

Analysis of the Learning Effectiveness of Atayal Culture CPS Spatial Concept Course on Indigenous Students

Jenyi Chao ^{1*}, Chuan-Hsi Liu ², Yi-Hsin Yeh ¹

¹ National Taipei University of Education, Taipei, TAIWAN

² National Taiwan Normal University, Taipei, TAIWAN

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ABSTRACT

This study was conducted by integrating Atayal culture into CPS education strategy to develop spatial concept courses, teaching materials, and assessment tests that served to analyze the effectiveness of spatial concept learning on indigenous students after two years of course. The participants of this study were 16 5th grade students from an Atayal elementary school located in Nan'ao, Yilan County. The period of study spanned from 2015 to 2016, and was conducted by gathering data through teaching demonstrations and tests. The tests developed for this study were used as the research tool, and had been examined and pretested by 3 content specialists. The finalized tests included a total of 19 segments (59 problems) on 6 spatial concepts: "rotation", "reflection", "folding", "perspective", "stacking", and "cubic enumeration". The tests were conducted before and after the study and verified against sample t to examine if the indigenous students' spatial concepts exhibited significant changes. Study results showed that with regard to the 6 different spatial concept tests, indigenous students performed significantly better in the after-tests than in the pre-tests. The integration of Atayal culture into CPS spatial concept courses was therefore determined to have significant positive impact on the spatial concepts of indigenous students.

Keywords: indigenous elementary children, spatial concept, Atayal culture, collaborative problem solving

INTRODUCTION

This study comprises the partial research outcomes of the "Development and Implementation of a Teaching Platform for Indigenous Student CPS Spatial Conceptualization Learning Courses and Assessments--Main Project" funded by the Ministry of Science and Technology, Taiwan. A spatial conceptualization CPS teaching course and corresponding assessment test were designed in accordance with the context of Atayal culture to improve indigenous student' learning motivation toward spatial concepts so as to improve their learning outcomes and problem-solving skills. Student also acquired a better understanding of their culture.

Among Taiwanese indigenous peoples, the population of the Atayal tribe is about eighty thousand people, making them the third largest indigenous group after the Amis and the Payuan peoples (Department of Statistics, Ministry of the Interior, 2015). In particular, Nan'ao Township and its northwest neighbor Datong Township are the only two highland indigenous townships within Yilan County. Residents comprise mostly of Taiwanese indigenous people, the Atayal tribe, who have established a very unique culture. Since most of the indigenous students from Yilan County, Taiwan, who participated in this study were Atayal, the course incorporated the cultural features of the Atayal tribe so that the students are better able to connect emotionally with their tribal culture.

The objectives of this study are as follows: To learn whether or not there is significant improvement on the learning outcome of Atayal indigenous students in terms of six spatial concepts, namely, "Rotation," "Reflection,"

Contribution of this paper to the literature

- There is significant improvement on the learning outcome of Atayal indigenous students in terms of six spatial concepts, namely, "Rotation," "Reflection," "Folding," "Perspective," "Stacking," and "Cubic enumeration," after CPS coursework.
- This study is to improve the motivation for learning and learning outcomes of indigenous students. By integrating course design with indigenous culture and formulating appropriate CPS teaching strategies, both instructors and indigenous students can be empowered.
- The lifestyle-oriented assessment questions were incorporated indigenous cultural elements and utilized interactive digital materials designed by this study for CPS teaching demonstrations. This enabled us to understand the spatial intelligence of indigenous students and to improve their scientific, mathematic, and collaborative problem-solving skills.

"Folding," "Perspective," "Stacking," and "Cubic enumeration," after two years of coursework. The research question is as follows: Is there significant progress between pre-test and post-test scores in the six spatial concepts?

LITERATURE

The Learning Difficulties of Indigenous Students

Alleviating the difficulties faced by indigenous students has always been a focus of indigenous education. John Ogbu (as cited in Ho, 2015), an anthropologist of education, once mentioned that one of the reasons why minority students perform poorly was that the education they received was not compatible with their cultural backgrounds. This is a keen observation of the difficulties faced by indigenous students today in a Han-dominated culture. Moreover, indigenous populations in remote regions have relatively fewer economic, cultural, and educational resources. Lack of cultural stimulus and estrangement from mainstream culture has caused indigenous students to be less motivated in learning and thus exhibit poorer learning outcomes. In the long run, being disadvantaged both academically and in terms of career development restricts the social mobility of indigenous populations and prevents them from pursuing professional careers, creating a vicious cycle.

Upon the compilation of domestic studies on indigenous student learning patterns, it was found that cultural differences between the indigenous and Han populations have contributed to the differences in learning patterns and characteristics of the two groups. Taking the Atayal students of this study as an example, it was found that "peer-oriented learning" with an emphasis the values of cooperation and sharing was characteristic of their learning. They also enjoyed a stress-free learning atmosphere that had no competition pressure, and a dynamic, investigation-oriented learning environment with hands-on experiences. These characteristics made it difficult for Atayal students to become accustomed to the education system that was formulated based on Han culture. Atayal students disliked the lifeless instruction methods and learning materials comprised of symbols and abstractions (Chi & Liu, 2000).

Studies on the learning of indigenous students have pointed out that the gap between indigenous students and traditional teaching and the mainstream Han culture has not only affected their learning, but has also been the primary factor resulting in learning difficulties and poor learning outcomes (Chou et al., 2015). If culture is indeed the primary factor affecting the learning process of indigenous students, then, according to learning theories, teaching activities could be designed based on students' characteristics so as to increase their potential and resolve the issues encountered. Both domestic and foreign scholars have suggested that the learning characteristics of student should be taken into consideration in the formulation of methods, designs, and strategies for teaching indigenous students. Their cultural and living experiences should be incorporated, and instruction should be given according to how the students learn best so that their motivation for learning and learning outcomes can be improved.

Spatial Ability and Scientific Learning

Indigenous education and culture are both issues of the research concern. Our research focus on the indigenous student science education all the time, and has been devoted to improving the motivation for learning and learning outcomes of indigenous students. By integrating course design with indigenous culture and formulating appropriate teaching strategies, both instructors and indigenous students can be empowered.

It has be found, however, that due to the influence of their living environment, indigenous students may not express their spatial concepts precisely enough, which, in turn, affects their performance in the natural sciences (Chao et al., 2014). There is also a significant gap between the spatial test results of indigenous students and of Han

students; in short, indigenous students in general have poorer spatial intelligence. It can be seen from the above observation that, in the process of helping indigenous students achieve better performances in scientific learning, their spatial concepts must also be improved (Chao et al., 2012, 2015).

In a recent domestic study, Lin (1994) pointed out that spatial intelligence is a basic capability for learning all sorts of knowledge. Wu (2001) also believes that those who have a higher spatial intelligence perform better in terms of learning ability, ability in scientific deduction, and creativity. Moreover, they are more proactive, aggressive and willing to challenge themselves. Wang and Chen (2016), on the other hand, suggested that to help a child overcome difficulties in the learning of mathematics (geometry, in particular), the instructor should begin from building the child's spatial ability.

Psychologists from earlier eras used factor analysis to discover the so-called "spatial ability" as one of the human mental abilities, which was not thought to affect the learning of academic subjects. It was not until the 1970s that many scholars started to study the relation between "spatial ability" and "scientific learning;" many subsequent studies pointed out that "spatial ability" clearly has an influence on a student's scientific learning (Lord, 1985a, 1985b; Weckbacher & Okamoto, 2014). Researchers each have their individual perspectives and stances, and have also formulated different definitions and interpretations of "spatial ability." For example, for McGee (1979), Linn and Peterson (1985), and Lohman (1988), a "spatial ability" refers to the ability to re-order, turn, and manipulate objects. Even though all these three studies proposed that "spatial visualization" is one of the spatial abilities, each proposed varying definitions for the concept of "spatial visualization."

McGee's "spatial visualization" has a relatively broader scope. "Spatial perception," according to Linn and Peterson, is close in meaning to "spatial orientation," whereas another two factors, "mental spin" and "spatial visualization" are closer in meaning to their definition of "spatial visualization." Therefore, in this study McGee's categorization of spatial capacity was adopted, including the six concepts of "Rotation," "Reflection," "Perspective," "Folding," "Stacking," and "Cubic enumeration." Digital teaching materials and assessment tests were all developed using these six general categories.

Collaborative Problem Solving (CPS) and PISA

As mentioned above, indigenous education should take students' learning characteristics into account and their culture and background should be integrated. Teaching methods that cater to how students learn best is indispensable for improving their motivation for learning and learning outcomes. Other than preference for team work, hands-on experience, and learning with the senses, Fu (2004) also pointed out that within the traditional indigenous lifestyle, interpersonal relations include not only interactions between humans, but also between humans and plants, animals, and other substances. Therefore, indigenous people tend to learn via cooperation. The design of natural science instruction should adopt cooperative learning in place of individual competition, and be conducted primarily through outdoor rather than indoor learning activities.

Cooperative learning theories began to proliferate in the 1970s. These theories, based on democratic learning theory, theories of motivation, cognitive development theory, theories of social construction, and multiple Intelligence theory. Scholars have moreover developed many learning strategies for group collaborative work--at least eighty types have been identified abroad (Chang, 2010). Cooperative learning is mostly commonly utilized for group-based teaching, and is applicable to all sorts of subject and fields.

Problem-based learning (PBL) is another learning activity that enables students to solve problems structurally through group-based learning. In the process of problem-solving, not only do learners acquire and develop deductive creativity and cognitive ability, but can also exchange and build up their knowledge in the interactive process of group learning. Ultimately, information can be integrated into an effective action plan. Thereafter, Nelson (1999) proposed another teaching strategy, the collaborative problem solving (CPS) strategy, which combines the two methods of collaborative learning and problem-based learning to create an improved teaching strategy. This teaching strategy emphasizes a collaborative learning environment that is learner-oriented, integrable, and real. It encourages students to learn from doing and become active participants of the learning process. It stresses critical thinking and problem-solving abilities, helps cultivate social interaction and cooperation skills, and encourages the discovery and analysis of learning content from various perspectives.

DeWitt et al. (2017) referred that CPS can support online learning by enabling interactions for social and cognitive processes. The pretests and posttests of this study were conducted to determine whether the learning outcomes were achieved. The findings suggest that the module could be used to improve outcomes of learning and encourage interactions for cognitive processes and online presences. Although the subject and topic were not the same as ours, they still have similar views about that CPS strategies were effective in science education and enabled interactions for social and cognitive processes. It also mentioned that social interaction prompted cognitive processes such as concept-formation, resolving differences and critical thinking in the process of CPS, and it would

help students to obtain knowledge and skills (DeWitt et al., 2017; Huang, Yang, Chiang, & Tzeng, 2012; Chao et al., 2016a, 2016b; Karpov & Haywood, 1998; Kim & Song, 2006).

Chan and Clarke (2017) observed the students' social interactions and collaborative problem solving skills while completing open-ended mathematical tasks. It provided distinct entry points for teacher instructional intervention (or scaffolding) in the promotion of CPS skill. The researchers considered that open-ended mathematical tasks were workable in class. However, the novice teachers were not equipped to utilize it in a pedagogically meaningful way, experienced teachers were suggested to be more suitable. This study also mentioned that both collaborative problem solving and negotiated skills should be developed for the contemporary curriculum.

Furthermore, in recent year, the nation has been placing increasing emphasis on the importance of developing student capabilities that are applicable in their daily lives. The OECD (Organization for Economic Co-operation and Development) has stated that from 2015 onward, PISA (the Programme for International Student Assessment) will be assessing students' collaborative problem-solving skills (Serda, 2012). This shows that collaborative problem-solving is an important skill in today's international society. A scientific evaluation emphasizes a student's ability to "explain phenomena scientifically," "identify scientific issues," and "use scientific evidence." Advanced nations are taking PISA results more and more seriously because it serves to compare students' problem-solving abilities on an international scale and can be utilized to inspect the effectiveness of each nation's education policies. Unlike other international competitions on academic subjects, the focuses of PISA are the abilities in life skill application, logical thinking, and problem-solving.

For the aforementioned reasons, this study referenced the key components of the PISA CPS assessment, the content fields for assessing mathematical ability, and key points of implementation for the exclusive design of a PISA evaluative assessment featuring the six key concepts of spatial ability, "Rotation," "Reflection," "Perspective," "Folding," "Stacking," and "Cubic enumeration." The lifestyle-oriented assessment questions incorporated indigenous cultural elements and utilized interactive digital materials designed by the researchers for CPS teaching demonstrations. This enabled the researchers to understand the spatial intelligence of indigenous students and to in turn improve their scientific, mathematic, and collaborative problem-solving skills.

RESEARCH METHOD

This study is experimental design, and the design of Pre-test and Post-test comparison was used. Students were given pre- and post-test assessments on Atayal culture-based CPS spatial concept teaching activities, the results of which were compiled into data for quantified research. A single group pre- and post-test experimental setup was adopted. The assessment questions were evaluated for effectiveness and reliability and pre-tested by experts to improve the reliability of the lifestyle-oriented assessment questions developed exclusively by the research team.

Course Planning

Based on CPS teaching strategy, the course developed in this study was divided into the nine following steps: (A) Preparation: preparation by the instructor and learners for team collaboration; (B) the instructors or the learners formed small and heterogeneous working groups to plan the basic procedures for conducting group work; (C) in the initial process, the group would define the problem being solved; (D) each team defined and distributed the roles necessary for the completion of the project; (E) the teams devoted to the main, repetitive CPS processes; (F) the teams started to make a conclusion on a solution or a project; (G) the lesson designer and the learners devoted themselves to activities that helped them reflect upon and integrate their experiences; (H) the instructors and the learners evaluated their achievement and process; (I) the instructors and the learners ended their activities for the learning event.

Six sessions conducted over the course of twelve class hours were taught; each class was 100 minutes in length and consisted of two sections. The six spatial ability concepts, "Rotation," "Reflection," "Perspective," "Folding," "Stacking," and "Cubic enumeration" were included in these courses. Through heterogeneous grouping, each team discussed and learned one specific spatial concept together, after which they presented their findings. Afterwards, instructors assisted the students in reflecting on and integrating their learning experiences. Finally, the learning outcomes were assessed via self-evaluation and teachers' assessments (PISA assessment content, class observation, observation of the use of interactive digital materials).

Research Subject

The main research subjects were sixteen fifth-grade Atayal elementary students from Nan'ao Township, Yilan County, Taiwan. A lifestyle-oriented assessment test of the students was conducted prior to the teaching demonstration, and another was carried out after completion of the teaching activity. The results underwent dependent Wilcoxon signed-rank test analysis.

Table 1. Rank of the six spatial concepts

		N	Mean Rank	Sum of Rank
Rotation post -pre	Native rank	0 ^a	.00	.00
	Positive rank	10 ^b	5.50	55.00
	Ties	2 ^c		
	Total	12		
Reflection post -pre	Native rank	1 ^d	1.50	1.50
	Positive rank	13 ^e	7.96	103.50
	Ties	0 ^f		
	Total	14		
Cubic enumeration post -pre	Native rank	0 ^g	.00	.00
	Positive rank	13 ^h	7.00	91.00
	Ties	2 ⁱ		
	Total	15		
Stacking post -pre	Native rank	0 ^j	.00	.00
	Positive rank	14 ^k	7.50	105.00
	Ties	1 ^l		
	Total	15		
Perspective post -pre	Native rank	0 ^m	.00	.00
	Positive rank	6 ⁿ	3.50	21.00
	Ties	8 ^o		
	Total	14		
Folding post -pre	Native rank	0 ^p	.00	.00
	Positive rank	11 ^q	6.00	66.00
	Ties	3 ^r		
	Total	14		
Six spatial concept post -pre	Native rank	0 ^s	.00	.00
	Positive rank	15 ^t	8.00	120.00
	Ties	0 ^u		
	Total	15		

a. Rotation _post < Rotation _pre b. Rotation _post > Rotation _pre c. Rotation _post = Rotation _pre
 d. Reflection _post < Reflection _pre e. Reflection _post > Reflection _pre f. Reflection _post = R Reflection _pre
 g. Cubic enumeration _post < Cubic enumeration _pre h. Cubic enumeration _post > Cubic enumeration _pre
 i. Cubic enumeration _post = Cubic enumeration _pre
 j. Stacking _post < Stacking _pre k. Stacking _post > Stacking _pre l. Stacking _post = Stacking _pre
 m. Perspective _post < Perspective _pre n. Perspective _post > Perspective _pre o. Perspective _post = Perspective _pre
 p. Folding _post < Folding _pre q. Folding _post > Folding _pre r. Folding _post = Folding _pre
 s. Six spatial concept _post < Six spatial concept _pre t. Six spatial concept _post > Six spatial concept _pre u. Six spatial concept _post = Six spatial concept _pre

Research Tools

The research tool was a test battery assessment that had been approved and pre-tested (Cronbach $\alpha = 0.947$) by three subject matter experts, and comprised of a formal test sheet on the six spatial concepts, “Rotation,” “Reflection,” “Folding,” “Perspective,” and “Cubic enumeration” with a total of 19 question sets (59 individual questions). Dependent Wilcoxon signed-rank test was conducted on the results of the pre- and post-tests to analyze whether or not significant changes in the spatial conceptualization of indigenous school children had occurred.

RESEARCH RESULT

A total of sixteen fifth-grade indigenous students participated in the pre- and post-tests of the teaching demonstration and completed the formal assessment test with a total of 19 question sets on the six spatial concepts. The full mark for each test was 100 points. Out of the 19 question sets, nine questions were on “Rotation,” fourteen questions on “Reflection,” seven on “Folding,” twelve on “Perspective,” six on “Stacking,” and eleven on “Cubic enumeration,” totaling 59 individual questions.

Because of the small sample size, the Wilcoxon signed-rank test was used to analyze the data. It was found that after the courses conducted for this study, fifth-grade indigenous students improved test grades both individually and as a group. Their post-test scores were clearly better than the pre-test scores (Table 1). According to the results of the Wilcoxon signed-rank test analysis (Table 2), the six spatial concept score was $z = -3.41$ and $p = 0.001$, showing that a significant difference was achieved between pre- and post-tests in this study. In particular, the difference was extremely remarkable in terms of these three concepts: “Reflection,” “Cubic enumeration,” and “Stacking.”

Table 2. Test statistic of the six spatial concepts

	Rotation post -pre	Reflection post -pre	Cubic enumeration post -pre	Stacking post -pre	Perspective post -pre	Folding post -pre	Six spatial concept post -pre
Z test	-2.85	-3.21	-3.19	-3.32	-2.21	-3.02	-3.41
Asymp. Sig. (two tailed)	.004**	.001**	.001**	.001**	.027**	.003**	.001**

***p<0.001, **p<0.01, *p<0.05

DISCUSSION

In the processing of research, it truly proved the reference about the learning style and characteristics of indigenous children. The indigenous children enjoyed a dynamic, investigation-oriented learning environment with hands-on experiences and cooperation (Tan et al., 2008). Atayal students disliked the lifeless instruction methods and learning materials comprised of symbols and abstractions (Chi & Liu, 2000). It is important to the teachers in tribe elementary schools to apply suitable teaching strategy to fit characteristics of indigenous children.

This study is an idiographic case, the main subjects are Atayal elementary school students in Nan'ao. We designed the CPS spatial concept course and assessment for them according to their culture and environment. Hence, there was the limitations of the area and subjects. Although the learning style and characteristics of indigenous children were common in principle, the researchers who might want to research the same topic should adjust CPS Curriculum design and assessment depending on different area and tribe.

Apart from this, interestingly, indigenous children preferred to complete the classwork by cooperation, but they did not know how to start group discussion and work assignments at beginning of course. It took us a lot of time to lead them to learn teamwork and CPS skills. Because of this, it caused the less efficiency of the course. Our study data also reflected this situation. The course of "Rotation" was the first course, and the difference between pre and post-test was small. As students' CPS skills enhanced, the improvement were more significant.

CONCLUSION AND SUGGESTION

Conclusion

This study incorporated the contexts of Atayal culture and took into consideration the learning characteristics of indigenous students in the exclusive design of a course on CPS spatial concepts. At the same time, the accuracy of student performance assessment was also duly considered. As such, a lifestyle-oriented PISA test battery assessment with questions that incorporated indigenous cultural elements and utilized interactive digital materials was exclusively designed by the researchers for CPS teaching demonstrations. This enabled the researchers to understand the spatial intelligence of indigenous students and to in turn improve their scientific learning and problem-solving skills.

After two years of learning, the Atayal indigenous students who participated in the courses improved their scores on the six spatial concepts, "Rotation," "Reflection," "Folding," "Perspective," "Stacking," and "Cubic enumeration." Their learning outcomes showed significant improvement.

Suggestion

It can be found from literature review that many scholars have been focusing on mitigating the learning difficulties of indigenous students, enhancing their motivation for learning, and improving their learning outcomes. This research project has been conducted at Atayal indigenous schools for many years, and research and development of courses on CPS spatial concepts that incorporate Atayal culture continues to this date. We suggests those who wish to conduct relevant research to consider the learning characteristics of indigenous students and the different cultural contexts of each tribe in combination with currently utilized textbook units for the design of courses that integrate indigenous cultures and appropriate teaching strategies.

In addition, according to the data of this study in the conclusions, CPS strategies of the spatial concept course were effective. But the students didn't know how to make group discussion and work assignments at beginning of course, they spent two years learning by doing and got used to crop with problem by using cps nine steps. In consideration of above, we suggested designing the pre-course about how to do group discussion and work assignments before the beginning of spatial concept course. The pre-course could help students to increases their ability of teamwork and CPS skill. If students already have ability of teamwork and expression, it will make CPS strategies more effective in the process.

Finally, in terms of assessments, an exclusively designed lifestyle-oriented PISA test battery assessment included elements from indigenous culture was utilized. When retrieving the tests, it was found that some indigenous students still lacked patience and answered in a haste, therefore invalidating the assessment results. We suggests that researchers factor in this issue when implementing the assessment; for example, implementing the test over several sittings or selecting the most representative questions could potentially reduce the number of null values.

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