Using the innovative cooperative learning model with the interactive whiteboard to primary school students' mathematical class: Statistic vs. pie chart and solid diagram

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The study designs an innovative cooperative learning model which combines Student Teams Achievement Divisions with Team Game Tournament and investigates the impact of students' attainment and their learning motivation on statistics and solid diagram of 6th grade. The interactive whiteboard can not only display complex teaching materials but also attract teacher and students to interact in classes. Through the creative cooperative learning model, the interactive whiteboard assists students' learning because of the interaction between students and teacher. The experimental group used an interactive whiteboard as an instrument but the control group used an overhead projector. The results of the experiment reveal a statistical significant difference in learning effects and motivation of mathematics. The study proved that using the innovative cooperative learning model with the IWBs could make great interaction and best effect of learning between teacher and students in class.

Keywords: Interactive Whiteboard, Cooperative Learning, Student Teams Achievement Divisions, Team Game Tournament

Introduction

Since1997, the government of the United Kingdom has invested huge amount of money in Information and Communication Technologies (ICTs) in the education sector. In January 2002, the UK government announced that every primary school and high school was equipped three suites of Interactive Whiteboard, personal computer and overhead projector and the guide of the IWB Initiative would proceed. Afterwards, Schools Interactive Whiteboard Expansion project (SWE) was proclaimed at September 2003(DfES, 2004). Between 2001 and 2004, the Department for Education and Skills (DfES, 2004) pointed out that the overall figure in each school for the IWB and National Whiteboard Network at ￡50 million pounds. The project made the IWB become the highlight in educative discussions and related researches (Beauchamp, 2004). Generally, the technical functions of the IWB can replace the traditional instruction which used a blackboard to give a lesson and it can integrate a great deal of educational resources. It is not just a platform for demonstrating teaching materials but also a tool which can increase the interaction between teacher and students.

Learning science is not just a matter of accumulating science facts. In addition, it is a gradual process by which teachers introduce students to new aspects and helping them to develop new ways of seeing the world (Mercer, 2005). More and more studies which laid great stress on curriculum design and pedagogies described the research of introducing the IWB into teaching (Beauchamp, 2004; Glover & Miller, 2001; Glover & Miller, 2002; Goodison, 2002; Morgan & Kennewell, 2006). Mathematics is the foundation of science and it is inseparable from life. However, it was indicated that many students encountered numerous difficulties in learning mathematics and it was the subject which students felt most anxious and afraid. Kennewell et al. (2007) said “we would expect effective teaching to incorporate a variety of levels of interactivity, as appropriate to the learning objectives”. Therefore, if teachers can use information technology wisely in teaching mathematics, the traditional classroom would become a multi-function learning environment. Chung and Cheng (2005) pointed out it would be helpful since students learn with fun. They also argue that students like the IWB because its versatility which can be put down to the fact that they are a combination of all previous educational technologies.

Cooperative learning is a successful teaching strategy in which small teams, each with students of different levels of ability, use a variety of learning activities to improve their understanding of a subject. It can encourage students to interact each other positively and substantially. Indeed, the IWB is an approach to connect students with teacher. Ke and Grabowski (2007) indicated that students had better learning attitude and effect when the teacher introduced mathematics by Team Game Tournament (TGT) method. Furthermore, Kamuran and Fikri (2008) employed Student Team-Achievement Division to teach mathematics, the performances also improved. In relation to this, the work reported on here investigated how the IWB resources impact students’ learning attitude in the primary school students’ mathematics classes by cooperative learning. The purposes of the study were:

1. The impact of using the innovative cooperative learning model with the IWB on students’ attainment;
2. The impact of using the innovative cooperative learning model with the IWB on students’ learning motivation.

Method

Objects

The purposes of this case study included the effects of students’ learning results and students’ learning motives using the Interactive Whiteboard in mathematical class of primary school. The participants of the study were sixth grade students of a medium-sized school which was one of schools enhanced in information technology in Taipei City, Taiwan. There were thirteen sixth grade classes in the school; two classrooms of all owned IWBs and others owned overhead projectors. Data were presented from experiments with 60 students. Because of the limited of the teaching facilities, the sample was selected by purposive sampling. There were four conditions: 1. an IWB classroom; 2. an overhead projector classroom; 3. a teacher who would like to operate in coordination with the experiment; 4. classes which can be arranged easily. Therefore, in this case study, we chose one of the classes with the IWB for experimental group and one of the classes with overhead projector for control group. The number of participants was 60 totally.

Experiment Design

This study adopted quasi-experimental research method. Firstly, the pre-test questionnaire included the concept of statistics, solid diagram and learning motive of mathematics. Afterwards, the experiment spent one month. Both of the two groups were used cooperative learning, but the teaching instruments were different. In experimental group, teacher taught them by the Interactive Whiteboard; another group was presented by an overhead projector. The variables are displayed below.

Table 1: Experiment Variables

Variables	*Description*
Independent Variable	1. experimental group: the Interactive Whiteboard 2. control group: the overhead projector
Dependent Variable	1. Students' Attainment: compare the scores of students' achievement test of Statistics and Solid Diagram between pre-test and post-test. 2. Learning Motivation: compare the scores of students' achievement motive scale between pre-test and post-test.
Control Variable	1. Teaching Materials: Statistics and Solid Diagram of sixth grade 2. Teaching Hours: one month 3. Grade: sixth grade 4. Teacher: the same 5. Pedagogy: cooperative learning

Environment

The two classrooms both arranged to six groups (see figure 1). The left of figure 1 shows the arrangement of experiment group: there is an IWB in the front of the classroom. The right part of figure 1 is the floor plan of control group; the traditional blackboard, the overhead projector and project-screen are set in the classroom.

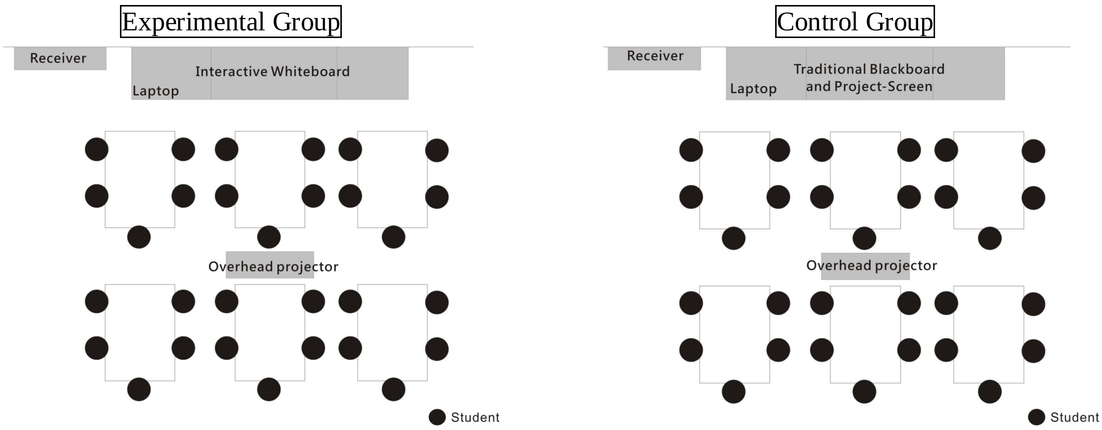

Figure 1: The Floor Plan of Experimental Group and Control Group

Facilities

1. Interactive Whiteboard

The Interactive Whiteboard of the experiment was an electromagnetic induction IWB. The electromagnetic Interactive Whiteboard was constructed of lots of coils and it needed a special digital pen. When the digital pen wrote or touched the Interactive Whiteboard, the electrical signals would be delivered to computer through electromagnetic induction and be recognised the position as the mouse.

2. Tablet PC

The screen of the tablet PC was a touch panel which was operated by electromagnetic induction digital pen and the host was under its keyboard. The functions of the tablet PC were the same as a laptop. The laptop always used a mouse and a keyboard as input devices but a tablet PC used a digitizer to insert data by touching its screen. The electrical signals which were written on touch panel directly would be transformed into characters or figures by specific recognition software.

Research Tools

1. Achievement test of statistics in primary school

According to the content of mathematics courses (textbook 1 to textbook 11), the questions of pre-test were chosen by using random sampling from a question bank which was built by several expert teachers. In addition, the post-test also chose the questions by using random sampling from the question bank and the level stands on the content of textbook 12. Furthermore, three mathematics experts examined these questions before the test. Afterwards, the result of the pilot study from eighty junior high school students displayed these two tests had a high unique relationship found between pre-test and post-test (p=0.708).

2. Achievement test of solid diagram in primary school
   As the achievement test of statistics, this test also chose questions by using random sampling from the question bank. Pre-test contained mathematics textbook 1 to textbook 11 and post-test comprised mathematics textbook 12. In order to survey the suitability and reliability of these tests, three mathematics experts also examined these questions before the tests put into practice. After then, the eighty students did these two tests. The results of Pearson Product Moment correlation coefficient was 0.888. It meant these two test questions have high correlation.

3. Achievement motive scale of mathematics
   The achievement motive scale was based on Motivated Strategies for Learning Questionnaire (MSLQ). It divided learning motive into five parts: intrinsic goal orientation, extrinsic goal orientation, task value, control of learning beliefs and test anxiety. Intrinsic goal orientation, extrinsic goal orientation and task value belonged to value components; control of learning beliefs was expectation and test anxiety was part of emotions. The marks of the motive scale of mathematics meant the learning motive of mathematics in this study. In other words, students got high scores meant that their learning motives were strong.
4. Teaching diary and interview records
   The researcher wrote down the teaching situation and interview contents after every class for the sake of comprehending the students' responses in depth. The conversation and answers between teacher and students in class were recorded authentically and students of experimental group were interviewed about their feelings and thoughts of the teaching with the IWB. The information all explained the results of the experiment and supplied positive evidence. In the following discussion, 'E' and 'C' meant experimental group's and control group's students and the number after the letter meant students' seat number.

Teaching Method

As results of the IWB's were big touch screens, they could display the teaching materials more conveniently and encourage students to interact with teacher or other students. The study designed an innovative cooperative learning model with the interactive whiteboard which was built on student teams-achievement divisions and team game tournament. The steps were as follows:
1. Heterogeneous grouping: bottoming on the pre-test scores, students were divided into groups by heterogeneity. Students in groups should complete their works or teaching materials together through discussing and arguing their opinions to each other, and then they would build correct concepts in their mind.
2. Class presentation: teacher taught all students in class at the same time and explained the manners of cooperative learning and game tournament. The main idea was to direct students that they can construct information depend on interaction and discussion.
3. Quiz, group discussion or academic game tournament: teacher held quizzes or competitions in accordance with the course. Through quizzes, teacher could realize students' calculation capability; group discussion and game tournament could help students get more solutions.
4. Group commendation: groups would be encouraged since the group earned the most marks or someone in the group increasing most.

Results and Discussion

Learning Attainment

1. Statistics and pie charts
   The data of pre-test of statistics and pie charts was showed in Table 2. The mean of experimental group and control groups were 80.97 and 82.17; standard deviations were 12.754 and 16.282 respectively. It indicated that there was no statistically significant difference (p=0.752) between students' scores in statistics and pie charts. After the teaching experiment, the mean and standard deviation of these two groups changed. The whole class of experimental group increased more than 10 marks but control group only increased 2 marks. Further, the standard deviation of experimental group dropped drastically but control group still had 12.646 marks. According to the result of *t-test* analysis, there were statistically significant differences (p=0.003) in statistics and pie charts between instruction with the IWB and instruction with overhead projector.

   According to the researcher's observation, students could choose the charts or graphs (i.e. pie chats, bar charts and line graphs) more conveniently on Interactive Whiteboard when they draw a statistics figure. Although the teacher offered control group students the computer when they shared their opinions with others, they preferred to draw the result on blackboard. There were few students like to use the computer and mouse to share their ideas. Moreover, because students were used to look attentively at the big screen in the front of the classroom, some students would lose their concentration since others explained their views. Moreover, compared with control group, experimental group students more enjoyed to share their solutions. Students thought that sharing their work with others in class would help them to clarify their ideas. Also, to perform the solutions on the IWB was not only to show their own answers but also learn different explanations from others. Students would look at the big screen closely while someone showed as an example. Students could see the process and strategy of solutions clearly and think over the difference with theirs. The progress could help students understand the question deeply and promote their concentration of learning mathematics. Otherwise, the students who addressed their opinions would get same generation approbation and add their own confidence.

Table 2: Analysis of the Learning Effect of Experimental Group and Control Group in Statistics and Pie Charts between Pre-test and Post-test

Groups	*Pre-test*					*Post-test*				
	M	*SD*	*df*	*T*	*p*	*M*	*SD*	*df*	*T*	*p*
Experimental Group (N=30)	80.97	12.754	58	-0.318	0.752	92.58	6.307	58	3.094	0.003**
Control Group (N=30)	82.17	16.282				84.53	12.646			

* $p< 0.05$

   The convenience and flexibility of the IWB helped students to learn the tips for answering mathematics questions easily. Students appreciated the range of resources that could be accessed through the technology. When students studied a median they often forgot to sort all numerals from smallest to biggest especially the value of them were very close. On the IWB, it was very clear when teacher move all the numbers at pleasure and arrange them by value again, hence students would impress about how to solve this kind of questions and know the skills of using the IWB. It was found that the tips for answering median questions of two groups have some variations. The experimental group students would remember to arrange all the numbers before they found out the median but the control group students often just ticked number on the caption immediately. This way would make mistakes because they pass by some.

2. Solid Diagram
   The mean score of pre-test of experimental group and control group were 65.77 and 65.67 and the standard deviations were 18.691 and 18.753. It had no significant difference between these two groups (p=0.984) on Solid Diagram. However, there were significant differences between groups after the experiment (p=0.003). The details were in Table 3.

Table 3: Analysis of the Learning Effect of Experimental Group and Control Group in Solid Diagram between Pre-test and Post-test

Groups	*Pre-test*					*Post-test*				
	M	*SD*	*df*	*T*	*p*	*M*	*SD*	*df*	*T*	*p*
Experimental Group (N=30)	65.77	18.691	58	0.21	0.984	89.60	8.398	58	3.057	0.003**
Control Group (N=30)	65.67	18.753				80.83	13.275			

* $p < 0.05$

Students could use multiple resources (i.e. ruler and protractor) on the IWB in a Solid Diagram class and the 3D pattern could also be revolved on the IWB. Student could see the surface distinctly and get conception and mental image of the solid diagram when they operated these 3D patterns. Another feature of IWBs, which could copy and paste objects unlimitedly, was very easy for students to work. Students would not spend needless time to draw a square, a polygon and a cube; they could just concentrate on the solution and think more deeply. At the same time, students could discuss the solutions when teacher or other students answering questions. Moreover, the facilities of IWBs were to annotate, conceal, manipulate, move and zoom in/on or focus on images. The presentation stimulated visual image and helped students to remember; they could still see the images in their mind even after the class. This was not only because there was more information available but also a wider variety of information so that students thought the ideas and concepts easier to control. Further, the assignment was solved by student A could be recorded and saved on the IWB to compare with another student's tip and discuss their works in class. They would enjoy the opportunity to see and discuss other's assignments and be clearer about the correct solutions of solid diagram.

Comparing to experimental group, students of control group could not interact with the patterns on big screen shoot from the overhead projector immediately and it's not as real as objects. Owing to the IWB connecting students assignments with whiteboard immediately and drawing the perspective drawings exactly, students can link solid diagrams and perspective drawings together. Students could not have good sense of space perception while their volume and conservation perception were not mature. Cutting and compounding skills could help students to develop the concept of space perception; students would perceive the abstraction and bring mental image during operating. In addition, teachers could use masks of the IWB to instruct students how to count the volume of solid diagrams by cutting and compounding skills. It would help students to understand and count the volume of an irregular figure. After explaining the ideas of solid diagram, teachers could add some related games in class. Through practicing these games, students would be proficient in it and feel the curriculum was fun.

Learning Motivation

1. Analysis of the Learning Motivation Questionnaire
   Based on the learning motivation questionnaire, the mean of post-test increased 16 and 4.2 marks in experimental group and control group respectively. In value factor, experimental group increased 12.2 marks and control group increased 2.9 marks. Experimental group and control group raised 3.6 and 1.6 marks on expectation factor. Moreover, the less increase on emotion section, experimental group and control group raised 0.3 and 0.4 marks only. After T-test (see *Table 4*), there were significant differences in value (p=0.000) and expectation (p=0.010) sections but emotion sector was none (p=0.381).

Table 4: The Contrast of Pre-test and Post-test on Students' Learning Motivation

Items		Pre-test					Post-test				
		Mean	*SD*	*df*	*T*	*Significant*	*Mean*	*SD*	*df*	*T*	*Significant*
Value (N=30)	*Exp.* *Control*	46.1 48.0	6.9 7.9	58	-1.001	0.321	58.3 50.9	6.3 7.5	58	2.652	0.010**
Expectation (N=30)	*Exp.* *Control*	16.2 15.5	3.6 3.9		0.643	0.523	19.8 17.1	3.5 3.3		1.008	0.000***
Emotion (N=30)	*Exp.* *Control*	15.3 15.6	3.9 3.6		0.802	0.426	14.4 14.8	3.4 3.5		3.756	0.318
Total (N=30)	*Exp.* *Control*	77.8 93.8	10.6 12.5		-1.78	0.860	78.3 82.5	9.8 11.4		4.101	0.000***

Exp.= Experimental Group; Control= Control Group; * $p<0.05$; ** $p<0.01$; *** $p<0.001$

Expectation was one of self-efficacy dimensions. Students believed that they can acquire all contents, help others to answer mathematic questions and explain their own opinions in front of whole classmates. After the experiment, some students of experimental group indicated that:

> E21: teacher used variety manners to introduce us the solutions of Statistic and Pie Chart and Solid Diagram. It made us not to be afraid of mathematics and increase the interest of it.

> E5: I would like learn mathematics by the IWB because of the computer recourse. Furthermore, I comprehended the ideas deeply and earned more confidence in math.

In the case, emotion factor meant the degree of worries and misgivings: for instance, students would feel the pressure of learning mathematic, tests and the mid-term examination. However, there were no significant differences in this part between using the IWB or not.

2. Analysis of the elements of value
   There were three elements of value factor: intrinsic goal orientation, extrinsic goal orientation and task value. In the post-test, experimental group raised 4 marks in intrinsic goal orientation; 0.7 marks in extrinsic goal orientation and 7.7 marks in task value. Nevertheless, control group only increased 0.1 marks in intrinsic goal orientation, 0.5 marks in extrinsic goal orientation and 2.4 marks in task value. According to the result of t-test analysis, there were no statistically significant differences in intrinsic goal orientation in pre-test (p=0.78) but there were a significant difference in post-test (p=0.038). Extrinsic goal orientation did not reveal a statistically significant difference what ever pre-test (p=0.902) or post-test (p=0.876). There was also no significant difference in task value in pre-test (p=0.523) but in post-test had significant difference (p=0.000). The Contrast of pre-test and post-test on value factor were displayed in Table 5.

Table 5: The Contrast of Pre-test and Post-test on value factor

Items		Pre-test					Post-test				
		Mean	*SD*	*df*	*T*	*Significance*	*Mean*	*SD*	*df*	*T*	*Significance*
intrinsic goal orientation (N=30)	*Exp.* *Control*	15.0667 16.8000	2.7784 4.4983	58	-1.796	0.78	19.0667 16.9000	3.1616 4.6189	58	2.12	0.038*
extrinsic goal orientation (N=30)	*Exp.* *Control*	8.8667 8.9333	1.9429 2.2427		-0.123	0.902	9.5000 9.4000	2.4176 2.5134		0.157	0.876
task value (N=30)	*Exp.* *Control*	22.1333 22.2667	4.3370 4.5481		-0.116	0.523	29.8000 24.6333	3.8810 4.3110		4.879	0.000***

Exp.= Experimental Group; Control= Control Group; * $p<0.05$; ** $p<0.01$; *** $p<0.001$

Intrinsic goal orientation indicated that students like to learn new ideas and curious concepts of mathematics and they would try their best. There were significant differences in intrinsic goal orientation and this result illustrated that students would increase their intrinsic goal orientation of leaning motivation and attempt harder programme by using the IWB in mathematic class. Task value displayed the feelings (i.e. cheerful, free and easy) of students when they attended the math classes. Those were important that students discussed with each other and addressed their own opinions to all classmates for finding out the subject matters. It had a significant difference in task value after the experiment. The result expressed that students raised their task value of learning motivation by teaching with the IWB and they liked learning mathematic through discussing and sharing with each other. All of the students said that IWB contributes to lessons in terms of making them more enjoyable and fun (Hall & Higgins, 2005). A student replied as following:

> E1: I thought the IWB was very helpful for learning mathematics. Everyone liked to operate the solutions on the IWB on the stage and we can learn it by multiple ways. Therefore, I enjoyed the math classed by using the IWB.

And then, extrinsic goal orientation designates that students learned something hard in order to avoid criticism and blame or obtain reward and praise from teacher or other students. This part did not appear significant differences between pre-test and post-test. It exhibited that using the IWB in math class would not change students' extrinsic goal orientation. Students would not learn hard just only for getting positive or keeping censure away. The change of learning attainment came from students thinking they enjoyed the math classes and starting to be interested in it through using the IWB.

In brief, because of the convenience, composite and variety functions of the IWB, teacher and students saved a lot of time for writing or drawing and concentrated on specific solutions. Students can learn more clearly what ever the teacher or a student explained the idea or his/her opinion with the specific figures and words on the IWB. Students believed their capabilities to comprehend what teacher taught as well. It also increased students learning expectation of them.

> C11: I like the IWB very much. I never seem this kind of touch whiteboard before. It make me want to operate it in the front of the class and share my opinions to everyone.
>
> C14: I like it but I would be a little nervous in class.
>
> C15: I like the IWB because teacher and classmates can correct me immediately when I was wrong.
>
> C21: I like the IWB. The teacher would let us explain our idea on the stage by turns, so I can know other solutions from others and I can compare which is better.
>
> C11: I thought it was very interesting. It would be fascinating if we can use the IWB in every class.
>
> C22: I preferred the IWB to the traditional blackboard. I had much fun with the IWB in class.

Conclusion

The purpose of the study was to investigate the effect of the IWB integrated into mathematics instruction on the learning achievement and learning motivation of primary school students. According to this study, the use of the IWB was more effective for learner comprehension, retention and learning motivation than the use of overhead projector, project-screen and traditional blackboard instruction in statistic and pie chart and solid diagram of primary school students' mathematical class.

It was found that students possessed correct perceptions when the teacher explain and discuss the notion through explicit constructionism instructions on the IWB. The reason for students' favorable views about the IWB, however, may be related to a certain extent to the versatility. The IWB was not only a tool for teaching and learning but also a platform combined multimedia resource. Besides, the effects of cooperative learning activities had been positive for increased academic achievement in empirical studies. The students learnt something of value from working together as a team to accomplish a common goal. In addition, it also influenced students learning attitudes, towards students with disabilities and enhanced the learning attainment.

One of the fundamental challenges of the IWB, for education purposes, was to ensure that it actually enhances the quality of the learning experience. In this case, students' learning motivation had distinct increase in value and expectation factors. It could be argued that students felt mathematics classes were interesting and helpful. All students thought that the multimedia aspects of the IWB as advantageous especially in engaging and holding their attention (Hall & Higgins, 2005). The IWB and cooperation learning activities were valuable in easing the time of the representation and test, building cumulative knowledge and integrating previous and new information. ICTs did effect change the roles of teachers and students (Kozma & McGhee, 2003). Teachers became a facilitator and a knowledgeable guide not as the traditional lecturing role. Students would be more independent and self-directed learning. While as noted above, the study had revealed a clear preference for the IWB use by both teacher and students. It provided a more flexible and collaborative approach between teachers and students in class.

This study was limited to a set of experiences in one primary school in Taiwan. In order for us to understand the best way for practitioners to use the IWB technology in the future class, research was needed to collect empirical evidence. The evidence had been presented which would enable to evaluate an attempt to innovate in the process of teaching. However, the tools were dead; only the instructions were alive. It would be argued that the uniqueness and the gift of the IWB technology lay on the possibility for an intersection between technical and pedagogic interaction (Smith, Higgins, Wall & Miller, 2005). The most important was not what teachers use; it was how teachers use the IWB. Only teachers holds the spirit in every class; the IWB would bring the biggest effectiveness.

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Biographical notes

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