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The Effect of Mind tools in Mathematic Infusion Web-enhanced Project-Based Learning

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Abstract: - Web-enhanced Project-Based Learning (WPBL) that emphasized on reality, diversification, comprehension, and technology-integration is a new learning trend conforming to mathematic education revolution. The purpose of this study was to discuss benefits of using Mindtools in project-based learning, including dynamic geometry (Geometer Sketchpad, GSP) and concept mapping. Sixty-two sixth-grade students of elementary schools in Tainan and Kaohsiung were selected for experimental instruction. The samples participated in infusion web-enhanced project-based learning to learn the symmetrical unit of space graph. This paper describes the dynamic progress of students learning and appraises the achievement of each group on concept mapping and dynamic geometry (GSP) in quantification. In a word, each group could present their ideas clear by using concept mapping in project plans drafted by themselves. They could also show their designs specifically in GSP. Study assignments of eight groups in concept mapping and GSP during the primary stage, middle stage and later stage all had obvious improvements following projects progression. It showed that the suitable system anchored instruction plan could help and develop students in using Mindtools to assist learning mathematic concepts, and then showed conspicuous progresses in project results. Pre-project learning experiences of students also affected the intermediary effect of two Mindtools. Approximately, groups with abundant experiences could present concepts clearer and be more plentiful in using concept mapping. Their presents were more mathematical, accurate, rich, creative, and adventurous than those of new learner groups. Exceeding researchers' expectancy, students had more active attitude and originality in products. It showed that Mindtools had positive potential in project-based learning application. This study also addressed difficulties of teachers and proposed practical suggestions for infusion WPBL.

Key-Words: - Web-enhanced Project-Based Learning, Mindtools

1 Introduction

For the policy of internationalization, mathematic education was taken as key factor to improve international competition, and the revolution trend of mathematic education seemed more important. Network technology is rising and flourishing in 21th century, so that the scope of mathematic education were from knowledge structural training emphasized on curriculum logic to a wider learning space surmounting national boundaries. How to integrate information technology into mathematic foundation education, pass on education and enhance national competitive will be an unavoidable and urgent mission of teachers.

Krajcik, Czerniak and Berger ([6]) defined cooperation as mental efforts of students, same generation, teachers and community members focusing on one problem. Network learning environment provided efficient cooperation chances to mitigate cognitive loading of each other, improved learning achievement and developed skills for real life by group collaborative mechanism. Net cooperative learning is not only information exchange but also common progress interaction that learners can create and have new meaningful learning ([5]).

Project-based learning emphasized on interests of exploring and learning; and it made learning feeler cross over textbook scope. It's expected to make learning full of vitality and then students could experience firsthand of the mathematic learning's suitability, challenge and interests. Project-based learning let students draw up and execute plan themselves to solve problems. Students could enjoy the progress of constructing knowledge which connect to real life closely. Hence, it was a reasonable striving way to build up common learning consensus by members' interaction and to seek meaningful structure advance ([2]).

Mindtools or mental tool or cognitive tool that stressed on computer renovation and infusion instruction was taken as a method to develop learners thinking, to improve students' creativity potential and reasoning ability, to cultivate students' high level thinking and to train up their capability of problem solving. For example, Derry([3]) thought that Mindtools(or mental tool) was an efficient tool to assist cognitive learning. Mindtools helped learners strongly to make knowledge meaningful, to utilize knowledge and to organize knowledge context delicately ([4]).

This research combined concept mapping and the geometer's sketchpad (GSP) as Mindtools for 'symmetry' unit learning. The design was mainly for efficient communication by concept mapping, for assisting learners' self-rethinking and for geometry concepts combination. Novak ([7]) aimed that concept mapping was suitable for instruction, learning, research and evaluation. It was a tool to let learners organize a group of conceptions to a meaningful meshed concept map by appropriate conjunctions ([8]). In practical application, concept mapping improved learners to present tacit concepts of subject messages by a schema organization method ([1]), and became learners' 'windows to the mind'. Students could stimulate space shift and variation of graphics and induce a regular pattern of geometry graph dynamic changes in GSP interface. It also overcame the defect of traditional geometry instruction that start off from definition and go from theorem to theorem.

For the specific functions of Mindtools in learning meaningful, there were three research purposes of this research:

(1). To assist students' infusion WPBL using two Mindtools, concept mapping and GSP. To explore the cognitive performance progress profile of students in applying two Mindtools communicating and integrating mathematic conceptions.

(2). To investigate the relationship between students' project learning experiences and Mindtools benefits.

(3). To provide practical suggestions for teachers of leading infusion WPBL through empirical research.

2 Research Environment

This research probed into progress of students' cognition in the application of integrating Mindtools into infusion Web-enhanced Project-Based mathematic learning. Two open Mindtools, concept mapping and GSP, were intervened into learning to assist student in integrating learning conceptions. Learning platform of WPBL and two Mindtools was introduced as follows:

2.1 Project-Based Learning Net Platform

YP WPBL platform (http://yp.ntntc.edu.tw) was developed by Tainan University for WPBL. This platform provided project-based learning and online multi-assessments for learners from different divisions through online discussion function.

2.2 Concept Mapping System

This study used the concept mapping website (http://houston.ntntc.edu.tw) developed by Tainan University as graphical and space concept mapping platform and it provided three types of concept mapping: closed, semi-open and open. Learners would have single or cooperation learning through this website and have evaluation of works. This research used open-cooperation concept mapping for mathematic concept communication.

2.3 The Geometer Sketchpad (GSP) System

This study used GSP package software developed by Swarthmore College and Curriculum Press and sponsored by NSF vision geometry project. It's a geometry drafting software and its user interface is based on Windows, object-oriented dynamic linkage.

3 Research Design

Research methodology, research instrument and data analysis will be described in this section.

The experimental learning unit is "symmetry" of five-grade mathematics, and the experimental period is two and half months from Dec 1, 2002 to Feb 15, 2003. There were two hours collective learning activities on line of two schools per Tuesday, and eight student groups had network cooperative learning during the period. Students also could have learning flexibly any other time.

3.1 Subjects and Grouping

Two six-grade classes, sixty-two students, were chosen as the sampling target for mathematic infusion WPBL; one is from elementary school in Tainan and the other is in Kaohsiung.

"Heterogeneous group" was used to divide students into eight groups, which contains three-to-eight students. Two groups had three project learning experiences, one group had two, and the other one had one experience. Distribution and background of samples was shown in Table1.

Table1. Subjects of mathematic infusion WPBL

Group	Number of Project experiences	Samples(Male，Female) Tainan	Samples(Male，Female) Kaohsiung
A	3	3（2，1）	3（0，3）
B	3	3（0，3）	4（3，1）
C	2	3（2，1）	4（2，2）
D	0	3（0，3）	5（3，2）
E	0	3（0，3）	5（3，2）
F	0	3（2，1）	6（4，2）
G	0	3（0，3）	5（1，4）
H	1	3（0，3）	6（4，2）
Total		62	

3.2 Research Procedure

3.2.1 Procedure of applying Mindtools system in anchored instruction

Mindtools application system, concept mapping and the Geometer Sketchpad (GSP), includes anchored instruction, symmetry concept learning activity and student work sheets (see Table2). Anchored instruction was focused in operation of concept mapping software and geometer sketchpad, and it introduced "What is it in and out the mirror?" using picture books. Research progress was divided into the initial stage, the middle stage and the later stage; in each stage students must finish work sheets of the symmetry unit including concept mapping and GSP.

Table2. The anchored instruction procedure of Mindtools, concept mapping and GSP

Items	Activity content	Electrical homework	Time
System operation anchored instruction	● Operation of concept mapping interface ● Operation of GSP	● practice of concept mapping closed-form example ● GSP practice of line segment, point and the perpendicular bisector	91.12 .01
Symmetry concept anchored instruction	Is there a magic in interior and external mirror?		91.12 .07
anchored instruction picture books			

3.2.2 Procedure of student project-based learning activity

Student activities of infusion WPBL were separated into three stages, and each group had to accomplish one concept mapping and one GSP electronic work sheet in each stage.

Students from two schools had online discussion and learning through YP learning website. Students of the same group who come from two schools had to upload their cooperative work sheet to teachers for evaluation and feedback. They should complete their own work and then integrate and modify their sheets through online cooperation, discussion and feedback. Electronic GSP design work sheets included work ideas, concept and procedure illustration.

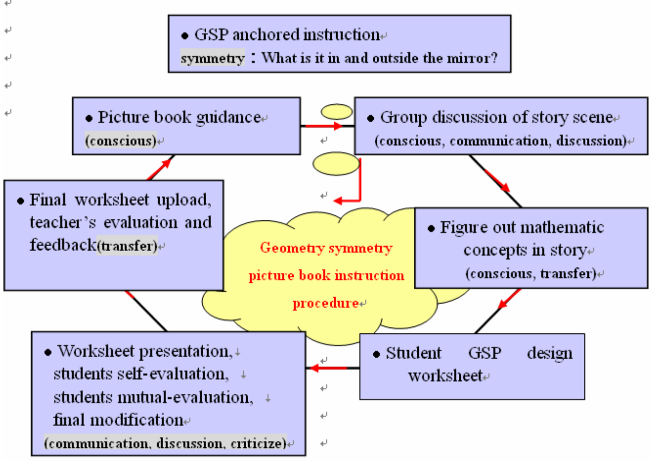

Fig.1 Procedures plan of Geometry symmetry picture book instruction activities

Instruction activity used picture books for GSP anchored instruction guideline. The driving question designed by teacher is "What is it inside and outside the mirror?" which included story tutor, group discussion of story scene, finding the mathematic concepts of story, completing all stages' concept mapping and GSP electronic work sheets, group presentation, discussion and feedback, modification of the first draft, worksheet upload, teacher evaluation and feedback(see Fig.1).

3.3 Evaluation design and data analysis

Evaluation in this study has two parts: one is Mindtools concept mapping electronic works review, and the other is Mindtools GSP electronic works review. The purpose of concept mapping application is to be the tool of students' knowledge integration. Students modified concept mapping in the draft proposal to a refined and plentiful mapping through group discussion. This research evaluated the students' knowledge learning and progress by students' three stages works. GSP used the quantification way in five dimensions to evaluate the GSP works' mathematic concepts and creativity. The methods of evaluation are described as below:

(1). Evaluation of concept mapping Mindtools works: Concept mapping evaluation was modified from the method in 'Learning How Learn' ([7]) and the evaluation rules are scored as the following structure: relationships, hierarchies, cross-links, examples, branch.

(2). Evaluation of GSP Mindtools works: Mindtools GSP works evaluation were focus on five levels including mathematics, accuracy, richness, innovation and adventure. Evaluation grade was divided into excellent, good, and approved levels, which had quantification score 3, 2 and 1. The GSP works evaluation was described as follows: mathematics, accuracy, richness, innovation, adventure.

4 Result and Discussions

The purpose of this research is to confer on the benefit of inter-school infusion mathematic WPBL application, and the learning topic is 'symmetry' of elementary mathematic course, using Mindtools concept mapping and GSP to improve learning meaningful. Inter-school students groups had to discuss and complete the 'symmetry' project learning through YP website, and accomplished Mindtools works at the initial, middle and final stages. This study analyzed students' cognitive progress profile by evaluating groups works quantified.

4.1 The typical examples of students progress of using Mindtools in infusion WPBL

Table3 showed description statistic of all groups performs for concept mapping and GSP at different stages. Evaluations of two Mindtools were as follows: 1) concept mapping, focused on design works relationships, hierarchies, cross-links, examples and branch presentation. 2) GSP, focused on design works mathematics, accuracy, richness, innovation and adventure presentation. In conclusion, following the time passing, eight groups all gained progress in two Mindtools achievement.

Table3. The performs of all groups for concept mapping and GSP at different stages (n=8)

stage	concept mapping		GSP	
	MEAN	STDEV	MEAN	STDEV
The initial stage	17.00	11.34	5.50	1.07
The middle stage	26.13	12.29	8.00	1.77
The later stage	42.75	16.57	10.13	2.03

Those results showed that experiences of concept mapping had real help for students in interconnecting mathematic concepts, The composition at final stage is more deliberate and plentiful than that in initial and middle stages, and the concepts presented were more pellucid (showed in Fig.2). We also found that students were easy to make self-examination and modification through concept mapping. This tool assisted students to carry conception communication out in comprehensive proposal. GSP design works at later stage showed harder mathematic design and application, and interconnected more accurate mathematic knowledge to design dynamic displacement with originality (see Fig.3).

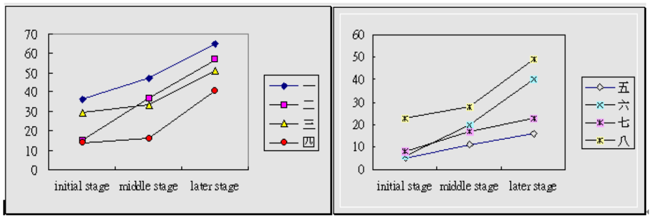

Fig. 2. The performs of eight groups for concept mapping at different stages

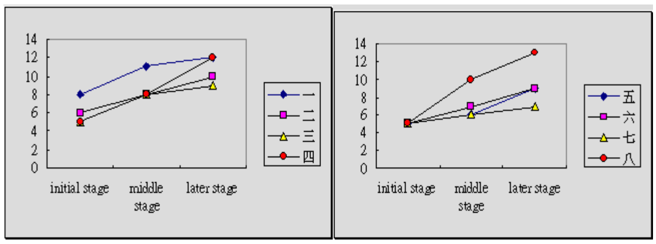

Fig. 3. The performs of eight groups for GSP at different stages

Through the empirical examination, Mindtools concept mapping and GSP could significantly improve PBL design works and construct of 'symmetry' conception. The results showed the feasibility and potential of applying Mindtools concept mapping and GSP in infusion WPBL.

4.2 Presentation comparison of two Mindtools in each dimension at different stages

Students' concept mapping works presentation in relationships, hierarchies, cross-links, examples and branch dimensions showed that: 1) there was significant improvement at final stages; 2) the advancement of 'cross-links' was most evident; 3) the 'branch' score of five dimensions was lowest in works. GSP works had great improvement in mathematics, richness and innovation in whole progress; and in accuracy, there was significant rising trend at final stage than at middle stage (see Table4、Table5 and Fig.4). We also found that there was significant progress in criticized thinking and interconnected thinking of groups' comprehensive discussion using concept mapping and GSP.

Table 4. The performs of eight groups in two Mindtools at three stages

Mindtools	items	Initial stage MEAN	Initial stage STDEV
Concept mapping	relationships	3.00	1.41
	hierarchies	4.75	2.55
	cross-links	4.25	4.03
	examples	3.25	4.68
	branch	0.00	0.00
GSP	mathematics	1.00	0.00
	accuracy	1.88	0.35
	richness	1.13	0.35
	innovation	1.13	0.35
	adventure	1.00	0.00

Table 5. The performs of eight groups in Middle stage and Later stage

Mindtools	items	Middle stage MEAN	Middle stage STDEV	Later stage MEAN	Later stage STDEV
Concept mapping	relationships	4.88	2.03	7.25	2.43
	hierarchies	7.38	4.66	8.88	4.16
	cross-links	8.50	6.57	18.00	10.81
	examples	5.13	4.22	7.50	4.41
	branch	1.00	1.51	1.00	0.76
GSP	mathematics	1.25	0.46	1.88	0.64
	accuracy	1.88	0.35	2.25	0.46
	richness	1.63	0.52	2.38	0.52
	innovation	1.63	0.74	2.25	0.71
	adventure	1.38	0.52	1.50	0.53

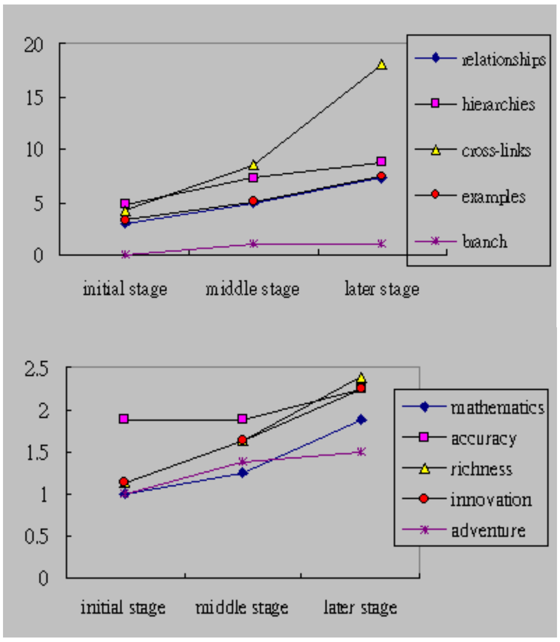

Fig. 4. A cross-section comparison of eight groups progress in items of two Mindtools

4.3 Presentation comparison of different project-learning-experience background

In eight groups, there were two having three experiences of mathematic project learning, one having one experience, and other four new learner groups having no experience. The concept mapping grade means of groups of different experiences from three to zero were 42.83, 37.67, 33.33 and 18.08 in order. The GSP grade means of groups of different experiences from three to zero were 9.17, 7.33, 9.33, and 7.00 in order. The raw data showed that, at the level of Mindtools application in PBL, mathematic project-based learning experience had positive help/influence for students in integrating mathematic concept and improving GSP design ability.

4.4 Difficult and suggestions of infusion WPBL practice

Students needed longer learning time in project-based leaning than tradition learning, so that there was time pressure and difficulty for teachers to manage a infusion WPBL. This research had carried practically WPBL out for two and half months using inter-school infusion network cooperation. Teachers generalized six unavoidable difficulty through complete instruction profile, those were: insufficient of learning time, difficult of taking care of low-spirited learning students, difficult of governing computer classroom, difficult of group cooperation, straying from network game and difficult of project-based learning measurement. Teachers needed to adjust management strategy aimed to real situation forthwith.

5 Conclusion

This research held infusion mathematic project-based learning activities through network inter-school cooperation. One side, we observed the dynamic track of groups design work completed through online discussion from different school in math WPBL progress. The other side, we tried to set up a distinct, clear and systematic evaluation rules to analyze students cognitive performs in concept mapping and GSP works. Meanwhile, through empirical practice, we figured out the difficulty that teachers will confront when they apply infusion WPBL, and then addressed some suggestions.

(1). Constructive benefit of Mindtools in infusion WPBL

Through two and half months mathematic WPBL, eight groups students all completed 'symmetry' works in proper sequence at initial, middle and later stages with supports of Mindtools learning environment. Group students from different school finished first draft work of each stage through online discussion mechanism, modified it to final manuscript by groups' feedback, and then sent it to teachers. This paper described students' dynamic learning progress specifically and quantified evaluated groups design works of two Mindtools, concept mapping and GSP. In a word, each group could use concept mapping to present their conception clearly and could use GSP to present their design concretely. This research also found out that students with project-based learning experiences had better application capability in using Minstools to assist mathematic concepts learning. Those groups needed shorter time to get with it and their works appeared high quality refined thinking and originality. This aimed the active possibility of applying Mindtools in PBL, and revealed that PBL should be designed as long-term plan. We also examined the feasibility of elementary PBL through network cooperation mechanism.

(2). Practical suggestions of infusion WPBL

This study brought up practical suggestions and handle model of infusion WPBL through leading empirical activities. However, PBL needed to go deep into investigation, teachers often needed to face the pressure of time limitation. This research generalized six difficulty through empirical infusion WPBL instruction profile, those were: insufficient of learning time, difficult of taking care of low-spirited learning students, difficult of governing computer classroom, difficult of group cooperation, straying from network game and difficult of project-based learning measurement. To solve those, we provided some adjustment program for teachers as below: (a) teachers should involve in students collaborative activities at the right moment to improve learning efficiency; (b) teachers should assist groups to set up good cooperation value actively; (c) teachers should make a contract with students of learning and normal orders; (d) after school interview or measurement should be planned in advance.

Furthermore, we proposed the difficulty and handle model for infusion WPBL teachers through empirical activities. The WPBL Mindtools evaluation method designed in this study also provided learning objectives, communication, and feedback function for students' project learning. This structured and systematic evaluation design also appeared application possibilities in integrating and accumulating students' perform data/profile for over-time mathematic PBL.

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