The Study of Indigenous Students' Learning Effect on Geometry Course with CPS Mobile Learning and Atayal Culture

Chao Jen-Yi[2], Liu Chuan-His[1], and Yeh Yi-Hsin[2]
[1] Department of Industrial Education, National Taiwan Normal University, Taipei, Taiwan
[2] Graduate School of Curriculum and Instructional Communications and Technology, National Taipei University of Education, Taipei, Taiwan
Email: jychao@tea.ntue.edu.tw, liuch@ntnu.edu.tw, s9003223@stu.ntue.edu.tw

Abstract—**This study established an indigenous culture-oriented collaborative problem solving–based (CPS-based) mobile lesson plans, teaching materials (game apps), and assessments for elementary school geometry, providing the indigenous students with another way to learn geometry (the chapter of Angles) and breaking the time and space boundaries of learning through mobile learning. The period of study spanned from 2017 to 2018, and the participants in this study were 16 5th grade students from an elementary school in which there are almost indigenous students located in Yilan County, Taiwan. This study provided geometry-related CPS mobile learning demonstration activities such as using mobile device learning and the game app competition of Angles. In the process, the tests that similar to the Programme for International Student Assessment (PISA) were conducted before and after the course to verify if the indigenous students' Angles concept exhibited significant changes by using the paired-sample t-test. Study results showed that the students' test results from the post-test were significantly better than those from the pre-test. Therefore, the combination of Atayal culture with CPS mobile learning courses was determined to have a significant positive impact on the geometry concept (Angles) of indigenous students.**

Index Terms—**Indigenous student; Geometry; Mobile learning; Collaborative Problem Solving (CPS); the Programme for International Student Assessment (PISA)**

I. Introduction

This study established courses and materials (to teach geometric concepts) by using CPS mobile learning (M-learning) methods and considering Atayal culture. The M-learning model freed learning from the confinements of time and space. Additionally, this model enabled students to learn anytime and anywhere, which enabled them to become active in learning, thereby improving the geometry learning outcomes of indigenous students.

For a long time, the authors have dedicated themselves to the research and promotion of indigenous science education in the Yilan County, Taiwan between 2009 and 2016.Because the learning styles of indigenous students include collaborative, dynamic, and hands-on learning, and this study integrated the CPS teaching strategy. In addition, aspects of Atayal culture were integrated into teaching materials for other science education topics in indigenous elementary schools, such as energy, robots, and creativity; this was implemented for an 8-year project for course-teaching and teacher-training activities. The objective of the present study was to expand previous research on the CPS teaching strategy integrated with Atayal culture and introduce the trend of M-learning. The study tried to design and establish M-learning CPS courses and materials that were suitable for indigenous students, and enable them to learn geometry concepts. An additional aim was to continue to train indigenous students in terms of applying geometric knowledge to real life and CPS ability.

This study explored the following research question: Did Atayal elementary school students' exhibit learning outcome improvements after learning the geometric concept of angles through a CPS teaching demonstration?

II. Literature

A. Related Research of Indigenous Learning

The majority of studies on indigenous education in Taiwan have determined that reasons for the slightly behind performance of minority students include their cultural backgrounds and teaching inconsistency. Additionally, indigenous people in remote areas have relatively fewer economic, cultural, and educational resources resulted in indigenous students' lower learning motivation and achievements [1], [2].

This study starts with improving the learning motivation and outcomes of indigenous students. To accomplish this, researchers must first understand the learning characteristics and predicaments of indigenous students. Taiwanese studies on the learning styles of indigenous students have revealed that the main learning difficulty faced by indigenous students is the difference between their culture and mainstream culture. Specifically, their cultural experiences and life experiences are not valued in their courses of learning, and their experiences differ from the mainstream

Manuscript received September 21, 2019; revised December 21, 2019.

doi: 10.18178/ijlt.6.1.1-6

experience and examples given in schools. These conditions hinder their ability to connect courses and knowledge as well as diminish their learning motivation and achievements [3], [4]. In addition, we should understand the preferred learning style of Indigenous students. In terms of learning characteristics, the Atayal students who participated in the present study preferred peer learning, focusing on collaboration and sharing, and a free-learning ambience without stress or competition as well as dynamic, hands-on, and inquiry-based learning situations [5]-[7].

Furthermore, studies both in Taiwan and worldwide have recommended considering learning characteristics in indigenous education when developing teaching methods, teaching designs, and teaching strategies. In addition, studies have suggested integrating the cultural and life experiences of students and teaching in accordance with their preferred learning methods to improve their learning motivation and outcomes [8]-[12].

A foreign study revealed that minority students, children of immigrants, and students from underprivileged groups were relative underachievers in mathematics [13]. Among the numerous studies on the mathematics learning of indigenous students in Taiwan, one study indicated that indigenous students experienced difficulties and their performance is different from students in the mainstream groups [14]. Perhaps because of the structural problems which the difference between indigenous and mainstream in culture and life experience, previous studies of the present author conducted in indigenous schools in Yilan County have revealed that the spatial ability test results of indigenous students were significant difference from those of Han students [15], [16]. However, subsequent implementations of teaching methods and materials for spatial concepts developed by integrating local Atayal culture have resulted in notable improvements in the spatial concepts of fifth- and sixth-grade indigenous students [17]. Therefore, the present study aimed to design and develop an M-learning course and materials (that were integrated with Atayal culture) to teach indigenous students geometrical concepts.

B. Geometry Learning

In addition to promoting indigenous students' learning motivation and spatial ability, a reason for the present study selecting geometry as its teaching topic was that geometry is an applied science and an idealized concept. For instance, daily utensils from ancient times can be categorized by their shape, and in some cases, their functionality was related to their shapes. A study indicated that geometry is a subject concerned with the shape, size, and location of an object, and their respective relationships. The primary elements of geometry studies include points, lines, curves, circle, planes, and dimensions [18].

With respect to research related to geometry learning outcomes in Taiwan, teaching in elementary schools primarily focuses on recognizing patterns and understanding pattern concepts. In recent years, studies have focused on the learning outcomes of using multimedia and mobile devices as learning assistants [19], [20]. Cheng studied teaching materials for the Grade 1–9 curriculum and revealed that current geometry course designs for elementary and junior high schools in Taiwan were aimed at developing the ability of formal deduction, gradually developing it from intuitive visualization to formal deduction. Furthermore, although geometry learning in elementary schools was found to be abundant with plentiful introductions to geometric properties, proper thinking environments for decomposition and reconstruction had not been established. In particular, students learned each property individually, and were unable to visualize properties in complex patterns. Therefore, Cheng emphasized the importance of teachers enhancing recognition and inference of pattern properties in addition to linguistic communication when teaching geometric properties [21]. One study indicated that students with excellent spatial and geometry performance were also more likely to excel at painting, mechanics, and science, in addition to possessing an extraordinary understanding of geometry concepts [22]. In addition, because of the rise of the three-dimensional printing application industry, excellent spatial ability was found to increase the competitiveness of a student in terms of both academic achievements and employment scenarios [23]. Therefore, the present study focused on geometric ability teaching in schools to prepare indigenous students with the abilities required for future academic and professional competition.

C. M-Learning

Since 1997, the Taiwan Ministry of Education has implemented the Information Education Infrastructure Project and Taiwan's Master plan for K-12 ICT Education. In 2006, the Whitepaper for ICT in K-12 Education as well as other E-learning projects were established. The objectives of these projects were for teachers to take advantage of information technology to enhance their teaching quality and students' learning ability, and to provide equal opportunities in E-learning [24]. These projects have obtained numerous achievements in information education and E-learning developments. With the aim of achieving "in-depth learning and digital citizenship," the objective of Taiwan's 2016–2020 Master plan for ICT in Education was to cultivate students' ability to effectively use information technology to familiarize themselves with learning contents and apply them in various scenarios. The ICT education master plan includes four aspects, namely learning, teaching, environment, and organization. In particular, the environment aspect was aimed at overcoming limitations of space and time through providing resources in the cloud for students to learn anytime and anywhere. In addition, addressing and improving the rural–urban digital environment gap was another focal point of the project [25]. With the advancements in ICT and developments in the mobile technology industry, learning situations and learning contexts have changed. Because of the Internet environment and information tools, learning is no longer confined to classrooms. Moreover, ICT education has shifted from digital learning to mobile learning. M-learning refers to creating a diversified learning environment free from local limitations through the use of mobile devices and the mobile Internet environment. Such a learning environment enables individuals to engage in personal mobile learning. The convenience, expediency, and immediacy of M-learning is obtained when learners learn about appropriate activities and contents in a timely manner using wireless Internet and mobile devices [26]-[28]. The ideal progress of M-learning is to begin from E-learning, then progress to M-learning, and ultimately achieve ubiquitous learning (U-learning); simultaneously, this process progresses from wired to wireless and finally to achieving a state of disappeared [29].

In recent years, Taiwan Ministry of Education has proactively developed the Elementary and High School Mobile Learning Project, which reflects the importance of mobile learning to the government. A total of 179 elementary and high schools in Taiwan currently participate in the project (a detailed list can be found at http://mlearning.ntue.edu.tw/about/school.html).Although nine elementary schools in Yilan Country participated in this project, the Rainbow Elementary School (anonymous), the research subject of the present study, was not one of them. However, the present study sought to help the teachers at the Rainbow Elementary School to introduce mobile learning to mathematics and science courses.

D. Collaborative Problem-solving Strategy and Ability

In addition to employing mobile learning as a teaching strategy, CPS was used as a main teaching and learning strategy. The reason for this as well as its specific implementation methods are described as follows.

Nelson proposed the CPS teaching strategy, which is a collaborative learning method oriented by problem solving. First, the teacher must divide students into different groups. Members of each group are then asked to discuss a specific topic based on the knowledge they have acquired and then work on an assigned task concerning learning roles. Subsequently, members of the group complete the learning task through communication and support within the group [30].

This study employed the CPS teaching strategy because indigenous students prefer collaborative learning methods. Moreover, the CPS method coincided with international and national trends in education and the ability to collaborate with others, which the CPS method emphasizes is a crucial ability in future society. In response to this trend, the Ministry of Education has commissioned the National Taichung University of Education to organize CPS teaching ability improvement projects over the past 2 years [31]. The goal was to use the CPS teaching strategy to nurture students' problem-solving ability in real life as well as their ability to explore and analyze learning contents from diversified perspectives. With the development of technology, human interactions have diversified and situations requiring problem-solving skills have become more common. Therefore, CPS ability is considered a crucial skill for the twenty-first century. In 2015, the Organization for Economic Co-operation and Development added CPS ability to the list of core literacies in its Programme for International Student Assessment (PISA), in addition to the original science, reading, and mathematics skills [32].

The assessment for CPS ability is currently under development. The majority of studies are still in the trial stage without a foundation theory for assessment. The PISA employs a computer-simulated human agent in online chat rooms to conduct a discussion on a particular topic. Moreover, studies have applied computer-based collaborative behavior assessments to assess CPS ability [33], [34]. International studies have indicated that the CPS teaching strategy could improve the learning outcomes of students; moreover, social interactions in collaborative learning have enhanced students' cognition [35]. Therefore, the authors of the present study believed that incorporating the CPS strategy with mobile learning for geometry courses can promote the formation of spatial concepts, enhance problem-solving abilities, and improve the self-confidence of indigenous students.

III. Research Method

The present study employed a case-study design. Assessment tests were administered to students before and after participating in the Atayal culture-integrated CPS spatial concept teaching activities, and the results were used as quantitative research data. The research employed a single-group pretest-posttest design. Items established for the tests were examined for validity by experts, and pretests and a reliability analysis were conducted to enhance the validity and reliability of these self-developed, real-life-based question-group assessments.

A. Course Planning

The class was 100 minutes in length and consisted of two sections. Through heterogeneous grouping, each team discussed and learned the geometry concept (Angles) 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, and observation of the use of teaching materials (game apps).

All mobile learning game apps established in this study were written for the Android operating system, and thus are fit for Android mobile devices. The app used to assist teaching the geometric concept of angles, developed this year, is described as follows:

The context of the interactive digital teaching material of the "angle" unit is based on the "hunting culture" in the Atayal culture. The app game of angles is divided into two levels: Prey Search and Hunting Practice (Fig. 1–Fig. 3).

Figure 1. Prey Search level description; (Top) Goal: You need to catch the frogs in a limited time, only one chance per task; (Bottom) Description: After selecting the "rotation angle" that you need, the boat will rotate to the direction you want. After selecting the left or right prey, please press OK to hunt.

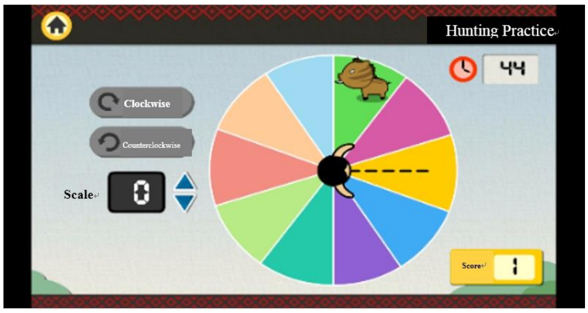

Figure 2. Hunting Practice game screen; Left button (top to bottom): clockwise, counterclockwise, scale; Right icon (top to bottom): level remaining time, score.

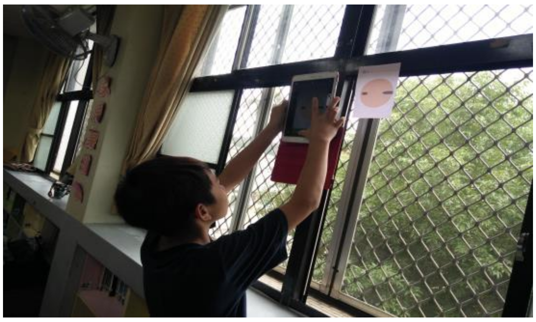

Figure 3. The student used tablets for mobile learning.

B. *Research Subject*

The main research subjects were 16 5th grade Atayal elementary students from 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 sample t-test analysis.

C. *Research Tools*

The research tool was a test assessment that had been approved and pre-tested (Cronbach $\alpha = 0.781$) by three subject matter experts with a total of 9 question sets (9 individual questions). Dependent sample t-tests were 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.

D. *Research Result*

In this study, a total of 16 fifth-grade indigenous students from the Rainbow Elementary School participated in the pretest and posttest of the teaching demonstration. The total number of valid tests was 15 because one student was absent. Both tests comprised three question groups and nine question items, which added up to 100 points in total. The results of these real-life-based question-group assessments revealed that the mean score of the posttest was notably higher than that of the pretest among students who received the CPS mobile learning teaching demonstration on the geometric concept of angles (Table I). In addition, the analysis results of a dependent samples t-test (Table II) revealed that the difference in pretest and posttest mean scores was11.6, and t value=3.477, degree of freedom=14, and $p=0.004<0.01$, which reached the level of significance (0.01). These results indicated that according to the dependent samples test results on the concept of angles, the posttest scores were significantly higher than the pretest scores.

TABLE I. DESCRIPTION AND STATISTICAL ANALYSIS OF THE REAL-LIFE-BASED QUESTION-GROUP ASSESSMENTS ON THE CONCEPT OF ANGLES

	Amount	Mean Score	Standard Deviation
Pretest	15	65.60	17.488
Posttest	15	77.20	16.894

TABLE II. STATISTICAL ANALYSIS ON THE DEPENDENT SAMPLES T-TEST OF THE REAL LIFE-BASED QUESTION-GROUP ASSESSMENTS ON THE CONCEPT OF ANGLES

	Mean	SD	SEM	t	DOF	Significance
Posttest Sum–Pretest Sum	11.6	12.922	3.336	3.477	14	.004**

**P<0.01

IV. DISCUSSION

A. *Indigenous Students Prefer a Dynamic and Lively Learning Method*

Studies have revealed that Atayal students in the Yilan Country are fond of lively, dynamic, and interactive teaching strategies. In addition, research have revealed that some indigenous students were impatient to read instructions even when the pretest and posttest featured numerous scenarios related to and images of Atayal culture. They would quickly answer questions without fully comprehending their meanings. Therefore, in the present study, teachers went through and explained all the questions to the students before each test was conducted to prevent the abovementioned situations.

In addition, studies on applying game-based digital materials to elementary schools as teaching aids have led to improvements in students' learning motivation and outcomes in terms of mathematic concept learning, such as Euclidean geometry and spatial concepts. Similarly, the results of the present study revealed that the mobile learning digital material was remarkably effective at improving the indigenous students' understanding of angles.

B. Indigenous Students Appreciate Collaboration and Sharing but Lack CPS Skills

Because this study employed the CPS teaching strategy, all courses and learning activities were designed to be conducted in groups. Although indigenous students are fond of the peer learning style that emphasizes the value of collaboration and sharing, observations of the in-class group discussions revealed that these students still had room for improvement in terms of discussing and distributing tasks. Therefore, the design of future classes for similar subjects should familiarize students with teamwork by increasing discussion and employing the CPS method to resolve problems and complete tasks.

V. Conclusion and Suggestion

A. Conclusion

This study established a CPS learning course for geometry concepts that incorporated Atayal cultural context and considered the learning characteristics of indigenous students. In addition, PISA-like real-life-based question-group assessments with indigenous cultural elements were established to assess the real learning performance of students. An interactive mobile learning material designed for this study was employed to conduct the CPS teaching demonstration. The geometry performance of indigenous students was determined to improve their mathematic learning and problem-solving abilities.

According to this study, Atayal students who participated in the CPS teaching demonstration achieved higher scores in posttests than in pretests assessing the geometric concept of angles. In other words, learning outcomes were notably improved.

B. Suggestion

1) Adapt measures of mobile learning in remote areas

The Internet bandwidth and speed in remote areas have always been challenges for this project, from previous research until the current stage. The authors suggest that future researchers who plan to employ apps or Internet resources for teaching in mobile learning courses to download relevant apps or resources to the mobile devices beforehand. Another solution is to sign up for mobile Internet plans that can share data to cope with any Internet or device-related problems. In addition, they should test the mobile device (e.g., tablets or mobile phones) before the classes and prepare extra devices to reduce the chances of unexpected incidents as well as retain the quality and outcomes of teaching.

2) Nurture collaboration ability step by step

According to the experiences of previous research, students must have similar experiences several times in class to gradually develop models of and skills for group collaboration and discussion. Therefore, for testing the actual CPS ability of indigenous students, students must first be given time to familiarize themselves with working on and completing tasks as a team as well as learn relevant skills in class. In other words, students must learn to conduct group discussions and problem-solving through step-by-step collaborative measures beforehand. A further measure that will be adopted by the authors is adding an introduction and practice on collaborative methods before classes begin to quickly integrate students into the course as well as reduce the time required for instruction during the actual class.

Conflict of Interest

The authors declare no conflict of interest ,financial or otherwise.

Author Contributions

Chao Jen-Yi and Liu Chuan-His conceived of the presented idea and conducted the research. Chao Jen-Yi and Liu Chuan-His also verified the analytical methods. Chao Jen-Yi encouraged Yeh, Yi-Hsin to analyze the data and wrote the findings of this work. All authors discussed the results and contributed to the final manuscript; all authors had approved the final version.

Acknowledgment

This research is part of the project "A study of embedding indigenous culture into elementary mathematics and sciences courses for CPS mobile learning, evaluation system and teacher training" of the Taiwan Ministry of Science.

References

[1] H. J. Huang, "Problems of indigenous education and countermeasures," *Taiwan Educational Review Monthly*, vol. 4, no. 1, pp. 179–181, Jan 2015.

[2] H. N. Kao and C. C. Lin, "Discussion on the unfavorable attribution of indigenous students' academic achievement," *Taiwan Educational Review Monthly*, vol. 5, no. 4, pp. 50–54, Apr. 2016.

[3] M. H. Lin, C. F. Yen, and H. Lee "The envision and difficulty of indigenous science education," *Studies on Humanity and Ecology in Taiwan*, vol. 10, no. 1, pp. 89–112, Jan. 2008.

[4] Y. C. Liu and S. H. Huang, "Determining learning methods of indigenous students through small experiments," *Science Development*, vol. 510, pp. 66–71, Jun. 2015.

[5] K. D. Tan and Y. T. Guo, "The qualitative study of Atayal adolescents' learning styles," *Educational Research & Information*, vol. 10, no. 3, pp. 149–165, Jun. 2002.

[6] K. D. Tan, M. H. Liu, and M. H. Yu, *Multicultural Education*, Higher Education Culture Press, Taipei, Taiwan, 2008, pp. 113-150.

[7] M. H. Su, "Learning styles of indigenous students and the educational application," *E-Soc Journal*, vol. 40, Jun. 2004.

[8] Y. S. Chou, S. H. Huang, and P. T. Yu, "The influences of the application of animation teaching toward indigenous students' aesthetic experience," *Educational Technology & Learning*, vol. 3, no. 1, pp. 1–24, Jan. 2015.

[9] H. M. Chou, "Integrating indigenous knowledge in culturally responsive curriculum," *Journal of the Taiwan Indigenous Studies Association*, vol. 1, no. 2, pp. 167–190, Jun. 2011.

[10] C. Y. Chang and T. Y. Lo, "Study on the effectiveness of mathematics and science class activity design and experimental teaching for indigenous elementary school Students in Remote Areas," (NSC 96-2515-S-320-001-MY2). National Science Council of the Executive Yuan, Taipei, Taiwan, 2009. (unpublished)

[11] Gay, G. *Culturally Responsive Teaching: Theory, Research, and Practice*, Teachers College Press, New York, NY, 2000.

[12] U. Palaliau and P. Rusagasag, “How to make mathematics education aboriginalized,” *Aboriginal Education World*, vol. 28, pp. 60–63, Aug. 2009.

[13] J. G. Benson and G. D. Borman, “Family and contextual socioeconomic effects across seasons: When do they matter for the achievement growth of young children?” (WCER Working Paper No. 2007-5). University of Wisconsin–Madison, Wisconsin Center for Education, Madison, WI. Research, 2007.

[14] W. M. Hsu and Y. C. Yang, “What factors influence indigenous students' mathematics learning: An action research in a tribal elementary school of Pingtung county,” *Journal of National Taichung University: Education*, vol. 23, no. 1, pp. 129–152, Aug 2009.

[15] C. Y. Chao, C. H. Liu, C. Y. Chen, and Y. C. Liu, “Elementary school science class development and implementation integrating Atayal culture, CPS, and ‘do it yourself’: A case study on energy, computer robots, and creativity,” presented at 2011 National Indigenous Studies Paper Presentation, Chiayi, Taiwan, December 20, 2011.

[16] J. Y. Chao, J. Y. Chen, and S. C. Chi, “Exploring the differences between learning of indigenous and Han children in the instructional approach of building blocks by hand,” *Advances in Education Research*, vol. 9, pp. 332-337, Dec. 2012.

[17] J. Y. Chao, C. H. Liu, and Y. H. Yeh, “Analysis of the learning effectiveness of Atayal culture CPS spatial concept course on indigenous students,” *Eurasia Journal of Mathematics, Science & Technology Education*, vol. 14, no. 6, pp. 2059-2066, Jun 2018..

[18] M. H. Huang, C. C. Chu, C. Hsieh, S. L. Liao, P. H. Lu, Eds., *Analysis of Elementary School Mathematics Teaching Materials: Geometry*, National Academy for Educational Research, New Taipei City, Taiwan, 2006.

[19] Y. Y. Chang, “Investigation of the effects of measuring authentic contexts to geometry learning achievement, geometry estimation ability, spatial ability and van Hiele levels,” M.S. thesis, Dept. Network Learning Technology National Central Univ., Taoyuan, Taiwan, 2016.

[20] H. Y. Lin, “A study of applying van hiele geometric thinking level theory to develop the multimedia materials of plane geometry for elementary students,” M.S. thesis, Dept. digital Technology Design, National Taipei Univ. of Education, Taipei, Taiwan, 2015.

[21] Y. H. Cheng, “Difficulties of visualizing geometrical patterns for elementary school students,” presented at 2010 Conference of Mathematics and Information Education, Taipei, Taiwan, June 19, 2010.

[22] T. H. Kuo, Y. P. Chen, and R. Y. Yuan, “The relationship between mental imagery and drawing performance style of Taiwan elementary students,” *Taiwan Educational Review Monthly*, vol. 5, no. 4, pp. 166-193, Apr. 2016.

[23] W. C. Shan, “Literacy, curriculum, and teaching materials: A case study of mathematics,” *Pulse of Education*, vol. 5, pp. 1-19, Jan. 2016.

[24] The Ministry of Education, “2008–2011 Taiwan MOE’s whitepaper for ICT in K-12 education,” The Ministry of Education, Taipei, Taiwan, 2008.

[25] The Ministry of Education, “Taiwan’s 2016-2020 master plan for ICT in education,” The Ministry of Education, Taipei, Taiwan, 2016.

[26] Y. J. Su, H. Y. Peng, and C. Chou, “Mobile learning re-visited: Definition and the essential components,” *Instructional Technology & Media*, vol. 70, pp. 4-14, Dec. 2004.

[27] K. Peters, “M-Learning: Positioning educators for a mobile, connected future,” *The International Review of Research in Open and Distributed Learning*, vol. 8, no. 2, pp. 19-28, Jun 2007.

[28] Y. H. Chiang, “Mobile learning: Breakthrough and difficulties of flipped learning capacity,” *Taiwan Educational Review Monthly*, vol. 5, no. 12, pp. 5-8, Dec. 2016.

[29] Y. Park, “A pedagogical framework for mobile learning: Categorizing educational applications of mobile technologies into four types,” *The International Review of Research in Open and Distributed Learning*, vol. 12, no. 2, pp. 78-102, Nov. 2011.

[30] L. M. Nelson, “Collaborative problem solving,” in *Instructional-Design Theories and Models: A New Paradigm of Instructional Theory*, C. M. Reigeluth Ed., Erlbaum Associates, Mahwah, NJ, 1999.

[31] Y. C. Wu, “Be a God-like teammate: Collaborative problem solving for teaching improvements,” *Latest News of the Ministry of Education*, 2016.

[32] Y. C. Chou, “A study on collaborative problem-solving ability and attitude of students in upper elementary grades,” M.S. thesis, Dept. Education, National Univ. of Tainan, Tainan, Taiwan, 2017.

[33] K. Herborn, M. Mustafić, and S. Greiff, “Mapping an experiment-based assessment of collaborative behavior onto collaborative problem solving in PISA 2015: A cluster analysis approach for collaborator profiles,” *Journal of Educational Measurement*, vol. 54, no. 1, pp. 103-122, Mar. 2017.

[34] C. W. Hsiao, “Introduction of PISA collaborative problem-solving evaluation,” *National Academy of Educational Research e-Newsletter*, vol. 106, Feb 2017.

[35] D. DeWitt, N. Alias, S. Siraj, and J. M. Spector, “Wikis for a collaborative problem-solving (CPS) module for secondary school science,” *Educational Technology & Society*, vol. 20, no. 1, pp. 144-155, Jan 2017.

Chao Jen-Yi is currently the Prof. of Graduate School of Curriculum and Instructional Communications Technology, National Taipei University of Education, Taiwan. Her expertise includes Instructional Design, Project-Based Learning, E-Learning, Digital Content Design and Development, and Educational Technology. Her current research interests mainly cover Indigenous Education and Information Technology Education for the elderly. She has long been concerned and studied the mathematics and science learning of elementary and high school indigenous students in Nan'ao. She is also the principal investigator of two integrated research projects, including: (1) Integrating Indigenous Culture with CPS Science Curriculum: The Study on Metacognition and Creativity of Problem Solving in Science for Indigenous Elementary Children (2009-2013), and (2) The Development and Establishment of a CPS Teaching and Assessment Platform for Spatial Concept Courses for Indigenous Students (2013-2017). Dr. Chao is also the principal investigator of the project entitled “Effects of Information Technology Application Courses on the Information Literacy and Learning Experience of Senior Citizens” (2016-2018).

Liu Chuan-His received his Ph.D. in Electrical Engineering from Arizona State University, USA, in 1997. He is a Full Professor at Department of Mechatronic Engineering, National Taiwan Normal University. He has published over 100 journal and conference papers and being granted over 20 patents. He has also coauthored a book (in Chinese) entitled Semiconductor Device Physics and Process: Theory & Practice (3rd edition). His current research interests include advanced CMOS technology and its process optimization. Prof. Liu served in the Committee of the IEEE International Electron Devices Meeting (IEDM) in 2003 and 2004.