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Effect of Integrating Blended Teaching into Mathematics Learning for Junior High School Students

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ABSTRACT. *This case study aimed to establish a blended teaching model and investigate math learning effectiveness among junior high school students. A quasi-experiment was employed in this study. A total of 55 subjects from 2 classes were placed into either an experimental group (28 students) or a control group (27 students). The research tools included the FingerClick Interactive Response System, AVer F50real object projector, Facebook instructional club, the mathematics learning attitudes scale, and an interview. All of the collected quantitative data were analyzed using one-sample t test, independent t test, ANOVA, and ANCOVA. The findings of the study reveal that (1) the students' learning desire, learning process, learning method, mathematics beliefs, and total mathematics learning attitude scores are positive and statistically significant; (2) the experimental group's discussion and feedback are more active than those of the control group; and (3) blended learning is significantly more effective than traditional learning. Finally, a blended teaching model and suggestions are proposed for practitioners and educators.*
Keywords: *blended teaching, Facebook, mathematics learning attitude, Interactive Response System (IRS)*

1.Introduction

Mathematics is the language of science. Siyepu (2013) stated that mathematics is a requirement for various jobs in every discipline, and it is a core subject in basic educational settings. Math

education emphasizes opportunities for students to have meaningful and efficient learning experiences. Hence, students should obtain the critical "math knowledge" and "math capacities" needed in daily life and in the workplace (Berlin and White, 1998; Czerniak and others, 1999). According to an investigation by the Ministry of Education's Department of Statistics of 154,426 students in 866 elementary and junior high schools in Taiwan, mathematics is the most disliked subject among elementary, junior high and senior high school students. Siyepu (2013) also noted that in South Africa, there is a high mathematics failure rate and a huge shortage of skilled workers with appropriate mathematics competencies. Stodolsky, Salk, and Glaessner (1991) suggested that the keys to successful math learning are logic, abstraction skills, and the instructional method. Mathematics cannot be essentially changed, but improvements in a teacher's instructional skills and designing instructional activities for peer interactions can result in active learning for students. Burgess (2003) indicated that through e-learning, students can learn in different places at any time, and they can keep practicing until they master a skill. E-learning creates a flexible educational environment that can satisfy diverse learning needs and thereby enhance and expand educational effectiveness (Garrison and Vaughan, 2008; Usta and Ozdemir, 2007). Therefore, learning effectiveness is expected to be enhanced by information-technology-based mathematics instruction.

According to Thorne (2003), blended learning refers to an approach in which individuals are provided with an adaptive learning method that combines innovative e-learning tools, the advantages of technology and traditional classroom instruction. Blended e-learning has the advantages of both teacher-oriented traditional classroom education and student-oriented e-learning. This approach reduces the indifference associated with online courses and avoids the interpersonal apathy and frustration that can inhibit learning; furthermore, blended learning enhances learning quality and effectiveness (Cottrell and Robison, 2003; Singh, 2003). In recent years, research on blended e-learning has become increasingly common. Some research has suggested that blended e-learning can enhance students' learning effectiveness (Gulbahar and Madran, 2009; Usta and Ozdemir, 2007; Vaughan and Garrison, 2005). Hence, studies on the enhancement of mathematics learning effectiveness via blended teaching—compared to traditional instruction—are essential to better understand blended learning.

Thus, from the perspective of information-technology-based mathematics instruction, this study examines the effect of blended teaching on the mathematics learning effectiveness and attitudes of students in grades 6 to 8. The study attempted to determine how to apply information technology within traditional instruction by treating information technology as a learning tool and learning partner and by combining instruction and learning with information technology as a new model for teachers and students. The aims of the research are below:

1. Construct an instructional model "to apply blended teaching to enhance mathematics learning effectiveness and learning attitudes of junior high school students"
2. Understand the effect of blended teaching on junior high school students' mathematics learning

attitudes

3. Compare differences in junior high school students' mathematics learning effectiveness based on blended teaching and traditional instruction

2. Literature Review

For research purposes, the literature review addresses blended learning, mathematics learning attitudes, mathematics learning effectiveness and interactive learning platforms.

Research related to blended learning

Stacey and Gerbic (2009) note that many definitions of blended learning refer to combining face-to-face and online learning. They also describe blended learning as "the combination of modes of learning and teaching made possible through the mediation of ICT" (Stacey & Gerbic, 2007, p.166). Blended learning combines traditional face-to-face instruction with information-technology-based instruction to enhance interactions between teachers and students and to increase students' high-level independent learning (Graham, 2006). Thorne (2003) suggested that blended learning integrates innovative e-learning tools and the advantages of technology with traditional classroom learning to provide individuals with the most adaptive learning method. Researchers argue the real indicator of blended learning is not the amount of face-to-face or online learning but its effective integration within a course (Garrison and Kanuka, 2004; Stacy and Gerbic, 2009).

Blended teaching has become popular because it combines the advantages of digital online learning and those of traditional classroom learning (Morgan, 2002; Young, 2002). The appropriate use of instructional media, such as online learning courses, DVDs, computer simulations and demonstrations, e-books, the internet, and PowerPoint presentations, should result in efficient blended learning (Bersin, 2004; Graham, 2006). Mayisela (2013) concluded that using mobile technology with blended learning can effectively enhance accessibility and communication for learners in South Africa.

Thus, blended learning can be treated as an instructional model that integrates various synchronous or asynchronous online techniques to enhance interactive learning and values collaborative learning and individuals' independent learning needs. Only continuous innovation and development can result in the maximum effectiveness and flexibility of blended learning. This study uses the theory of blended learning as the basis on which blended teaching is designed.

Research on mathematics learning attitudes and mathematics learning effectiveness

Mager (1968) suggested that guiding a student's attitude is one strategy to enhance learning. An active learning attitude is the ideal learning base, and cultivation of a positive learning attitude should not be neglected. Garfield (1977) divided mathematics learning attitudes into five components: (1) acceptance: intention to learn mathematics; (2) reaction: intention to participate in math activities; (3) value: active acknowledgement of the practicality of mathematics and promotion of math activities; (4)

organization: integration of mathematics concepts into the student's personal value system; and (5) confirmation of value: total identification with math concepts and values as part of personality. Thus, according to research, although mathematics learning is a cognitive process, attitudes toward mathematics are critical factors that influence a student's choice to continue studying mathematics or to pursue a job in the mathematics industry. Students with optimistic mathematics attitudes tend to have higher learning achievement.

The most basic operational definition of learning effectiveness is based on a student's academic grades (midterm and final grades) (Piccoli and others, 2001). Mathematics learning effectiveness in this study refers to a student's scores on "mathematics achievement tests in junior high school." Higher scores reflect greater effectiveness; lower scores reflect lower effectiveness. Among foreign scholars who research mathematics learning attitudes and learning effectiveness, Ma and Xu (2004) suggested that the degree of mathematics learning effectiveness plays a critical role in mathematics learning attitudes. Better mathematics learning attitudes lead to better mathematics learning effectiveness. In addition, the findings of McCoy (2005) demonstrate that mathematics learning attitudes significantly influence mathematics learning effectiveness.

In terms of mathematics education in South Africa over recent years, some South African scholars have implemented projects with various learning strategies and models to address certain issues. For instance, Roberts and Vanska (2011) studied 30 public secondary school mathematics projects using Nokia Mobile Learning in South Africa. Spire and Reed (2011) discuss the findings from a case study of a collaborative OER development project initiated by the South African Institute of Distance Education (SAIDE). Muthukrishna (2013) concluded that explicit and fully developed instructional plans can be provided to mathematics teachers with limited content and pedagogical knowledge and positively affect the mathematics proficiency of children in South Africa. Bester and Brand (2013) also showed that the association between motivation and concentration was significant and positive and that the correlation among attention, concentration and motivation was moderately to highly positive for learning geography, English, and mathematics through technology. Siyepu (2013) also addressed the importance of mathematics in various disciplines in South Africa and suggested some possible solutions for the development of mathematics instructional practices.

Interactive learning tools

The interactive learning tools in this study included (1) an AVer F50 real object video camera, (2) a FingerClick IRS and (3) a Facebook (FB) community website, as shown below.

(1) AVer F50 real object video camera (also called real object projector): using the portable real object video camera and its built-in computer, teachers can easily construct notes on the screen. The AVer F50 can produce high-definition images and can focus rapidly and automatically. It has a flexible goose arm and can capture excellent, clear images through single-stream video recording. The images can be saved on a USB or SDHC drive at any time for review and application after class. A

combination of teaching materials and real object projector videos can be used along with careful planning, design and implementation to enhance mathematics instruction and mathematics learning effectiveness in a blended teaching methodology.

(2) FingerClick Interactive Response System (IRS) and instructional interactive remote control: these are important devices in a "highly interactive e-classroom" that are applied in class. Students hold an interactive remote control that communicates with a USB receiver connected to a computer. Responses can be collected during instruction, and teachers can pose questions or give quizzes at any time. A highly interactive e-process can enhance learning effectiveness, provide a complete record, and analyze learning situations. The characteristics of this method include (1) e-teaching materials and easy lesson preparation; (2) e-explanations and interactive instruction; (3) e-evaluation and immediate feedback; and (4) e-management and learning analysis. Thus, teachers can use the FingerClick IRS and the corresponding instructional interactive remote control to evaluate mathematics instruction. In-class e-learning using the IRS facilitates weekly summative evaluations. There are 6 rounds of scores.

(3) FB community website: Facebook.com was founded by 23-year-old Mark Zuckerberg on May 24, 2005. The club function of Facebook is a platform for user discussion. Members in the club have equal status, and users can post activities related to the club's aims. Using the privacy settings, the clubs are only open to members. Non-members cannot see clubs' discussions and related activities. Therefore, we treated the experimental group as members who could establish an instructional club on FB. Using the real object projector, class videos were recorded and uploaded to FB for asynchronous online instruction. Students' online learning is personal and active, and it is not limited by time or location. Applying social networks in regular courses is worthwhile and beneficial to learners because they can learn interactively with others and the teacher can post their supplementary materials online for students (Cheng, Isman, Hsu, & Hsin, 2014).

3. Research design and implementation

This study employed a quasi-experiment. The research subjects were 55 seventh grade students from a junior high school in Pingtung, Taiwan. One class (28 students) was the experimental group, which received blended teaching, and the other was the control group (27 students), which received traditional/conventional instruction. The blended teaching method was the independent variable, including asynchronous online instruction, in-class e-learning, and group knowledge sharing. The dependent variables were mathematics learning attitude and mathematics learning effectiveness. The research materials include the mathematics learning attitude scale, mathematics learning effectiveness tests, the AVer F50real object projector, the FingerClick IRS, FB instructional club, and an interview. Before and after the experiment, pretests (the first math examination; O_1) and posttests (the second math examination; O_2) were given, respectively. After the experiment, "the mathematics learning

attitude scale" (O_3) was filled out by the experimental group. Statistical analyses were performed with SPSS16.0 to examine the effect of blended teaching on mathematics learning effectiveness and attitudes in junior high school students (Table 1).

Table 1 Quasi-experimental design of blended teaching

Group	Pretest	Experiment	Posttest
Experimental group	O_1	x	O_2, O_3
Control group	O_1		O_2

The research setting consisted of (1) the instructor, who was responsible for the instructional activities of the experimental and control groups, (2) the experiment in which (a) the experimental group received blended teaching for 6 weeks, including 5 sections per week, (b) the control group received traditional instruction for 6 weeks, including 5 sections per week, and (3) the instructional strategies for the 2 groups (Table 2).

Table 2 Instructional strategy differences between experimental and control groups

Items		Experimental group	Control group
Class learning	Preparation	Long lesson preparation time	Short lesson preparation time
	Practice	Blended teaching	Lecture
	Application	Interactive group sharing	One-way individual sharing
	Evaluation	Interactive Response System (IRS)	Written test
Review after class	Pattern	Asynchronous online instruction	Individual practice

Source: Compiled by the researchers

The collected data from the pre-test, post-test, and the mathematics learning attitude scale were analyzed by SPSS 16.0, including descriptive analysis, one-sample t-test, independent t-test, ANOVA, and ANCOVA. Qualitative data from the interview, FingerClick IRS, and Facebook instructional club were summarized and coded by the researchers.

4. Results and Discussion

This study examined the effect of blended mathematics teaching on the learning attitudes and effectiveness of junior high students compared to traditional instruction, as shown below.

Current situation and analysis of mathematics learning attitude

This study adopted Lin's (2001) "scale of mathematics learning attitudes," which includes a total of 30 items, such as the student's desire to learn, learning process, learning method and mathematics belief. Students who received blended teaching completed the scale after experimental instruction to measure the "mathematics learning attitude" of the experimental group, as shown in Table 3. The mean value for learning desire was 51.71, and the t-value was 24.62. The mean value for learning process was 32.60, and the t-value was 32.78. The mean value for learning method was 15.10, and the t-value was 21.64. The mean value for mathematics belief was 17.53, and the t-value was 28.77. The mean value for the overall performance was 116.96, and the t-value was 31.89. The *p*-values were lower than .000, and they were significant. Thus, after receiving experimental instruction, the experimental group showed positive values for desire to learn mathematics, learning process, learning method and belief.

Based on the above, the findings of this study show that blended teaching can effectively enhance learning attitudes, in agreement with Futch (2005). Hence, blended teaching in mathematics results in positive mathematics learning attitudes in junior high school students.

Table 3 Results of t-test values on the mathematics learning attitudes

Dimensions	Test value=3		
	Average score of each item	*T*	df
Learning desire	3.69	4.92***	27
Learning process	4.07	9.53***	27
Learning method	3.77	5.55***	27
Mathematics belief	4.38	10.96***	27
Total score	3.90	7.55***	27

***$p<.001$

Textual analysis of students' mathematics learning attitudes

To understand the experience of the students in the experimental group, an interview of the students' learning attitudes toward the real object projector, the FB instructional club and the IRS was developed. The analysis is shown below.

Instruction with the real object projector

(1) Multiple teaching materials can enhance a student's ability to learn course knowledge. Using a real object projector, a teacher can magnify images in textbooks or of real objects to explain key points and thereby enhance the student's learning environment and motivation. For instance, teachers can use examples in textbooks, interpret real objects, review tests, and analyze key points and video recordings and thereby trigger the learning potentials of different students. Hence, students will absorb core

knowledge. This approach helps students focus on the teacher's analysis of key points. Student learning and teacher instruction occur synchronously.

> *S1: Based on images of textbooks or the teacher's explanation, we easily recognized course content. S9: There is dead space on the blackboard and the real object projector can magnify the questions. S17: Teachers can record the content of a class for review. S25: Images of textbooks, tables and quizzes are presented by the real object projector and explained by teachers.*

(2) Share the learning process among peers and increase student interest in learning. Teachers can review tests using the magnification function of the real object projector. For students, this was a new and interesting learning method. By reviewing their classmates' tests, students can realize the possibility of errors and the key points of solutions. By sharing in the learning process, students learn from each other and review themselves, which enhances student interest in learning and motivation.

> *S7: I comprehended the questions and I enjoyed it. S19: I understood others' errors and I tried to avoid them. S23: We analyzed the errors in our classmates' quizzes or assignments, and it was interesting. S24: It was more interesting in lectures, and I was better able to concentrate.*

Instructional application of Facebook (FB)

(1) The ability to repeatedly play videos enhances a student's learning and increases convenience. Teachers uploaded instructional videos to FB for students to review after class. Hence, students could watch the videos repeatedly until they understood them. With mobile learning devices and a wireless connection, students can learn at any time and in any place and are thus provided with a friendly and barrier-free learning environment that increases convenience and effectiveness and enhances active learning.

> *S1: Teachers explained by video and we could easily understand the content of textbooks and the meanings of items. S6: We could repeatedly watch the videos to enhance our impressions. S17: As long as we had internet, mobile phones or tablet computers, we could watch instructional videos at any time and in any place. It was convenient. S18: We could replay or stop videos to clarify mistakes.*

(2) Apply online multi-learning and enhance teacher-student learning interactions. In addition to face-to-face instruction in class, teachers effectively adopted instructional FB clubs to offer students diverse learning options, such as uploading instructional videos, online teacher-student interactions, quick responses, descriptions of key points, online problem solving and student group discussions. Multiple pedagogical models enable students to enter the learning world. Teacher-student interactions

and peer cooperation and discussion trigger a student's desire to cultivate an active learning attitude and develop the capacity to think actively solve problems.

> *S1: Sometimes we could not concentrate in class due to interference. On FB, we could concentrate. S8: The teacher reorganized and analyzed the types of errors and showed them on FB to enhance our impression. We could ask the teacher mathematics questions from home. S21: On FB, we could discuss with classmates, unlike in class. S3: The quick response activity was fun. S17: After watching the videos, we could share views.*

Application of Interactive Response System (IRS)

(1) Highly efficient immediate feedback tests help enhance students' awareness of their learning effectiveness. Based on the immediateness of the IRS, teachers and students can assess the learning performance of other students, such as their knowledge before instruction, their progress during instruction and their knowledge after instruction. Teachers can adjust the schedule according to the students' learning situation, and students can assess their own learning performance and that of their peers to enhance self-cognition and to control learning points and directions.

> *S1: The operation was simple and easy, and it tested calculation speed and immediate reaction. Scores were shown immediately. S7: Tests could be recorded and they were easily reviewed. S14: We could know the scores immediately to recognize our learning and other classmates' mistakes. S26: I was tired of writing the tests. However, the method was interesting, and I would like to use it more often.*

(2) Participant learning and the cultivation of positive learning attitudes in students. Group problem-solving is interesting for students, and it resembles game playing. All students work collectively within a time limit, and everyone concentrates. This method enhanced participation in class, cultivated student concentration and learning achievement, and developed learning attitudes.

> *S2: When I finished one question, I obtained the sense of achievement. S19: We enjoyed solving math problems together and we concentrated in class. S7: It was interesting and had many functions. It resembled game playing. In comparison to traditional written tests, it was more interesting. S21: There was a time limit and it was exciting. We could review our classmates' mistakes.*

Based on the previous analysis, after 6 weeks of experimental instruction, students in the experimental group expressed that they had learned the most regarding the comprehension of questions,

transformations and basic calculations. They suggested that on-site instruction was more efficient than traditional instruction and that it was more convenient for them to obtain mathematics instruction. They had more time, and they learned more. By using online learning and teacher-student interactions and feedback, students recognized the shortcomings in their mathematics capacities. Using group knowledge sharing, FB instructional videos and message boards and the IRS, the junior high school students were able to effectively learn mathematics, improve their disadvantages and appreciate others' advantages to construct a base of mathematics knowledge and strengthen their confidence. These results validate the use of blended teaching for mathematics in junior high school. Learning mathematics was more interesting for junior high school students.

Current situation and analysis of mathematics learning effectiveness

The aim of this study was to compare the mathematics learning effectiveness of the experimental and control groups after they had received blended teaching and traditional instruction activities, respectively. The scores from the two groups of seventh grade students on the first math examination are pretest scores of learning effectiveness. After experimental instruction, the scores on the second math examination are posttest scores. The means and standard deviations of the pretests and posttests are shown in Table 4. For the learning effectiveness test, the posttest means for the two groups are lower than the pretest means. Although mean scores of the experimental group on the pretest were lower than control group, but the mean scores of the experimental group on the posttest was higher than control group, showing stronger growth overall between the experimental and control groups. We conducted a single-factor covariance analysis to determine the difference between the experimental and control groups. First, the in-group regression coefficient homogeneity test was conducted. According to the results, F was 6.974, and P was 0.328, which is higher than 0.05. Therefore, the regression coefficients of the experimental and control groups indicated homogeneity, suggesting no interactions between the instructional method and the pretest scores. The pretest scores were used as covariants in the covariance analysis.

Table 4 Analysis of students' pretest and posttest scores of learning effectiveness

Group	Number of people	Pretest		Posttest	
		Mean	Standard deviation	Mean	Standard deviation
Experimental group	28	55.21	24.85	54.72	22.95
Control group	27	58.81	30.27	48.44	26.92

The covariance analysis is shown in Table 5. After eliminating the effect of the two groups'

pretest scores, the posttest scores of mathematics effectiveness were treated as the dependent variable. According to the covariance analysis results, F was 5.04 and *p* was 0.029, which is lower than 0.05. Hence, the posttest scores of mathematics effectiveness for the two groups of students were significantly different. After experiments of different teaching methods, the learning effectiveness scores of the experimental group were significantly higher than those of the control group at a statistically significant level. After eliminating the pretest scores, the means of the two groups were adjusted. The statistical analysis of the adjusted means of the learning effectiveness test scores showed that the experimental and control group values were 56.02 and 47.09, respectively. This result shows that the scores of the experimental group were significantly higher than those of the control group.

Table 5 Single-factor covariance analysis of the learning effectiveness of the two groups

Source of variance	SS	df	MS	F	P
Covariance (pretest)	21816.75	1	21816.75	100.84	.000
Between-group (instructional method)	1089.26	1	1089.26	5.04	.029
In-group (error item)	11249.96	52	216.35		

Thus, the single-factor covariance analysis was used to assess differences in learning effectiveness associated with “blended teaching” and “traditional instruction” for junior high school students. According to the scores on the posttest examination, the learning effectiveness of “blended teaching” was significantly better than that of “traditional instruction”. This result is in line with previous research, such as that by Dziuban et al. (2005) and Futch (2005), who suggested that blended teaching can more effectively enhance learning effectiveness in comparison to traditional instruction.

Process analysis of blended teaching

This study collected related texts from 6 weeks of experimental instruction and conducted a qualitative analysis on the instructional feedback of teachers and the learning feedback of students, as shown below.

(1) To do a good job, one must first sharpen one’s tools. Teachers must be familiar with the functioning of a real object projector and arrange an environment suitable for blended teaching, such as illuminating the classroom for projection. The classroom should be dark in the front and bright in the back, with 2/3 of the lights turned on, as shown in Figure 1. In addition, students should be trained to install the real object projector. The instructional environment is created by teachers and students and should enhance student participation.

(2) Use online resources and multiple learning channels. Using the internet, the recorded videos were

uploaded on FB. Because the videos were large, uploading took time and was limited to one file at a time, making it inconvenient. Following our colleagues' suggestions, we first uploaded the videos on YouTube and then shared them to FB. The transmission speed was quick, and we were able to upload several files at the same time. Thus, students had access to diverse, high-quality learning channels.

(3) Increase of teacher-student interactions and students' learning intentions. FB instruction effectively changed students' learning attitudes, as shown in Figure 2. For instance, the experimental group's submission of assignments and responses were superior to those of the control group. In addition, the students' motivation to learn in class improved. They were more serious, and their intention to learn mathematics was enhanced. They were willing to actively watch videos on FB and leave messages in the discussion forum.

Figure 1. Blended teaching environment

Figure 2. FB instructional club

(4) Encourage posing questions and sharing learning; enhance collaborative peer learning. Teachers uploaded instructional videos for students to review after class. Students were encouraged to use message boards, pose questions or share problem solving techniques in the instructional club. Teachers then explained the solution. Based on their discussions, the collaborative peer learning was effectively increased.

(5) Immediateness of tests and analysis helps students understand key points. Using the IRS, tests can be produced immediately. The learning effectiveness test was conducted in writing, as shown in Figure 3. After the test, the scores show the outcome of the entire class and of individuals, thus recording the test process. Teachers can enhance specific topics or guide individual students according to the test results.

(6) With smart mobile devices, students can learn at any time regardless of absence. Uploaded instructional videos can be studied at any time with smart mobile devices, as shown in Figure 4. For instance, because of a dance competition, S21 of the experimental group was absent. The student learned on mobile devices, such as their cell phone. Although the score was small, the image was

defined clearly. Learning could happen in any place at any time, effectively solving truancy problems.

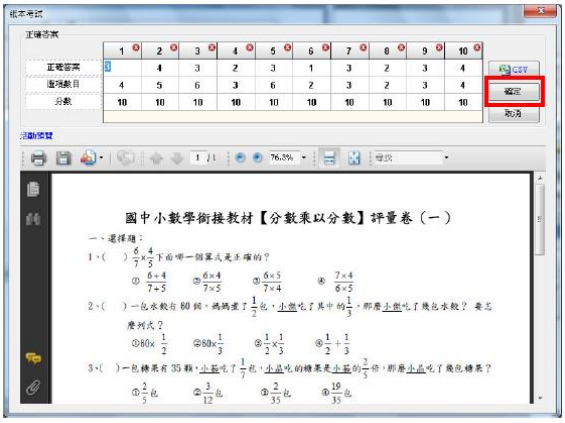

Figure 3. Tests are produced immediately

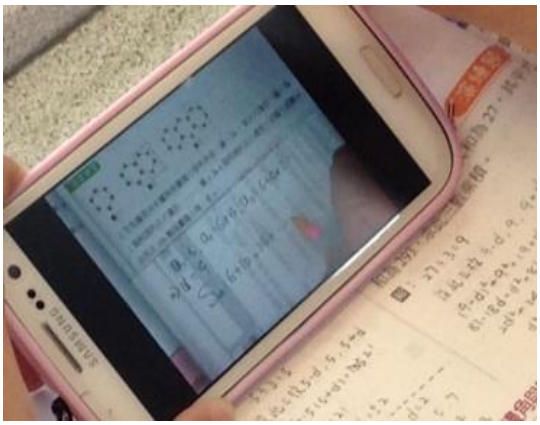

Figure 4. smart mobile devices

According to the previous textual analysis, after receiving instruction on the real object projector and FB, low-achievement students in the experimental group made progress in their mathematics learning effectiveness. The researcher corrected the students' assignments and realized that the error rate of the experimental group was lower than that of the control group. The varied solutions indicated the students' confidence in mathematics. In addition, based on the weekly summative evaluations, the experimental group made progress in their mathematics scores over the 6-week period. Because the experimental group used the IRS, which immediately produces tests and analyses of test results, teachers effectively focused on guidance, as opposed to writing tests and developing curriculum. Students' learning became more efficient. Hence, the results of the qualitative textual analysis match those of the quantitative analysis. According to class observations, the researcher realized that students enjoyed blended learning and made progress on quizzes and assignments, demonstrating that blended teaching can result in positive mathematics learning attitudes.

The construction of blended teaching model

Based on the previous discussion of the analytical results, the blended teaching model included three stages: (1) preparation, (2) practice and (3) review, as shown in Figure 5.

(1) Preparation: Before class, teachers must be familiar with the content of units and prepare appropriate instructional tools, quizzes or assignments for students and group knowledge sharing in class. Teachers design instructional steps and revise them after discussing with colleagues. In class, teachers must be familiar with the installation and function of a real object projector and must train some students to install it. Prior to instruction, teachers and students create a proper blended teaching environment. To facilitate online learning after class, teachers should provide two weeks of computer classes for students to obtain FB accounts and join the club. Students are taught the function and use of

the FB platform, and some students are trained to manage uploaded files on FB. For the instructional evaluation, a teacher's familiarity with the IRS is extremely important for allowing students to successfully operate remote controls for written tests. Prior to the instructional evaluation, students must be taught to operate remote controls. Students should be familiar with the operational model of the IRS.

(2) Practice: In blended teaching, instructional tools and scales are demonstrated and textbooks are explained using the real object projector for magnification. Key points can be recorded with teaching materials that can be easily comprehended by students. Simultaneously using images on the real object projector, the entire class can watch a teacher explain instructional data, analyze types of errors and present different solutions of the same problem. Students can easily comprehend their errors and shortcomings and thus modify their basic calculation and logical thinking procedures. Furthermore, using sound and video recordings, teachers' explanations of key points or student demonstration videos can be replayed in class or uploaded on FB for review. This encourages students to discuss lessons and exchange understanding on message boards. For weekly summative evaluations, the IRS can be used to immediately analyze individual and class learning so that teachers can properly conduct remediation and clarify concepts.

(3) Review: With blended teaching, students will keep complete records of information such as instruction-related data, demonstration videos, teacher-student interactions through message boards, knowledge sharing, suggestions, and scoring on FB. The learning records are not limited by time and space and can be easily saved. Using the internet, students can browse and learn at any time. Hence, blended teaching provides a new opportunity for mathematics instruction in junior high schools.

Based on the aforementioned model, to maximize the effectiveness of blended teaching, teachers should be familiar with the teaching materials, design the blended teaching environment completely and master instructional devices. However, the key lies in instructional delivery. Teachers should not only instruct the course but also monitor student quizzes, assignments and teacher-student interactions on FB, in addition to conducting summative instructional evaluations to immediately assist students and reorganize data. Finally, students can become interested in mathematics and cultivate their confidence in the learning process by analyzing their errors in basic calculations, developing logical thinking skills, and sharing in the learning experience of others. They can learn actively and appreciate others' thoughts.

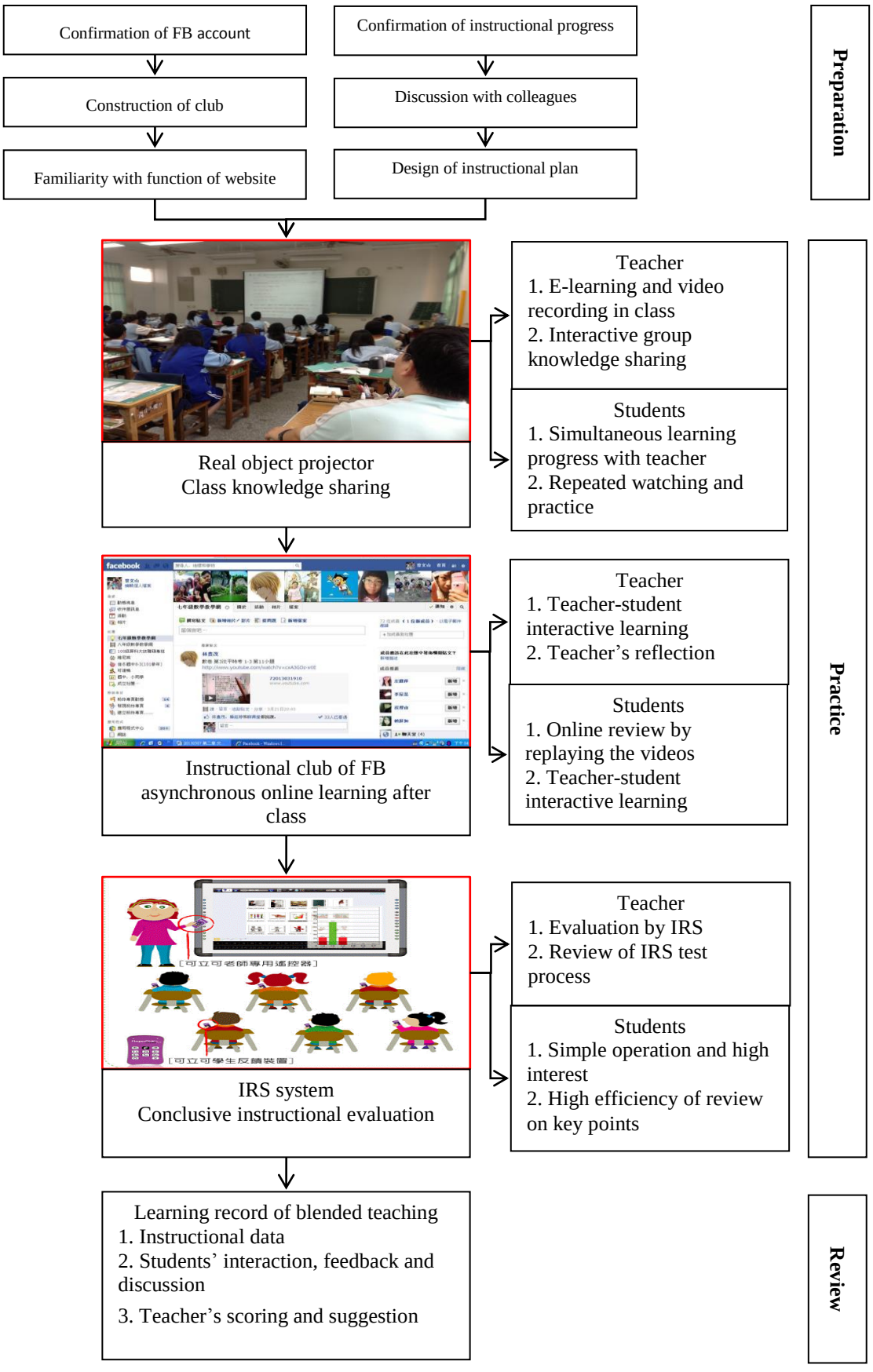
Confirmation of FB account
Construction of club
Familiarity with function of website
Confirmation of instructional progress
Discussion with colleagues
Design of instructional plan
Preparation
Real object projector
Class knowledge sharing
Teacher
1. E-learning and video recording in class
2. Interactive group knowledge sharing
Students
1. Simultaneous learning progress with teacher
2. Repeated watching and practice
Instructional club of FB asynchronous online learning after class
Teacher
1. Teacher-student interactive learning
2. Teacher's reflection
Students
1. Online review by replaying the videos
2. Teacher-student interactive learning
IRS system
Conclusive instructional evaluation
Teacher
1. Evaluation by IRS
2. Review of IRS test process
Students
1. Simple operation and high interest
2. High efficiency of review on key points
Practice
Learning record of blended teaching
1. Instructional data
2. Students' interaction, feedback and discussion
3. Teacher's scoring and suggestion
Review

Figure 5. The blended teaching model

5. Conclusions and Suggestions

Conclusions

The aim of this case study was to establish a blended teaching model and investigate the math learning effectiveness of junior high school students. The limitations of this case study include the small sample size; only a small number of students from a single school participated in the study. Thus, the results cannot be generalized to the entire population. Additionally, qualitative data should be recorded and analyzed to support the statistical results. However, the conclusions and suggestions are as follows.

First, the findings of this study indicated that the experimental group showed positive and statistically significant values for mathematics learning desire, learning process, learning method, and belief, indicating that most students felt that blended teaching is a more efficient way of teaching mathematics compared to traditional instruction. Additionally, this blended instructional model enables math instruction to be more flexible and interesting and helps students understand their mathematics strengths and shortcomings. Furthermore, group knowledge sharing via instructions, FB instructional videos, message boards, and the IRS can help students learn and enhance their math confidence. Siyepu (2013) noted that many students complain about the inappropriateness of textbooks in mathematics, especially in schools in South Africa. Thus, based on the findings of the current study, Facebook and the IRS can be employed in mathematics instruction to enhance learning effectiveness in South Africa.

Second, the results show that the simultaneous use of images helped the experimental group students recognize types of errors and immediately clarify concepts. As for after class guidance using FB, the experimental group students were able to interactively learn with their classmates online, leave messages to the instructors, and provide opinions about instruction. Regarding instructional evaluation using the IRS, the teachers were able to properly conduct remedial lessons or clarify concepts. As a result, applying blended teaching to mathematics for junior high school students can provide diverse learning options and thus enhance learning effectiveness.

Third, the statistical results show that the learning effectiveness levels of blended teaching and traditional instruction are significantly different. Hence, blended teaching enhanced students' learning and motivation in mathematics, cultivated confidence and independent thinking, and improved their learning effectiveness.

Finally, the results of the study indicate that blended teaching can enhance a student's learning attitude and effectiveness in mathematics. The blended teaching model for this study includes 3 stages: (1) preparation, (2) practice, and (3) review. The instructors must be familiar with the teaching materials, cultivate a blended teaching environment, and master instructional devices. They also need to plan proper activities, conduct face-to-face and online instruction, observe student learning,

teacher-student interaction and collaborative peer learning processes, as well as immediately assist students. Finally, student errors in basic calculation are analyzed, and the instructional method and schedule are adjusted accordingly. As a result, implementing a blended teaching model to match student needs can enhance learning attitudes and possibly improve learning effectiveness.

Suggestions

Based on the findings of this study, several suggestions are provided for future studies.

Suggestions related to blended teaching

(1) For schools: blended teaching should be applied to mathematics in junior high schools. Blended teaching can be introduced to other mathematics classes. Junior high school students will be able to review different teachers' lectures and comments using this platform. Due to schedule differences, students can preview lectures, review them on the platform at any time and ask for remedial teaching. In addition, the feedback and suggestions from peers in other classes can facilitate group knowledge sharing. The learning materials will be permanently stored on the blended teaching platform for students to review.

(2) For teachers: enhance instructional quality and instructional efficacy. As Stols (2013) discusses, teachers play a major role in shaping and creating opportunities to learn, especially in mathematics. Thus, blended teaching can enhance learning effectiveness. Therefore, in addition to traditional instruction, teachers should continuously improve their teaching materials and methods and include information-technology-assisted instruction. Hence, teacher-student interactions and student learning will be enhanced. Using the instructional model in this study, students will learn more, and their basic calculation capacity can be enhanced. This requires the use of logical thinking and cultivates an interest in mathematics.

(3) For students: enhance student discussion feedback. Through the interactive blended instruction platform, students are able to generate discussions and feedback. In addition to teachers' suggestions, students can expand their logical thinking capacity using their classmates' feedback and suggestions. Therefore, prior to instructional activities, the communicative capacity of students should be cultivated to enhance discussion feedback. By interacting with classmates, students can discuss topics and obtain meaningful feedback. As a result, mathematics can be effectively taught through interactive blended instruction platforms, such as Facebook and IRS.

Reference

Berlin, D., & White, A. (1998). Integrated science and mathematics education: Evolution and implications of a theoretical model. *International handbook of science education, 1*, 499-512.

Bersin, J. (2004). *The blended learning book: Best practices, proven methodologies, and lessons learned*: John Wiley & Sons.

Bester, G., & Brand, L. (2013). The effect of technology on learner attention and achievement in the classroom. *South African Journal of Education*, 33(2), 1-15.

Burgess, L. A. (2003). WebCT as an e-learning tool: A study of technology students' perceptions. *Journal of Technology Education, 15*(1), 6-15.

Cheng, Y. M., Isman, A., Hsu, T. C., & Hsin, T. (2014). A Study on Winsows Live Social Network Integrated into Information Instruction in Ementary Schools. Journal of Computers and Applied Science Education, 1(1), 26-44.

Cottrell, D. M., & Robison, R. A. (2003). Case 4: Blended Learning in an Accounting Course. *Quarterly Review of Distance Education, 4*(3), 261-269.

Czerniak, C. M., Weber, W. B., Sandmann, A., & Ahern, J. (1999). A literature review of science and mathematics integration. *School Science and Mathematics, 99*(8), 421-430.

Dziuban, C., Moskal, P., & Hartman, J. (2005). Higher education, blended learning, and the generations: Knowledge is power: No more. *Elements of quality online education: Engaging communities. Needham, MA: Sloan Center for Online Education*.

Futch, L. S. (2005). *A study of blended learning at a metropolitan research university.* University of Central Florida Orlando, Florida.

Garfield, J. B. (1977). *An investigation of junior high school students' attitudes toward components of Mathematics*. Unpublished master thesis. University of Minnesota.

Garrison, D. R., & Vaughan, N. D. (2008). *Blended learning in higher education: Framework, principles, and guidelines*: John Wiley & Sons.

Graham, C. R. (2006). Blended learning systems. *Handbook of blended learning: Global Perspectives, local designs. Pfeiffer Publishing, San Francisco, http://www. publicationshare. com/graham_intro. pdf.*

Gulbahar, Y., & Madran, R. O. (2009). Communication and Collaboration, Satisfaction, Equity, and Autonomy in Blended Learning Environments: A Case from Turkey. *International Review of Research in Open and Distance Learning, 10*(2), 117-138.

Lin, H. H. (2000). The Effectiveness of Function Course with GSP Assisted Teaching for Eigth Graders. Unpublished Master Thesis. National Kaohsiung Normal University.

Ma, X., & Xu, J. (2004). Determining the causal ordering between attitude toward mathematics and achievement in mathematics. *American journal of education, 110*(3), 256-280.

Mager, R. F. (1968). *Developing Attitude Toward Learning*. Palo Alto, CA: Fearon.

Mayisela, T. (2013). The potential use of mobile technology: enhancing accessibility and communication in a blended learning course. South African Journal of Education; 2013: 33(1), 1-18.

McCoy, L. P. (2005). Effect of demographic and personal variables on achievement in eighth-grade algebra. *The Journal of Educational Research, 98*(3), 131-135.

Morgan, K. R. (2002). Blended learning: A strategic action plan for a new campus. *Seminole, FL: University of*

Central Florida.

Muthukrishna, N. (2013). Raising the quality of primary level mathematics teaching and learning in schools in American Samoa: a model for South Africa. *Perspectives in Education: Primary mathematics: addressing the crisis*, 31(3), 122-138.\

Padayachee, P., Boshoff, H., Olivier, W., & Harding, A. (2011). A blended learning Grade 12 intervention using DVD technology to enhance the teaching and learning of mathematics. Pythagoras, 32(1), Art. #24, 8 pages. http://dx.doi.org/10.4102/ pythagoras.v32.i1.24

Piccoli, G., Ahmad, R., & Ives, B. (2001). Web-based virtual learning environments: A research framework and a preliminary assessment of effectiveness in basic IT skills training. *MIS quarterly*, *25*(4), 401-426.

Roberts, N.. & Vänskä, R. (2011). Challenging assumptions: Mobile Learning for Mathematics Project in South Africa. *Distance Education*, 32(2), 243-259.

Sapire, I., & Reed, I., (2011). Collaborative design and use of open educational resources: a case study of a mathematics teacher education project in South Africa. *Distance Education*, 32(2), 195-211.

Simpson, M., & Anderson, B. (2009). *Redesigning initial teacher education.* In E. Stacey & P. Gerbic (Eds.), Effective blended learning practices. Evidence-based perspectives in ICT-facilitated education, pp. 62-78. Hershey PA: Information Science Reference.

Singh, H. (2003). Building effective blended learning programs. *Educational Technology*, *43*(6), 51-54.

Siyepu, S. (2013). The zone of proximal development in the learning of mathematics. *South African Journal of Education*, 33(2), 1-13.

Stacey, E., & Gerbic, P.(2009). *Introduction to blended learning practices.* In E. Stacey & P. Gerbic (Eds.), Effective blended learning practices: Evidenced-based perspectives in ICT-facilitated education (pp. 1-20). Hershey, PA: Information Science Reference.

Stodolsky, S. S., Salk, S., & Glaessner, B. (1991). Student views about learning math and social studies. *American Educational Research Journal*, *28*(1), 89-116.

Stole, G. (2013). An investigation into the opportunity to learn that is available to Grade 12 mathematics learners. *South African Journal of Education*, 33(1), 1-18.

Thorne, K. (2003). *Blended learning: how to integrate online & traditional learning*. London, UK: Kogan Page.

Usta, E., & Ozdemir, S. M. (2007). An Analysis of Students' Opinions about Blended Learning Environment. *Online Submission*.

Vaughan, N., & Garrison, D. R. (2005). Creating cognitive presence in a blended faculty development community. *The Internet and Higher Education*, *8*(1), 1-12.

Young, J. R. (2002). " Hybrid" Teaching Seeks To End the Divide between Traditional and Online Instruction. *Chronicle of Higher Education*, *48*(28), 33-34.