PUPIL: International Journal of Teaching, Education and Learning
ISSN 2457-0648

Ting-Ying Lo, 2023
Volume 7 Issue 2, pp. 180-195
Received: 11th April 2023
Revised: 1st August 2023, 22nd August 2023
Accepted: 26th August 2023
Date of Publication: 15th September 2023
DOI- https://doi.org/10.20319/pijtel.2023.72.180195
This paper can be cited as: Lo, T.Y. (2023). The Investigation of Culture-Integrated Mathematics Remedial Modules on Indigenous Students' Learning Outcome. PUPIL: International Journal of Teaching, Education and Learning, 7(2) ,180-195.

THE INVESTIGATION OF CULTURE-INTEGRATED MATHEMATICS REMEDIAL MODULES ON INDIGENOUS STUDENTS' LEARNING OUTCOME

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Abstract

The purpose of this study was to use activity theory to analyze the mathematics difficulties of indigenous low-achieving students, to develop culturally integrated mathematics remedial modules to solve this difficulty and test the student's learning outcomes. This research applied the case study method and invited twelve grade 4-5 Truku indigenous students as the participants. The research tools used for analysis included a teacher-student interview outline, an indigenous culture integration mathematics remedial teaching module, classroom videos, and reflection logs. The results showed that the difficulties of indigenous low-achieving students were among the tools,

community, rule, and division of labor by activity theory analysis, which caused them to produce contradictory emotions towards mathematics. In the second stage, the study team developed an indigenous culture integrated into the mathematics remedial module to solve the difficulties. After teaching, 70% of the indigenous low-achieving students improved their math performance. The cultural dual-guidance teaching strategy expanded the indigenous students' ability to use multiple representations to solve problems, promoted confidence to present their solving method, and showed the ability to contribute to the group.

Keywords
Activity Theory, Indigenous Culture, Low-Achieving Students, Mathematics Module, Remedial Teaching

1. Introduction

In recent years, the Taiwan government has actively and continuously implemented educational interventions to the disadvantaged and promoted the cultural advantages of the indigenous students. In particular, the government has established indigenous culture experimental schools (Hsu, 2019) and offered many funds to implement mathematics remedial program for low-achieving students, which echoes the development trend of world education where multiculturalism is valued.

Much teaching research about ethnic mathematics, culturally responsive teaching or culturally integrated mathematics teaching modules have supported to promote conceptual understanding and problem-solving skills of indigenous students (e.g., Demitra, & Sarjoko, 2018).

The objectives of this study included (1) using activity theory to analyze the difficulties of low-achieving indigenous students in mathematics; (2) developing an indigenous culture-integrated mathematics remedial teaching module to solve the difficulties;(3)testing low-achieving indigenous students' math performance.

2. Literature Review

Activity theory originated in the work of Vygotsky (1978), he emphasized the influence of social culture on the development of human cognition. He pointed out that *when people participate in social and cultural activities, shared experiences among people, u*se the basic tools of culture, such as language, symbols, numbers, and words, and through the cooperative relationship between "*subjects, objects, and tools*"—act as an intermediary with each other affecting the whole activity. A collaborative dialogue allows people not only to be passive recipients of information but active participants in creating meaning (Qiu, 2006).

Based on the intermediary action triangle of subject, tool, and outcome by Vygotsky (1978), Engeström (1987) added three elements: *rule, community, and division of labor*, called "the activity model", as shown in Figure1. This model explains that the subject uses mediators: tools, rules, and division of labor to interact with the community, generating a perception of the goal and affecting the outcome.

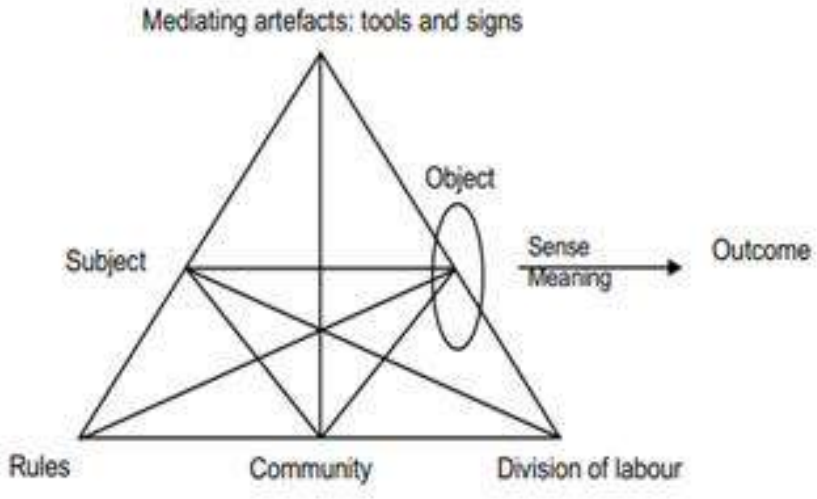

Figure 1*: Engeström's (1987) Activity Theory Model*
(Source: Taken from Daniels 2001)

Activity theory has been expanded through three generations, from Vygotsky focusing on mediating artifacts between subject and object (first generation); Leont'ev focusing on object-related collective

activity (second generation); and EngestrÖm focusing on a network of interacting activity systems-Cultural-historical activity theory (CHAT; third generation)(Colville et. al. 2023). Activity theory is widely used to analyze educational research issues. For example, Lewis published two papers (Lewis, 2016a; 2016b), both of which aimed at the problem-solving errors for students with mathematical disabilities to use social and cultural construction theory to analyze the cultural factors behind the errors to provide a reference for teaching method design.

In this study, the researchers will also use activity theory to analyze the indigenous low-achieving students in the mathematics learning system who experienced individual difficulty and the dilemma of the interaction between various elements in the learning system.

3. Research Methodology

3.1. Participants

The case study applied to this study (Yin, 2017). 12 grade 4-5 indigenous low-achieving students, eight boys and five girls, seven low-achieving and five high-achieving students, in the tribal Mountain Elementary School (pseudonym). The invited students failed to pass the mathematics basic competence test of the Ministry of Education (2019) and need to implement learning assistance and guidance. To strengthen the arithmetic operational skills and basic concepts of fractions is proposed by the two math teachers from grades 4-5.

The school is located in the tribes where 90% of Truku group people, the clan of the 16 indigenous peoples in Taiwan. Although the young people do not like the older adults communicating in their native language, they often participate in daily traditional cultural inheritance activities, such as marriage, winning awards, and child graduations, to prepare pork to share with everyone in the tribe.

3.2. Research Tools

The research tools include teaching videos, teaching materials, a mathematics module, reflection logs, and outlines of teacher and student interviews. The interview questions for teachers

include “What do you think of students with low math scores in the class?”, “Can you give us feedback on the remedial teaching module?” On the other hand, the interview questions for students include “Who do you think can help you the most in learning mathematics?”, “In today’s class, did you understand the concept where the teacher converted mixed fractions to improper fractions?

3.3. Data Processing and Analysis

The research data was analyzed qualitatively and quantitatively. In addition, the results of this qualitative research analysis use the triangulation method including multiple data, multiple raters, and multiple analysis methods, such as inviting two senior students who completed independent qualitative research to be the raters to discuss the inconsistencies with the researcher and obtain a consensus to promote reliability.

4. Results

4.1. Mathematics Resistance and Learning Difficulties of Low-Achieving Students

The researcher uses activity theory to analyze why students are resistant to learning to found that the difficulties arose mainly in the following three aspects:

First, it occurred between the *Subject-tools*: low-achieving indigenous subjects using poor mathematical representation tools such as digital representation, the material tools let them often produces unsuccessful outcome; the psychological tools such as ambivalence towards mathematics, that is, even with learning motivation but lack of assistance in solving math problems at home.

Second, it also occurred between the *Subject-division of labor-community:* it usually occurred that teachers often interact with high achiever students in the classroom. The unequal teacher-student relationship let the indigenous low-achieving students spend extra time even in holidays for math remedial teaching, and the ineffective implementation of peer guidance.

Third, it occurred between the Subject-*rule*: the inconsistencies existed between school culture and tribal learning culture; parents and students probably are low achievers in mathematics.

The above negative *Subject-outcome* reduced students' motivation to study mathematics and even expand other study areas.

4.2. The Mathematics Remedial Teaching Module

Based on the learning difficulties of the low-achieving indigenous students, the study team developed a mathematics remedial teaching module, "Come! Let's go hunting". After discussing with the math teachers of the two classes, the remedial teaching goal was aimed at strengthening the student's arithmetic operational skills and the basic concepts of fractions. Subsequently, three units were designed with the math concepts relevant to the Truku culture of hunting, sharing food, and music. For the difficulty of the subject-tools, the module taught multiple representation strategies with graphs representations of where students are good at. For the difficult of the subject-community, the module was based on the peer tutoring model, involving the "dual mentors", who were college students and high-achieving indigenous students, to cooperate in guiding the low-achieving students to solve problems. For difficult subject-community-division of labor, the peer tutoring model stressed that equal rights exist between mentors and mentees. For difficult of subject-rule, the module integrated indigenous culture into the mathematics problem-solving task, creating a friendly and "I can contribute to the team" learning atmosphere.

4.3. Teaching Process

The researcher took the first unit: "Collaborative Carrying Prey down the Mountain", as an example to illustrate the teaching process and served a teacher to implement a construction-oriented teaching method.

4.3.1. Introducing the ancient and modern hunter spirit to arise students' similar tribal experiences to promote mathematics learning motivation.

4.3.2. Designing problem-solving tasks in real-life situations and demonstrating multiple representation strategies to students to solve math problems.

4.3.3. Providing an opportunity to present problem-solving strategies to encourage the low-achieving indigenous students to gain achievement.

4.4. Low-Achieving Indigenous Students' Learning Effect

The researcher also took the first unit as an example to analyze the learning effects of the module and strategy on the low-achieving indigenous students as follows:

4.4.1. Mathematics Skill - Promote Arithmetic Operation Ability

The study team designed a summative assessment at the end of each unit to check the learning effectiveness of the low-achieving indigenous students. Based on the summative evaluation of Unit 1, the researcher took Task 1 as an example. The task is as follows: Six students want to work together to climb a mountain in seven days, and one needs to eat three kilograms of food a day. How much food do they have for seven days?

As shown in Figure 2, 5 indigenous low-achieving students (71.3%) answered the question correctly. LS56M (grade 5 low-achieving boy) found a regular relationship between the "Number of Classmates" and the "Seven-day food quantity". When a student is added, the number in brackets will be plus three; when the third student is added, they need to write (3+3+3) × 7 in the table cell. The student wrote down the solution tips very seriously: "The relationship was between twenty-one kg each time" (total weight) and "increase 3 kg each time" (number of students).

The low-achieving students frequently used multiplication to calculate the result. They directly wrote 9 × 7 = 63 in the column instead of calculating through continuous addition. This finding showed that the low-achieving students understood multiplication to calculate fast and accurately.

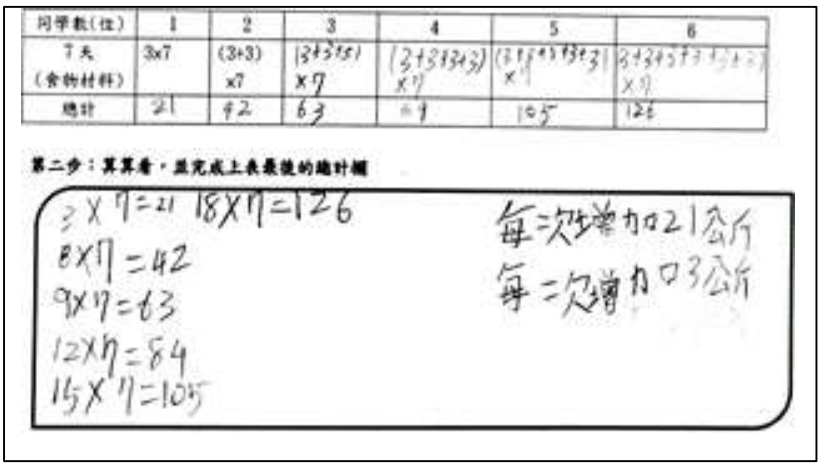

Figure 2: *LS56M Problem-Solving Process*
(Source: Authors' Own Illustration 2020)

4.4.2. Produce Expansive Learning

The double guiding strategy could enable the high-achieving and low-achieving indigenous students to practice more multiple representation strategies. The expansive learning cycle proposed by Engeström (2010) to analyze the learning performance of the indigenous students. The researcher took Task 3 as an example. This task included the following question: Please calculate How many times your team will move the heaviest prey down the mountain; how many kilograms will you move every time? A group member drawing a 68 kilograms prey as an example. In this group, the guidance difficulty encountered by high-achieving indigenous students, HS59F,a grad5 high-achieving girl, used oral language and digital representation alternately to LS52F (grad five low-achieving girl).it is too difficult to understand for her , she responded: I do not understand (Questioning, stage1of expansive learning cycle).A college student who joined the small group observed that the conflict and understood why LS52F does not understand it (Analysis, stage 2 of expansive learning cycle), and demonstrated the graphic method to understand the meaning of another math problem, and marked the main sentences with a color pen to help describe the problem meaning to two girls (Modeling the new solution, stage 3 of expansive learning cycle).HS59F then revised the guidance after learning to the guidance and demonstration of the college student guiding demonstration. She said: *LS52F! Let's read the task. First, this sentence meaning of this task means (demonstrate by pointing the sentences with your finger) you can circle the sentence and read again.*

Next, I can show my problem-solving method to you. There were six members in our group, and a circle represented one member and wrote ten kg in this circle, which means I can carry 10 kg. You draw the second circle and write ten Kilogram *in the second circle. For the first time, six members carried sixty* Kilogram prey downhill. *Look at my drawing method! Did you understand the meaning of 10×6?*

Figure.3 shows that the total weight of the prey drawn by the team was eighty-six kg. After LS52F understanding HS59F guidance (Examining the new model, stage 4 of expansive learning cycle), they started discussing and thinking about other mathematical representations. Finally, LS52F learned to use diagrams, tables, and word symbols of three representations strategies to solve the problem. The answer to this task was to carry the prey downhill twice; at first, six team members had to carry the ten kilogram prey, with a remaining twenty-six kg. Thus, two members must carry five kilogram prey downhill during the second time, and the other four must carry four kg (Implementing the new model, stage5 of expansive learning cycle). Through this process of cooperation, let them felt happy and got achievement (Reflecting and evaluating the process, stage 6 of expansive learning cycle).

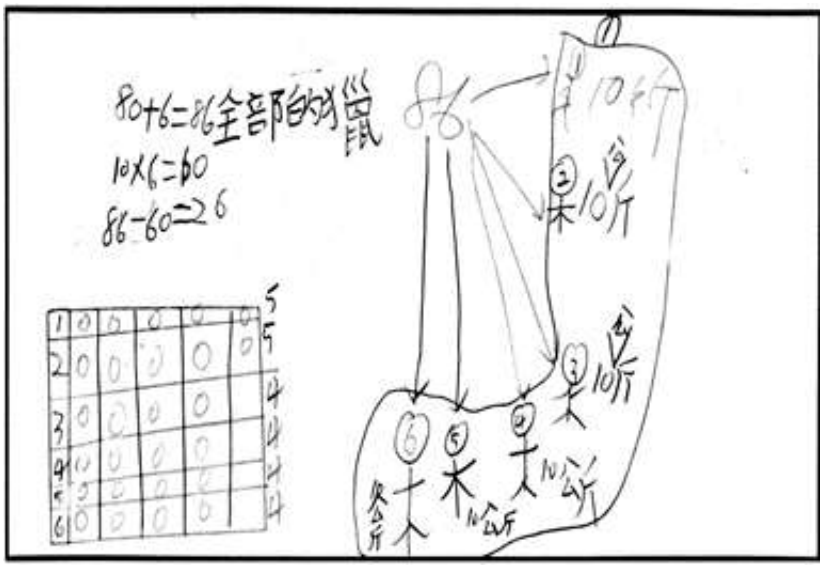

Figure 3: *LS52F Using Multiple Representation Strategies to Solve Problems*
(Source: Authors' Own Illustration 2020)

4.4.3. Improve Self-Confidence and Express Multiple Problem-Solving Strategies

This module made the equal rights situational atmosphere between the high- and low-achieving students to cooperate and discuss. This equality of rights allowed students contribute to the team scoring and transfer from the higher students who dominated the right to present.

Six low-achieving students (85.7%) were brave to present on stage, but they also calmly answered the teacher questioning. The module let them more confidently write the problem-solving strategy on the blackboard and practice oral presentation in the class.

5. Conclusion

In view of Taiwan education emphasis the important of multiculturalism and offer diverse remedial interventions for low-achieving indigenous students, this study provides a lot of information for analyzing the mathematics difficulties of culturally disadvantaged students and developing a mathematics remedial instruction module.

There are two reasons why this research can improve the learning outcomes of indigenous low-achieving students. As Liu (2023) said, *the most important thing for students to learn mathematics is to learn to think critically, enhances their creativity to solve problems and encourages them to seek new strategies*. But this kind of ability needs to rely on the teacher's teaching experience to develop it. The teaching implementation of this study is teaching multiple representation tools in the whole class; and in the small group, college students are also required to lead and encourage students to show cultural creativity when solving problems, and let them bravely show that they use their own good representation tools to solve problems.

Second, in addition to cultivating students' mathematical cognition and critical thinking ability in this module, the teaching research team also achieved Aristotle's ideology pointed out by Zhao (2023): *the importance of educating the heart!* The researchers observed that college students often in-depth interact with indigenous students to understand the impact of students' family environment on mathematics learning, so when they discuss the difficulties of indigenous students

with researchers, college students have an empathetic attitude that is *they often do beyond the eyes of my student, and learn to understand deeply what goes within the hearts and minds of the indigenous students* (Zhao, 2023).

To analyze the indigenous students resistance to learning mathematics lies in the difficulty of the four elements of tool, division of labor, community and rule in the learning system, just like Colville et al. (2023) analyzed special education students with activity theory. The researcher also held the same opinion: the learning difficulties of disadvantaged students are constructed by social, historical, and spatial culture.

The culture-integrated mathematics remedial modules help students reconstruct the definition above cultures. First, the students think about a good student who uses various mathematical representations to produce creative solutions, and sharing them with classmates. Second, the small group emphasizes collaboration to promote negotiation and discuss problem-solving strategies under the equal rights relationship. Third, the math problem is designed in the context of indigenous culture to let students learn the hard work of hunting and the virtues of hunters.

This study uses a small group of mixed genders, but the intervention also joined the mixed-age variables. Most girls were high achievers show power and authority to assist peer instead of having lower participation and verbal activity than boys (Wieselmann et. al. 2021).

However, in the guide process, the researcher observed girls easy felt frustrated and anxiety; because the boys not taking accept the guidance seriously. From the subject- *rule* element of activity theory to solve the problem the researcher observed that respecting the elders is virtue of indigenous culture. The module designed a peer tutoring system regards college students as mathematical elders. From the rule-tool elements to change this teacher-center assistance problem, the new module strengthened the indigenous students to show their good mathematical representations and help girls face frustration, such as encouragement and bonus points. From the

subject- division of labor elements to change the voices of unequal power, turn to cooperating to present problem solving strategy. It is also linked to the indigenous culture held by students that "as long as they contribute to the group, they are talented. Through the individual element or elements interaction of the activity theory could reduce the low-achieving students math anxiety and further got good performance.

5.1. Research Limitations

While this study provides important information about how indigenous low-achieving students attended the module to gain performance. Several limitations of the work must be considered. First, the tribal environment in which the participants grow and learn is relatively culturally closed; the peer tutoring methods of different school culture may affect learning outcomes. Second, the time for the remedial module teaching is after school, the time variable may also affect teaching and learning. Third, the peer tutoring team composed of university students to compare math teachers to tutor students may have different effects.

5.2. Future Research

Because of the above research limitations, this study proposes directions for future efforts in teaching practice. First, constructing the *Change Room* for mathematics remedial teachers: Thorgeirsdottir's (2019) *Change Room is to* let university teachers regularly participate in the action research group of school teachers, which will help teacher's innovative teaching. In the future, the teaching research team can invite mathematics remedial teachers and indigenous cultural workers to join in and cooperate in the design and implementation of mathematics modules.

Second, applying the concept of an expansive learning cycle elaborates the indigenous culture into the mathematics remedial module: refer to Suita Kuwai, which is a local traditional vegetable to design teaching in the integrated study (Tomizawa, 2020); then according to the three dimensions proposed by *expansion learning* (Engestrom, 2016) to elaborate the teaching content. In the socio-spatial dimension of expansion learning, the researcher will invite mathematics remedial

teachers and cultural workers of tribes to discuss and find the similarities and differences between the mathematical wisdom of indigenous culture and the school mathematics culture to reduce the tension between teachers and students in mathematics learning. In the temporal dimension of expansion learning, according to the cooperation of the above dialogue, the indigenous culture integrated into the mathematics module can not only respond to the delicacy of the indigenous traditional culture; and problem-solving methods in the future. In the political-ethical dimension of expansion learning, the module invited students to immerse themselves in the problem-solving tasks in real cultural practice to lead students to be like citizens of a democratic society, brave to present self-opinion and learn to negotiate the cooperation rules of the group in the future(Gutierrez 2012, p.21).

In terms of future research, two directions of efforts will propose. For the research topic, the researcher will individually interview the members of the teaching research team on issues such as indigenous students, disadvantaged cultures, and culture-integrated mathematics module and the conflicts generated by member interactions to understand the influence of society, spatial and history to this definition, and the use of activity theory to deal with conflict and the process of reaching the teaching innovation goal (Bal et. al. 2021).

For research participants, the teaching research team will include tribal cultural workers and school mathematics teachers to be research participants, to promote the social validity of the module.

ACKNOWLEDGEMENT

The current study is part of the research project (MOST 108-2511-H-320-001) supported by Taiwan’s Ministry of Science and Technology.

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