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Teaching mathematics, science and technology concepts through designing hands-on and reflective activity

Kuen-Yi Lin†, Ting-Chen Hu† & Hsiu-Chin Tsai‡

HungKuang University, Taichung, Taiwan†
Taiwan Foundation for Democracy, Taipei, Taiwan‡

ABSTRACT: The purposes of this study were focused on exploring students' learning performances in a hands-on and reflective activity, and exploring the effects of self-regulated learning strategy in hands-on and reflective activity. A quasi-experimental design was employed, and the following conclusions were made: (1) students had difficulties in applying newly learned Mathematics, Science and Technology (MST) concepts in designing and making a product; (2) the self-regulated learning strategy had no significant effect in helping students learn MST concepts, but it did have an important effect and is worthy of further study.

INTRODUCTION

In recent years, more and more positioned papers have emphasised exploring the possibility of teaching science through technology learning activity [1]. The main reason for this research trend was that science teaching focused on the theory and lacked practical application. However, technology teaching focused on the practical skill training and lacked theory. Therefore, how to combine the theoretical teaching with the practical teaching was becoming an important issue. In order to solve this question, the subject-matter integration concept was proposed and more and more scholars have stated their valuable opinions on this.

First of all, Foster proposed the importance of subject-matter integration [2], and Davies and Gilbert also stated that the integration of science and technology could minimise the shortcomings of lack of theory in technology and practical skills in science [3]. According to the ideal of bridging science and technology, Yu, Lin and Wang tried to put their emphasis on developing the MST-integrated curriculum, and cooperated on research for the purpose of implementing and reflecting the effects of the MST-integrated curriculum [4].

According to the above research, most of these results were focused on developing the MST-integrated curriculum or exploring the effects of the MST-integrated curriculum in cognitive learning achievements. Although the present research results of the MST-integrated curriculum were limited, there are many important issues worthy of further exploration. For example, Zuga stated the researchers of technology education should put their emphasis on exploring the students' concept learning process [5], and Cajas also believed that the researchers of technology education should focus on solving the question of how to improve students' performance in concepts and skills in technology education [6]. Therefore, according to the analysis of the related literature on the MST-integrated curriculum, the first important task was to clarify how students applied the MST concepts during the process of making technological products in the MST-integrated curriculum, then, the effects of the MST-integrated curriculum have a chance to be proved.

Except for the learning process, an important issue also was how to help students in learning MST concepts through hands-on activity. Many scholars adopted self-regulated learning as the major strategy in order to enhance students' cognitive learning [7]. Barak proposed a compensative model for self-regulated learning in technology education, and highlighted the interrelationships between cognitive, metacognitive and motivational aspects of learning [8].

On this theoretical basis, the researcher developed a hands-on and reflective activity, and tried to find out the students' MST-learning performances in this activity. Therefore, the research purposes of this study were focused on:

- exploring the students' MST-learning performances in the hands-on and reflective activity, and
- exploring the effects of self-regulated learning strategy in hands-on and reflective activity.

RESEARCH DESIGN AND IMPLEMENTATION

Research Methods

The research purposes of this study were focused on exploring the students' MST-learning performances in the hands-on and reflective activity, and exploring the effects of self-regulated learning strategy in hands-on and reflective activity. In order to achieve these research purposes, the quasi-experimental design was employed in this study (see Table 1) for controlling the non-experimental factors, such as characteristics of the experimental environment and the participants' attitude, during the teaching process, on the one hand, and for verifying the hands-on and reflective activity's real effect, on the other hand.

Table 1: Quasi-experimental design.

	Pre-test	Experimental Treatment	Post-test
Experimental group	O_1	X	O_2
Control group	O_3		O_4

The experimental group refers to the class assigned to the learning of hands-on and reflective activity, and the control group refers to the class assigned to the learning of only hands-on activity. The major difference between these two groups was that self-regulated learning strategy was employed in designing the experimental group's hands-on and reflective activity for the purpose of increasing students' MST concept learning. As well, the pre-test score was the students' natural science and living technology score in the 2008 school year, and students had to undertake the MST learning achievement test, which was developed by Yu and Lin [9] and its *Kuder-Richardson* reliability was 0.70, as the post-test score.

Participants

The research participants in this study were 102 grade 8 junior high school students, with 49 distributed as the experimental group and 53 distributed as the control group. The reason for choosing grade 8 students, instead of grade 7 or 9 students, was that grade 7 students did not have enough MST concepts, and grade 9 students faced the pressure of entering senior high school. So the best participants in the junior high school were grade 8 students, and in order to ensure the validity of data analysis, 102 grade 8 students were invited to join this study.

Research Implementation

The experimental teaching time was 2 hours a week and 12 weeks in total. The experimental group's teaching process was divided into five parts: (1) week 1: to introduce the approaches in self-regulated learning; (2) week 2–5: to design and make a glider; (3) week 6: to reflect the learning process of hands-on activity 1; (4) week 7–11: to design and make a glider again; (5) week 12: to conduct a MST concept learning test. As for the control group, the teaching process was divided into three parts: (1) week 1–5: to design and make a glider; (2) week 6–11: to design and make a glider again; (3) week 12: to conduct a MST concept learning test.

The difference between the experimental group and the control group was the utilisation of the self-regulated learning strategy in the experimental group; students had to reflect on their performance in utilising the MST concepts in designing and making a glider. Furthermore, they also had to utilise their reflection in designing and making a new glider.

Data Analysis

As for the quantitative data, the mean, average, standard deviation and analysis of covariance were utilised, on the one hand, and as for the in-depth interview and portfolio, the qualitative data analysis steps were utilised in order to generate the results with good validity.

RESULTS

In this study, the researcher developed a hands-on and reflective activity and tried to find out the students' MST learning performances in this activity. Therefore, the research purposes of this study were focused on exploring the students' MST learning performances in the hands-on and reflective activity, and exploring the effects of self-regulated learning strategy in hands-on and reflective activity.

Students' Concept Learning Performances in Hands-on Activity

According to the analysis of 102 grade 8 students' learning performances, they had difficulties in learning the concepts of dihedral angle, Bernoulli, and aspect ratio, and all of these concepts' correct percentage were under 40%. The grade 8 students were learning about these three concepts for the first time, so it was hard for them to apply these concepts in making a glider. In other words, students had to remember and understand the MST concepts, and then they could learn to apply and evaluate these MST concepts [10].

Table 2: Students' concept-learning performances in hands-on activity.

Dihedral Angle		XYZ Axis Control		Bernoulli		Aspect Ratio		Centre of Gravity	
correct	wrong	correct	wrong	correct	wrong	correct	wrong	correct	wrong
40(39%)	62(61%)	52(51%)	50(49%)	39(38%)	63(62%)	39(38%)	63(62%)	50(49%)	52(51%)

The Effects of Self-regulated Learning Strategy in Hands-on Activity

In order to verify the real effect of self-regulated learning, the quasi-experimental design was employed in this study; meanwhile, the grade 8 students' natural science and living technology scores in the 2008 school year were used to establish the covariance, and the MST concepts learning test scores were used as the post-test scores for the purpose of eliminating the effect of memory. According to the result of ANCOVA (see Table 3), the experimental group's and control group's performances in MST concept learning had not reached the significant level in eliminating the influence of covariance (F=0.08, p=0.77). In other words, the self-regulated learning strategy did not have the obvious effect in helping grade 8 students in learning MST concepts.

Table 3: The summary of ANCOVA.

Source	Sum of Squares	df	Mean Square	*F*	*p*
covariance[1]	356.88	1	356.88	0.58	0.45
within-group[2]	51.46	1	51.46	0.08	0.77
error	60740.730	98	619.803		

The results of ANCOVA did not correspond to the researcher's expectation, but the *t*-test results were not so disappointing. The experimental group had better performances than the control group on the concepts of dihedral angle (*t*=4.25, *p*=.00), XYZ axis control (*t*=4.28, *p*=.00), aspect ratio (*t*=2.17, *p*=.03), and centre of gravity (*t*=1.99, *p*=.04), and all of these differences reached the significant level (see Table 4). According to the results, the researcher believes the self-regulated learning strategy should have the same effect as stated by Barak [8].

Table 4: Students' concept learning performances *t*-test.

Dihedral Angle					XYZ Axis Control					Bernoulli					Aspect Ratio					Centre of Gravity				
X		C		*t*	X		C		*t*	X		C		*t*	X		C		*t*	X		C		*t*
M	*SD*	*M*	*SD*		*M*	*SD*	*M*	*SD*		*M*	*SD*	*M*	*SD*		*M*	*SD*	*M*	*SD*		*M*	*SD*	*M*	*SD*	
.59	.50	.21	.41	4.25*	.71	.46	.32	.47	4.28*	.45	.50	.32	.47	1.33	.49	.51	.28	.46	2.17*	.59	.50	.40	.49	1.99

Note 1: X represents the experimental group, C represents the control group.
Note 2: Line 4 represents the correct rate.

CONCLUSIONS

According to the data analysis and discussion, the following conclusions were made.

Students had difficulties in applying newly learned MST concepts in designing and making a product.

Grade 8 students had difficulties in learning the concepts of dihedral angle, Bernoulli, and aspect ratio. The grade 8 students were all learning for the first time about these concepts, so it was hard for the students to apply them in making a glider. Therefore, students had to remember and understand the MST concepts, and then they could learn to apply and evaluate these MST concepts [10]. In other words, the technology teacher should choose the MST concepts carefully, and then students could have the chance to put theory and practice together.

The self-regulated learning strategy had no significant effect in helping students to learn MST concepts, but it did have an important effect and is worthy of further study.

According to the previous analysis, the self-regulated learning strategy could not increase the students' performance in the Mathematics, Science and Technology learning achievement test, but it could help students in learning the concepts of dihedral angle, XYZ axis control, aspect ratio, and centre of gravity concepts in the hands-on activity. According to the results, the researcher believed that the self-regulated learning strategy should have the effect stated by Barak [8].

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