assessments Pre-test Results

Developed by our research institute, the spatial abilities assessments in the aspects of "rotation," "mapping," "perspective," "folding," "stacking," and "cube counting" were reviewed and examined by three experts. The pre-test questions were the revised versions based on their opinions. The pre-test questions were tested by 27 sixth grade students of a remote school. After deleting questions with unclear analytical purposes, the questionnaire demonstrates an α reliability coefficient of up to 0.946, equivalent to a formal assessment test with high reliability and validity.

RESULTS AND DISCUSSION

Formal Spatial Ability Assessment Questions

Out of a total score of 100, the spatial ability assessments designed by our institute are divided into 16 modules in the aspects of "rotation," "mapping," "perspective," "folding," "stacking," and "cube counting." The following are a brief explanation of the assessments:

Spatial Ability Assessments for the Aspect of "Rotation"

For the aspect of "rotation," there were 3 modules and 9 questions. A perfect score was 17 points. Sample questions are shown in **Figure 1**.

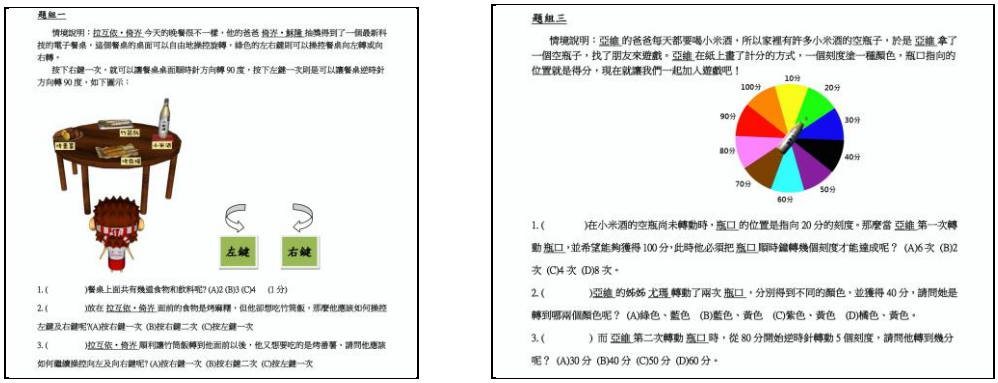


Figure 1. "Rotation" Test

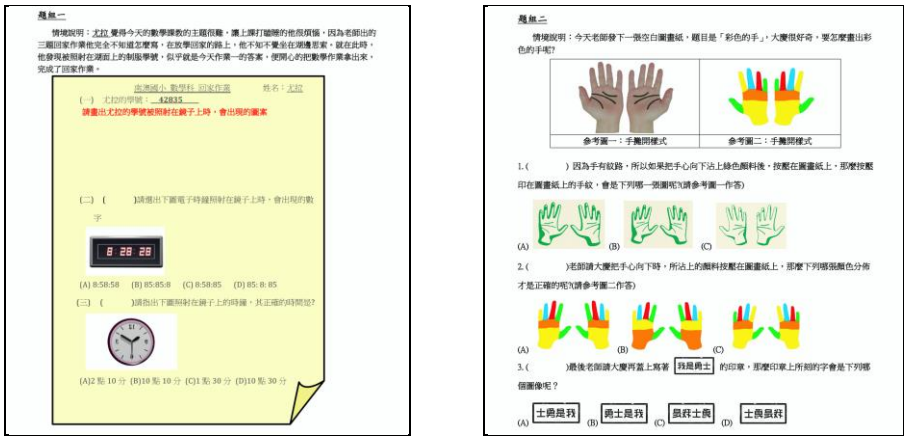


Figure 2. "Mapping" Test

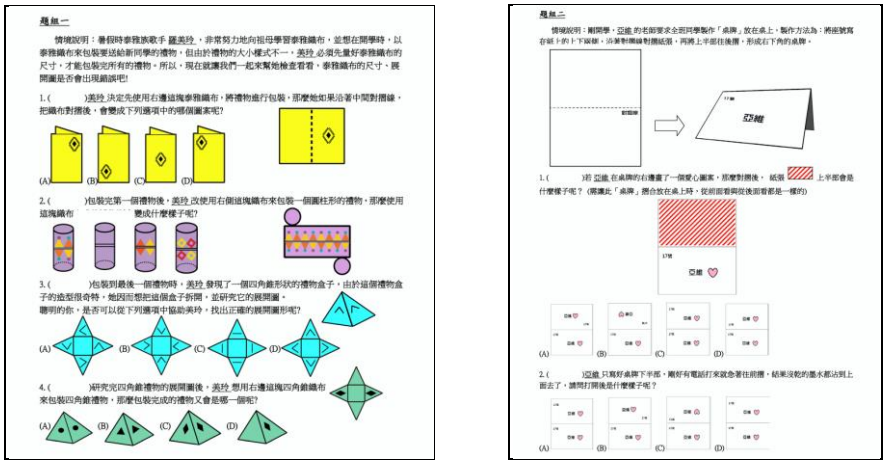


Figure 3. " Folding" Test

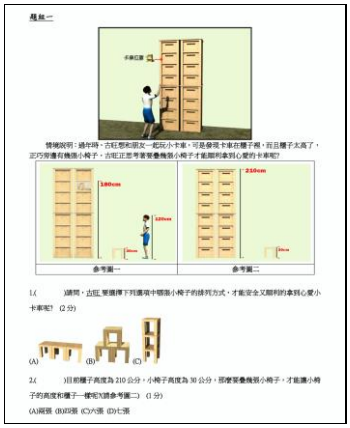
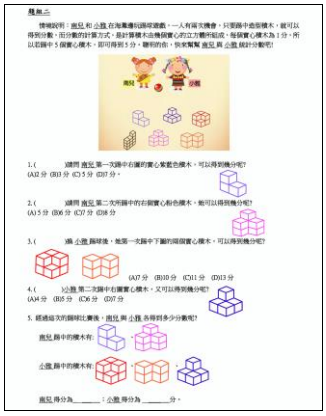


Figure 4. "Stacking" Test

Figure 5. "Perspective" Test



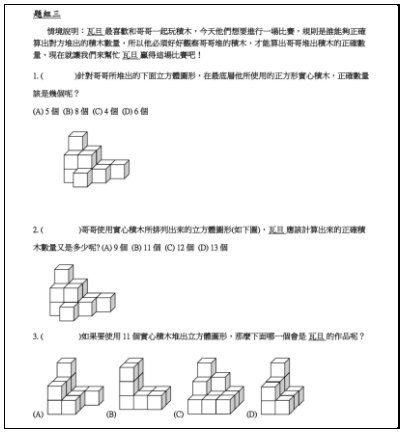


Figure 6. "Cube Counting" Test

Table 1. Statistical analysis of sixth grade students from an urban Han Chinese school and a suburban indigenous school

	School	N	M	SD	t	df	Sig.(2-tailed)
Rotation	Suburban	25	12.12	2.948	-5.402	49	.000***
	Urban	26	15.62	1.359			
Mapping	Suburban	25	13.76	3.192	-2.080	49	.044*
	Urban	26	16.19	4.996			
Folding	Suburban	25	8.96	3.116	-3.882	49	.001**
	Urban	26	11.54	1.174			
Stacking	Suburban	25	1.72	1.021	-2.823	49	.007**
	Urban	26	2.50	0.949			
Perspective	Suburban	25	19.84	4.625	-4.252	49	.000***
	Urban	26	24.00	1.625			
Cube calculation	Suburban	25	15.52	5.917	-4.524	49	.000***
	Urban	26	21.04	1.509			
Total Score	Suburban	25	71.92	14.566	-5.787	49	.000***
	Urban	26	90.88	7.654			

*P<0.05, **P<0.01, ***P<0.001

Spatial Ability Assessments for the Aspect of "Mapping"

For the aspect of "mapping," there were 3 modules and 10 questions. A perfect score was 21 points. Sample questions are shown in **Figure 2**.

Spatial Ability Assessments for the Aspect of "Folding"

For the aspect of "folding," there were 2 modules and 6 questions. A perfect score was 12 points. Sample questions are shown in **Figure 3**.

Spatial Ability Assessments for the Aspect of "Stacking"

For the aspect of "stacking," there were 1 module and 2 questions. A perfect score was 3 points. Sample questions are shown in **Figure 4**.

Spatial Ability Assessments for the Aspect of "Perspective"

For the aspect of "perspective," there were 4 modules and 12 questions. A perfect score was 25 points. Sample questions are shown in **Figure 5**.

Scenario-based Assessments in the Aspect of "Cube Counting"

In the aspect of "cube counting," there were 3 modules and 11 questions. A perfect score was 22 points. Sample questions are shown in **Figure 6**.

Analysis of the spatial ability assessments of sixth grade students from an urban Han Chinese school and a suburban indigenous school

According to the average scores of the spatial ability assessments of sixth grade students from the urban Han Chinese school and the suburban indigenous school (see **Table 1**), students from the urban Han Chinese school exhibited significantly higher spatial abilities than those from the suburban indigenous school in the aspects of "rotation," "perspective," "folding," "stacking," "cube counting" and total score. According to the independent sample t-test results (see **Table 1**), students from the urban Han Chinese school and the suburban indigenous school reached a statistically significant difference of 0.001 in the aspects of "rotation," "perspective," "cube counting" and total score, and of 0.01 in the aspects of "folding" and "stacking" and 0.05 in the aspect of "mapping." The results show that students from the urban Han Chinese school exhibited significantly higher spatial abilities than those from the suburban indigenous school.

Analysis of the spatial ability assessments of sixth grade students from an urban Han Chinese school and a remote indigenous school

According to the average scores of the spatial ability assessments of sixth grade students from the urban Han Chinese school and the remote indigenous school (see **Table 2**), students from the urban Han Chinese school exhibited significantly higher spatial abilities than those from the remote indigenous school in the aspects of "rotation," "perspective," "folding," "stacking," "cube counting" and total score. According to the independent sample t-test results (see **Table 2**), students from the urban Han Chinese school and the remote indigenous school reached a statistically significant difference of 0.001 in the aspects of "rotation," "folding," "perspective," "cube counting" and total score, and of 0.01 in the aspects of "stacking" and 0.05 in the aspect of "mapping." The results show that students from the urban Han Chinese school exhibited significantly higher spatial abilities than those from the remote indigenous school.

Analysis of the spatial ability assessments of sixth grade students from a suburban indigenous school and a remote indigenous school

According to the average scores of the spatial ability assessments of sixth grade students from the suburban indigenous school and the remote indigenous school (see **Table 3**), students from the suburban indigenous school exhibited significantly higher test scores than those from the remote indigenous school in the aspects of "rotation," "perspective," "folding," "stacking," "cube counting" and total score. However, in terms of the independent sample t-test results (see **Table 3**), students from the suburban indigenous school and the remote indigenous school did not reach a statistically significant difference.

Table 2. Statistical analysis of sixth grade students from an urban Han Chinese school and a remote indigenous school

	School	N	M	SD	t	df	Sig.(2-tailed)
Rotation	Remote	27	10.19	4.608	-5.864	51	.000***
	Urban	26	15.62	1.359			
Mapping	Remote	27	12.30	6.486	-2.455	51	.018*
	Urban	26	16.19	4.996			
Folding	Remote	27	7.19	3.690	-5.831	51	.000***
	Urban	26	11.54	1.174			
Stacking	Remote	27	1.44	1.155	-3.628	51	.001**
	Urban	26	2.50	0.949			
Perspective	Remote	27	17.04	7.709	-4.589	51	.000***
	Urban	26	24.00	1.625			
Cube calculation	Remote	27	13.93	7.179	-5.034	51	.000***
	Urban	26	21.04	1.509			
Total Score	Remote	27	62.07	26.639	-5.393	51	.000***
	Urban	26	90.88	7.654			

*P<0.05, **P<0.01, ***P<0.001

According to the results described above, sixth grade students from the urban Han Chinese school exhibited higher spatial abilities than those from the suburban indigenous school and the remote indigenous school, which matches results from other studies in Taiwan. However, students from the suburban indigenous school and the remote indigenous school did not reach a statistically significant difference, which exhibits a discrepancy with other studies in Taiwan. The reason for this may be as a result of a limited sample size, a total of 50 students from the suburban and remote indigenous schools. The researcher will collect more samples for further investigation.

The above results are consistent with the studies of Chao, and Chao, (2012), and Yang, (1997). That is, the Han Chinese students outperformed indigenous students.

Moreover, Tsai, (2008) revealed that junior high school students from urban areas exhibit better performance than those from suburban and remote areas, and students from suburban schools perform better than those from remote schools. However, this study found that sixth grade students in the spatial ability assessments, urban students scored significantly higher than suburban students, but there are no significant differences in the results between the suburban and remote students.

Table 3. Statistical analysis of sixth grade students from a remote indigenous school and a suburban indigenous school

	School	N	M	SD	t	df	Sig.(2-tailed)
Rotation	Remote	27	10.19	4.608	-1.817	50	.076
	Suburban	25	12.12	2.948			
Mapping	Remote	27	12.30	6.486	-1.044	50	.303
	Suburban	25	13.76	3.192			
Folding	Remote	27	7.19	3.690	-1.879	50	.066
	Suburban	25	8.96	3.116			
Stacking	Remote	27	1.44	1.155	-0.913	50	.366
	Suburban	25	1.72	1.021			
Perspective	Remote	27	17.04	7.709	-1.603	50	.116
	Suburban	25	19.84	4.625			
Cube calculation	Remote	27	13.93	7.179	-0.876	50	.385
	Suburban	25	15.52	5.917			
Total Score	Remote	27	62.07	26.639	-1.670	50	.103
	Suburban	25	71.92	14.566			

*P<0.05, **P<0.01, ***P<0.001

CONCLUSION

Results of the spatial ability assessments of sixth grade students from an urban Han Chinese school, a suburban indigenous school and a remote indigenous school are organized as follows:

1) According to the descriptive statistics results and the independent sample t-test results (see **Table 1-2**), students from the urban Han Chinese school exhibited significantly higher spatial abilities than those from the suburban and remote indigenous school in the aspects of "rotation," "mapping," "perspective," "folding," "stacking," "cube counting" and total score.
2) According to the descriptive statistics results (see **Table 3**), sixth grade students from the suburban indigenous school exhibited higher test scores than those from the remote indigenous school in the aspects of "rotation," "mapping," "perspective," "folding," "stacking," "cube counting" and total score. However, in terms of the independent sample t-test (see **Table 3**), students from the suburban indigenous school and the remote indigenous school do not reach a statistically significant difference, meaning that they share similar spatial abilities.

In conclusion, sixth grade students from an urban Han Chinese school exhibited significantly higher spatial abilities than those from a suburban indigenous school and a

remote indigenous school, while sixth grade students from a suburban indigenous school and a remote indigenous school do not show a statistically significant difference.

Recommendation

This research only completed a small scale investigation of sixth grade Han Chinese and indigenous students from the north and east of Taiwan with a total number of 78 test subjects. The researcher will expand the scope to the whole of Taiwan in order to fully understand whether sixth grade students' spatial abilities are affected by regional, ethnic and cultural divides.

REFERENCES

Bourdieu, P. (1979). *La distinction: Critique sociale du jugement.* Paris: Les Editions de Minuit.

Chao, M. W., & Chao, M. N. (2012). Exploring the influential factors of Chinese language grades on ninth graders. *Formosan Education and Society*, *24*, 41-74.

Chen, C. D., & Cheng, S. Y. (2008). A Study on the relations between cultural capital and academic achievement: A case study of sixth graders in the Yulin county elementary schools. *Educational Journal NHCUE*, *25*(1), 79-98.

Chen, J. Z. (1998). A model of ethnic and family background influence on children's academic achievement — A comparison between aboriginal and non-aboriginal students in Taitung. *Journal of Education & Psychology*, *21*(1), 85-106.

Chen, S. M., Wang, H. Y., & Huang, C. W. (2013). Exploring the equality of educational opportunity for low socioeconomic status and culturally diverse gifted students by using theories of cultural capital and capability approach. *Gifted Education, 126,* 33-40.

Chen, Y. C., & Liu, T. M. (2008). Educational attainment and Urban/Rural discrepancy: An analysis of spatial cluster. *Journal of Population Studies*, *37,* 1-43.

Chou, H. M. (2012). Deliberating indigenous education from the perspective of educational opportunity equality. *Taiwan Journal of Indigenous Studies, 5*(3), 1-18.

Lee, R. C. T. (2003). *Why is there an "M" Pattern in Taiwan's English Learning?* Retrieved from http://engsite.ncu.edu.tw/database/showfeature.asp?CO_no=74

Li, C. H. (2010). Individual and local factors explaining students' performance on the basic competence test for junior high students. *Journal of Geographical Science, 60,* 67-102.

Lin, L. (1994). Interactive multimedia and science learning. *Instructional Technology & Media, 16*, 3-13.

McGee, M. G. (1979). Human spatial abilities: psychometric studies and environmental, genetic, hormonal, and neurological influences. *Psychological Bulletin, 86*(5), 889-918.

Tsai, P.Y. (2008). *Influence of urban-rural differentials on academic performance of junior high school students* (Unpublished master's thesis). Graduate School of Social Informatics, Yuan Ze University, Taoyuan City, Taiwan.

Wu, H. C. (2001). *A study of the relationship between the performances of spatial ability and learning achievement of development drawing in the mechanical drawing of vocational high school student* (Unpublished master's thesis). Department of Industrial Education, National Taiwan Normal University, Taipei, Taiwan.

Yang, D. (1997). A study the relationship of ethnicity, IQ and academic achievement of elementary school students—The case of Taichung county. *Journal of Eastern Taiwan Studies, 2*, 197-216.

Yang, K. H., Yeh, S. C., & Tan, N. C. (2014). A design-based research study on developing the teaching program of volume for elementary schools. *Journal of Liberal Arts and Social Sciences, 10*(3), 225-252.

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