提升對天然災害的認識及防災能力—颱洪防災教案的試教及評量

Enhancing the Capacities on Natural Hazards Mitigation—A Pilot Study on a Typhoon Curriculum Module at High School Classrooms

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摘要

本文的研究目的在評估由“高中職防災教學資源發展與課程推廣”計畫案所開發的適用於高中職的颱洪防災教案的試教成效。本研究亦嘗試開發“颱洪學習成就”及“颱洪防災素養”兩評量問卷作為評量颱洪防災學習成效的工具。試教結果肯定此課程對提升高中學生對颱洪防災的認知及防災態度上皆有正向的影響。研究結果建議教師使用小組討論的教學方式能提升學生對預防及減緩颱風災害的思考廣度及層次。另外，此研究所蒐集的資料有助於本計劃案針對如何防災減災的議題開發自動評分系統以協助開放式問題的評量。

Abstract

This study was part of the hazards mitigation education program “Research on Teaching Resources Development and Curriculum Promotion on Natural Hazards Mitigation at High School Level.” The purpose of this study was to evaluate the newly developed 100 minutes curriculum module of typhoon hazards and its teaching practice at high school level. In addition, this study developed the learning assessment instruments for the evaluation of the typhoon hazards mitigation curriculum, which include “The Typhoon Learning Achievement Test” and “The Attitudes Toward Typhoon Hazards Mitigation Inventory.” The study results showed that the curriculum module has resulted positive learning outcomes in terms of students’ cognitive learning and their attitude toward typhoon hazards mitigation. Findings also suggested that group discussion as an instructional approach could stimulate students’ thinking and sharing about the perceptions and precautions against typhoon hazards. In addition, the information collected from this study offered insights for the development of an automatic grading system for grading the open-ended question on typhoon hazards mitigation.

1. Introduction

The impact of natural hazards on human lives and properties can be devastating. According to the annual report of the United Nations Development Programme (UNDP) (2006), natural hazards caused 91,900 deaths all over the world in 2005. Annual economic losses associated with such disasters averaged US$ 75.5 billion in the 1960s, US$ 138.4 billion in the 1970s, US$ 213.9 billion in the 1980s and US$ 659.9 billion in the 1990s (UNDP, 2004).

Due to its geographical location, natural hazards, like earthquake and typhoon, often cause severe disasters in Taiwan. With 73 percent of the land surface and the population exposed to three or more natural hazards, Taiwan is recognized as one of the most vulnerable places to natural hazards on Earth (World Bank, 2005). Therefore, the governments at all levels have recognized the impacts of the natural hazards and the importance of inter-agency integrated programs on hazards mitigation. For examples, the National Science and Technology Program for Hazard Mitigation (NAPHM) was approved by the National Science Council (NSC) in 1997. In 2003, the National Science & Technology for Disaster Reduction (NCDR) was established to manage the operations of NAPHM.

On the other hand, related programs by the Ministry of Education since the beginning of this century are a result of an understanding that hazards awareness through education is essential for disaster prevention and mitigation. Sponsored by the Advisory Office of Ministry of Education, a program named Science and Technology for Hazards Mitigation Education Program aimed at promoting hazards mitigation awareness and the establishment of correspondent evaluation system at all levels of education system has been in place since 2003. During the program's first stage from year 2003 to 2006, positive responses were received from the program's awareness promotion on hazards mitigation and preparing teachers for hazards mitigation education. Now the program has entered its second stage, from 2007 to 2010, where the goals are focused on combining educational resources for hazards mitigation, creating learning environment, and enhancing the capacities for hazards mitigation at all levels of the society.

This study is part of the Science and Technology for Hazards Mitigation Education Program named "Research on Teaching Resources Development and Curriculum Promotion on Natural Hazards Mitigation at High School Level." Developing national capacities on precautions against natural hazards through educational systems is one of the highest priorities of Ministry of Education (MOE). However, a recognized barrier to implementing the hazards mitigation education in schooling is the absence of related content standards in the mandated curriculum guidelines (MOE, 2001; MOE, 2004). It is imperative for educators and researchers to develop curriculum modules for the current earth science curriculum mandates to be implemented in classrooms. The development of such content in natural hazards would help students get better understanding of natural hazards and hazards mitigation.

The purpose of this study was to evaluate the newly developed 100 minutes curriculum module of typhoon hazards and its teaching practice at high school level. In addition, this study developed the learning assessment instruments for the evaluation of the typhoon curriculum, which include “The Typhoon Learning Achievement Test” and “The Attitudes Toward Typhoon Hazards Mitigation Inventory.” In addition, information collected from the students’ answers to the questions on typhoon hazards prevention was used for the development of an automatic grading system for open-ended question on the learning assessment of typhoon curriculum.

2. Overview of the Typhoon Hazards Mitigation Curriculum

With an emphasis on the positive attitudes toward the natural hazards in Taiwan, the new developed typhoon hazards mitigation curriculum aimed at promoting students’ awareness on natural hazards and to develop active attitudes and actions on typhoon hazards prevention and rehabilitation in their daily lives. The typhoon learning contents are based on the curriculum requirements of the topic Introduction to Earth Science of high school curriculum guidelines (MOE, 2004). The compatible learning content of hazards mitigation was developed accordingly with a focus on the hazards mitigation itself rather than the phenomenon and its impact. It was anticipated that the typhoon mitigation curriculum will equip high school students with knowledge, skills, and attitudes needed for typhoon hazards mitigation. The data collected from the classroom practices was informative for future high school classrooms practice in general and the refinement of the curriculum guidelines.

Three learning themes designed in the typhoon hazards curriculum were (1) the cause of typhoon and weather forecast; (2) typhoon hazards and mitigation; and (3) Flood hazards and mitigation. The 5E instructional model (BSCS, 1989; Bybee et al., 1989) was adopted to help students formulate a better understanding of knowledge, skills, and attitude toward typhoon phenomenon and the precautions capacity against natural hazards. The 5E instructional model is a five-step cyclical learning model which involves engagement, exploration, explanation, elaboration, and evaluation. This model allows of re-entering into different stages back and forth during the learning process. Multiple teaching approaches and materials are employed in the typhoon curriculum, including PowerPoint presentation, films (bought and self-made), demonstration, hands-on activities, direct instruction, question posing, concept presentation, class discussion, etc.

3. Methods

3.1 Participants

Two classes of 80 grade 10 high school students were involved in this study. There were 41 students in class one and 39 students in class two with 45 males and 35 females. One high

school teacher taught the same 100 minutes typhoon curriculum module and used the same teaching materials in these two classes during two-week period. The participating teacher held a master's degree in earth science and had 10 years of teaching experience in the field.

3.2 Learning Outcome Assessment Instruments

To assess students' typhoon hazards learning outcomes, two learning outcome assessment instruments were developed for this study: The Typhoon Learning Achievement Test and The Attitudes Toward Typhoon Hazards Mitigation Inventory. The Typhoon Learning Achievement Test contains 34 multiple choice questions, one short answer question, and one open-ended question. The questions items were selected from the database of the Scholastic Achievement Test (SAT) for college entrance examination. The Attitudes Toward Typhoon Mitigation Inventory consists of two sections with a total of 27 statements, 11 items on typhoon perceptions and 16 items on typhoon mitigation attitudes, on a 1-5 Likert scale ranging from "strongly disagree" to "strongly agree." To refine the instruments, by using Kuder-Richardson Formula 20 (KR-20) and Cronbach's alpha values, the internal reliabilities of the achievement and attitude questionnaires were estimated and the instruments were adjusted accordingly.

3.3 Study design and data analysis

Based on the assumption that students learn best not by information transmission, but by knowledge construction process (Brooks & Brooks, 1993; Jonassen & Land, 2000), it was hypothesized that students' learning outcomes would be enhanced by group/discussion-oriented learning activities. In the learning unit of "how to mitigate the typhoon hazards," students in class one (experimental group) were organized for group discussion activities while class two (control group) did not have discussion activities. This learning unit was later assessed by the open-ended question "what can we do to prevent the typhoon calamities before, during, and after the typhoon reaches land?" in the Typhoon Learning Achievement Test inventory.

A two-group quasi-experimental design (Campbell & Stanley, 1966) was adopted for this study. After the 2-week instruction period, the learning outcome assessment instruments were administered to both classes. It was noted that during the 2-week period, each class received an equal amount of instructional time and was provided with the same learning materials. The design and classroom practice on the newly developed typhoon hazards curriculum were monitored by classroom observations and video-recorded with a focus on the learning activities organized for the unit of typhoon hazard mitigation. To understand how different learning activities account for the variance in learning outcome, this study used the class as predictor in regression model to predict students' learning outcomes.

4. Results

4.1 Refining the Assessment Instruments

The reliability coefficient of the questionnaire estimated by Kuder-Richardson Formula 20 (KR-20) was 0.529 (Table 1). The KR-20 value of 0.529 may not be explained as low reliability of the test. It should be noted that during the two weeks of the typhoon classes, students were not informed that there would be an achievement test followed.

Table 1 *The internal reliability of the typhoon learning achievement test (multiple choice part)*

Learning achievement inventory	KR-20	N of Items
	0.529	34

Factor analysis was used to refine the attitude assessment inventory. As can be seen in Table 2, five items in each of the two subscales of attitudes were extracted by the three criteria in selecting valid questionnaire items. Items were deleted when (a) it belongs to different factors; (b) the factor loading amount is smaller than 0.6; and (3) the loading amounts are similar between the two components (typhoon content learning and attitude toward typhoon mitigation). The 10 extracted items from this study later will combine earthquake and flood question items for the design of “attitude toward natural hazards mitigation inventory.”

As shown in Table 3, the reliability coefficient of Cronbach’s alpha value on the attitudes toward typhoon hazards mitigation (10 items in total) was 0.739. The values of the attitudes toward typhoon curriculum and typhoon mitigation were 0.738 and 0.714, respectively.

Table 2 *Factor loading extraction from the typhoon hazards mitigation questionnaire items*

Items	Component	
	Perceptions on Typhoon Curriculum (C)	Attitude toward Typhoon Hazards Mitigation (A)
C11	.788	.254
C1	.765	.291
C10	.670	.085
C6	.635	-.318
C5	.619	.010
A25	-.010	.734
A16	.001	.730
A24	.229	.662
A13	.465	.616
A20	.008	.606

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

Table 3 *The internal reliability of the attitudes toward typhoon curriculum and hazards mitigation for the typhoon class*

	Attitude inventory	Cronbach's Alpha	N of Items
Sub-scale	Typhoon curriculum perception	0.738	5
	Typhoon mitigation attitude	0.714	5
Total	attitudes toward typhoon hazards mitigation	0.739	10

4.2 Students' Learning Outcomes

Summary of mean scores and SD in comparison of class and sex on typhoon hazards learning outcomes were shown in Table 4. The learning outcomes, 62.5 on achievement and 3.75 on attitude, suggested that the participating students generally acquired a reasonable level of knowledge on typhoon hazards mitigation and hold positive attitude toward typhoon hazards mitigation. It was also indicated that students in the class one gained higher scores than those in the class two both on the achievement and attitude assessments, mean scores of 67 and 3.88 for the class one and mean scores of 58 and 3.36 for the class two.

Table 4 *Students' Learning Outcomes in typhoon hazards mitigation classes, N=80*

	Class	Number	Mean	Std. Deviation
Learning Achievement Test	1	41	67	5.97
	2	39	58	4.99
Typhoon Hazards Attitudes	1	41	3.88	5.52
	2	39	3.36	5.54
	Sex	Number	Mean	Std. Deviation
Learning Achievement Test	M	45	62	5.99
	F	35	63	6.38
Typhoon Hazards Attitudes	M	45	3.70	5.47
	F	35	3.84	5.77
	Total	Number	Mean	Std. Deviation
Learning Achievement Test		80	62.5	6.14
Typhoon Hazards Attitudes		80	3.75	5.64

As seen in Table 5, there were significant learning differences between the two classes on students' cognitive and affective outcomes. It was indicated that different instructions did

influence students' cognitive understanding on typhoon hazards and enhance their positive attitude toward typhoon hazards mitigation. The study also found that students' typhoon learning achievement correlated with their typhoon hazards attitude. As indicated in Table 6, students' knowledge on how to mitigate typhoon hazards was strongly correlated with their attitude toward the typhoon hazards mitigation.

Table 5 *T test on the two class difference on learning outcomes*

	t	Sig. (2-tailed)	95% Confidence Interval of the Difference	
			Lower	Upper
Learning Achievement Test	4.47	0.000*	3.05	7.96
Typhoon hazards Attitude	2.37	.020**	0.46	5.34

* p < .0001; ** p < 0.05

Table 6 *Relationships between the typhoon learning achievement test and typhoon hazards mitigation attitudes*

	typhoon curriculum Perceptions (sub-scale)	Typhoon mitigation attitudes (sub-scale)	Attitudes toward the typhoon hazards mitigation (the total inventory)
Learning Achievement Test	0.11	0.213*	0.198*
Short Answer Question	0.14	0.036	0.117
Open-ended Question	0.12	0.304**	0.259*

** Correlation is significant at the 0.01 level (1-tailed)

* Correlation is significant at the 0.05 level (1-tailed)

4.3 The Impact of Discussions on Students' Perceptions on Typhoon Hazards Mitigation

According to the t-test on the midterm exam (prior knowledge), students in the two classes were at the same learning status (Table 7). The regression analysis was then adopted to test the impact of instructions on students' learning outcomes. As shown in Table 8 and 9, the regression analysis revealed that the instruction as a significant predictor in explaining students' achievement (t = -4.467, p < 0.001) and students' attitude (t = -2.365, p < 0.05), suggesting the importance of group discussion in students' learning. That is, group discussion could enhance students' cognitive learning on typhoon hazards knowledge and also encourage more positive attitudes on the issue of typhoon hazards mitigation.

It was found that the learning achievement difference between the two classes was

mainly affected by the scores gained on the open-ended question of “what can we do to prevent the typhoon hazards before, during, and after the typhoon reaches land?” The students’ answers in the class one demonstrated group discussions could stimulate their thinking. Besides, by sharing in the group discussions, multiple aspects on precautions against typhoon hazards and different actions for hazard mitigation were presented by students in the class one. The data collected from the open-ended question in this study were informative for the development of an automatic grading system for grading the open-ended question on typhoon hazards.

Table 7 *T-test on two class students’ prior knowledge in earth science*

		t	Sig. (2-tailed)	95% Confidence Interval of the Difference	
				Lower	Upper
Midterm Exam	Class1	0.794	4.30	-2.36	5.48
	Class2	0.793	4.30	-2.361	5.485

Table 8 *Regression model testing the group discussion on students’ achievement*

Predicting variable	B	S.E.	*B*	*t*	*p* value
Constant	48.094	1.935		24.853	.000
Class	-5.508	1.233	-.451	-4.467*	.000

Note: $R^2 = 0.204$; adjust $R^2 = 0.193$

$p < 0.001$

Table 9 *Regression model testing the group discussion on students’ attitude*

Predicting variable	B	S.E.	*B*	*t*	*p* value
Constant	49.452	1.924		25.705	.000
Class	-2.900	1.226	-.259	-2.365*	.020

Note: $R^2 = 0.067$; adjust $R^2 = 0.055$

$p < 0.05$

5. Summaries

As the study results showed, the teaching of the typhoon curriculum module has resulted positive learning outcomes. The learning in the typhoon hazards mitigation classes promoted students’ typhoon knowledge and encouraged their positive attitudes toward typhoon precaution and mitigation. For the development of the Attitudes Toward Natural Hazards Inventory, a total of ten items were extracted from the subscales of “typhoon hazards mitigation curriculum perceptions” and “typhoon hazards mitigation attitudes” as part of the

inventory development of attitudes toward natural hazards. Evidenced from the learning outcomes, instructions that teacher employed had impact on students' learning achievement and attitude. It was showed by the study findings, the group discussion activities designed for the learning of typhoon hazards mitigation could stimulate students' thinking and sharing about the perceptions and precautions against typhoon hazards. In addition, the information collected from the students' answers on the open-ended question of "what can we do to prevent the typhoon hazards?" provided multiple aspects of precautions and actions that could help prevent or mitigate typhoon hazards. These results offer insights for the development of an automatic grading system for grading the open-ended question on typhoon hazards.

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