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THE IMPACT OF A SCIENCE MUSEUM INVOKED LEARNING ENVIRONMENT (SMILE) ON STUDENTS

Chun-Yen Chang,
Yu-Ching Huang,
Chen-Yuan Chen

Abstract. *This study aims to develop an ESSMIM (Earth System-Science Museum Instructional Module) and evaluate its impacts on 11th grade high-school students' expected and actual perceptions of a Science Museum invoked Learning Environment (SMiLE). The ESSMIM was designed following the principles of the "Earth System Education (ESE) learning cycle mode" (Chang, 2005): Engage, Explore, Analysis/Explain, as well as Apply and Evaluate. In terms of research design, a one group pretest posttest research design was adopted. The research subjects were a group of 11th grade students from a national senior high-school in Taiwan. Students' expected and actual perceptions of SMiLE were investigated through the "SMiLE Inventory". The results of this study showed that: (1) students' scores, of expected SMiLE Inventory, both before and after the experimental teaching were higher than their actual SMiLE scores, (2) compared with previous actual experiences, ESSMIM created a SMiLE which was closer to students' expectation, and (3) after experiencing the ESSMIM, the difference between students' expectations and their actual experience of SMiLE was reduced.*
Key words: *earth science curriculum; learning environment; perception; science museum teaching.*

Chun-Yen Chang
National Taiwan Normal University, Taiwan
Yu-Ching Huang
FWU-SHAN Junior High School, Taiwan
Chen-Yuan Chen
National Pingtung University of Education, Taiwan

Introduction

Students trained under text based learning methods are often forced to use their imaginations when learning about earth science curriculum (ESC). Chang (2005) findings propose that earth science instruction in the secondary schools which bridge the gap between students' perceived, and actual learning environments serve to enhance their learning outcomes. Other alternative learning environments, such as museums, may help students to extend themselves from the confines of in school text based learning methods; direct contact with objects can inspire students to come up with different as well as new ideas (Hein, 1998).

In an earlier study, Roberts (1997) arranged for students to visit museums, reasoning that teaching activities where participants had direct contact with "objects," would help students to utilize multiple senses rather than learning simply from listening and reading. Other studies in museum learning have highlighted characteristics of museum's functions. Tunnicliffe (1996a) explored different categories of biological content between museums, zoos, and botanical gardens. In his studies, Tunnicliffe made a quantitative analysis using a systemic network, designed specifically for a learning task. Research by Tunnicliffe and his colleagues found that, in natural history museums, a critical element of interest and engagement for participants is that of narrative descriptions (Tunnicliffe, 1996b; Tunnicliffe et al., 1997). Several studies suggest that science museum resources are broadly underused by the teachers they hope to serve (Bevan, 2007; Finkelstein, 2005; Phillips et al., 2007). Furthermore, teacher and school participation are likely

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influenced by external factors such as accountability concerns and rising costs (Anderson et al., 2006; DeWitt & Storksdieck, 2008). Taken together, these prior museum studies have provided beneficial science learning experiences but reveal a significant need for more detailed examinations of what influences science museum learning.

The main purpose of science education is to improve the science literacy of all people. This purpose is usually carried out through formal and informal science education. The means to achieve the goals of science education include science curriculums in schools and social resources such as assistance from science museums. Jin (1995) believed that mediums used to deliver science education ideals between school education and society are the social and educational functions of museums (Figure 1).

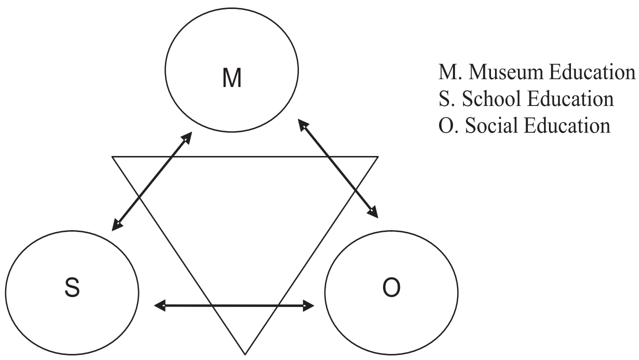

Figure 1: The relationships between museums, schools, and society in the aspect of promoting science education (Jin, 1995).

Thus, there is a common goal for both museums and schools, which is to provide learning environments for students (Chang, 1987). Therefore, museums are considered learning places for informal education outside schools. Museums' social education institution function not only complements school education, but also promotes the improvement of people's science literacy (Chang, 1987). Therefore, schools often arrange students visiting museums in groups to make up for the insufficiency of knowledge taught in schools. Museum exhibitions are considered tools for outside-school learning. In order to make sure resources provided by museums can be well used, partnerships must be built between museum users and educational institutions so that they can complement each other and be used by the social system, science education workers and learners in schools (Hamilton & Hardesty, 1987, Lord & May, 1996).

Through the integration of a series of curriculums visits, our hope is to design teaching content utilizing the abundant informal education resources found in science museums. This study targeted developing integrated curriculums for junior high-schools in Taiwan. Further reaching objectives include increasing students' flexibility in terms of applying academic knowledge into their daily lives.

The aim of research is to promote students' learning with their senses and create their own learning experiences. The learning and exploring environments of this module are science museums. This study proposes experiment research methods to understand the impacts of the teaching design, through integrated curriculums, with regard to second-grade high-school students.

The following research questions were formed based on students' learning perceptions. How do students' preferences and perception of the Science Museum Invoked Learning Environment (hereinafter "SMiLE") experiences differ before and after experiencing the ESSMIM? Furthermore, how do students' expected and actual experiences differ before and after experiencing the ESSMIM?

Methodology of Research

Data analysis for this study was performed using SPSS for Windows Version. SPSS is an approach similar to LISREL, where the covariance structure derived from observed data is used in the model. Such covariance-based approaches are appropriate for areas with strong a priori theory. Data analysis proceeded in two stages: the descriptive statistic was first examined for validating and refining the research instrument, followed by an analysis of the inferential statistic for testing the association's quantification in the research.

Research Participants

This study designs a curriculum for (the earth science chapter) part of the current science material for second graders in senior high-schools. According to the design of this curriculum, a half-day is spent in the exhibition area of the National Science Museum for teaching. The goal of The National Museum of Natural Science is to provide practicable science education and to collect and preserve the biological and cultural diversity in neighboring areas.

After considering the traffic time and teachers' class schedules, a convenience sample is used. A national senior high-school in Taichung is picked. The sample is separated into three groups. The first group, who major in social science, takes the Earth Science Course (ESC). Hence, 38 students from a normal second-grade class of the first academic group participate in the experimental teaching class of this study. Due to the attendance conditions of the students, the effective sample contains only 34 males with the average age being 17.

Teaching Module

As for the integrated teaching content of the ESSMIM, three exhibition areas including "The Origins of Life", "Life Landing", and "The Age of Dinosaurs", from the Life Science Hall of the National Museum of Natural Science, are chosen as the themes of "earth history" for this experimental teaching. As shown in figure 2, in the strategic aspect, the four-stage "learning cycle model" (Chang and Lai, 2001) and the "ESE learning cycle model" (Chang, 2005) are adopted as the main structure. In the aspect of the essence of the curriculum design, the reference is the idea of "earth system education" proposed by Mayer (1991 and 1995), which states that the learning of earth system education is not only about the pursuit of knowledge, but also about the development of sentiment. The validity of the content of ESSMIM was examined by two current high-school teachers and a professor (whose specialty is science education). This study is the research result of the "science museum chapter".

Research Tool

The "SMiLE Inventory" is mainly based on the "Science Outdoor Learning Environment Inventory," proposed by Tsai (2002), and is used to explore the students' perception of a SMiLE through their attitudes and reactions during outdoor teaching. This inventory was modified according to the characteristics of science museum learning. The inventory includes 5 aspects with 30 questions to find out the differences between the students' perception of a SMiLE experience that they expect and those they actually experience. By referencing the form of the "Attitudes toward Earth Science Inventory" developed by Li and Chang (2004), every question of a SMiLE inventory is divided into a question for each expected condition and a question for actual conditions according to the students' learning experiences in the science museum. Based on the assumption that the congruence between the preferred learning environment and the actual perceived learning environment would affect students' learning outcomes (Fraser & Fisher, 1983a, 1983b); it was hypothesized that students' learning achievement in ESC and their attitudes toward ESC would be enhanced when they actually perceived the instruction activities were congruent with their learning environment preferences.

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Therefore, this study, conducted through a quasi-experimental research design, has 60 questions in total. The 30 questions can be categorized into 5 aspects: (1) degree of integration with the curriculum (the relationship between classroom learning and science museum learning), (2) interpersonal relationship learning in classes, (3) knowledge of learning goals, (4) preparation and degree of curriculum organization, and (5) usage of relation assisting tools. The 5-point Likert-type scale is applied to this inventory, to reflect each student's degree of agreeing with the questions. The extent of their responses are shown in 5 rating scales: (A) "almost never" (B) "seldom" (C) "sometimes" (D) "often" (E) "almost always."

The tentative ESSMIM was validated using a focus group technique to collect qualitative data. Two focus groups with 54 participants in total were conducted, with a national senior high-school in Taiwan. Gender and age were not related to any of the outcome variables. Therefore, males and females of all ages were grouped together. The validity of this inventory was examined by one Professor (whose specialty is science education) and two high-school teachers. These experts checked the alignment between textbook content and test items and confirmed that the test items were coherent to important concepts introduced in the textbook. After the trial test and the formal test, the reliability was analyzed. The Cronbach's alpha values for the expected SMiLE were 0.84 and 0.85, while those in the actual SMiLE were 0.79 and 0.87.

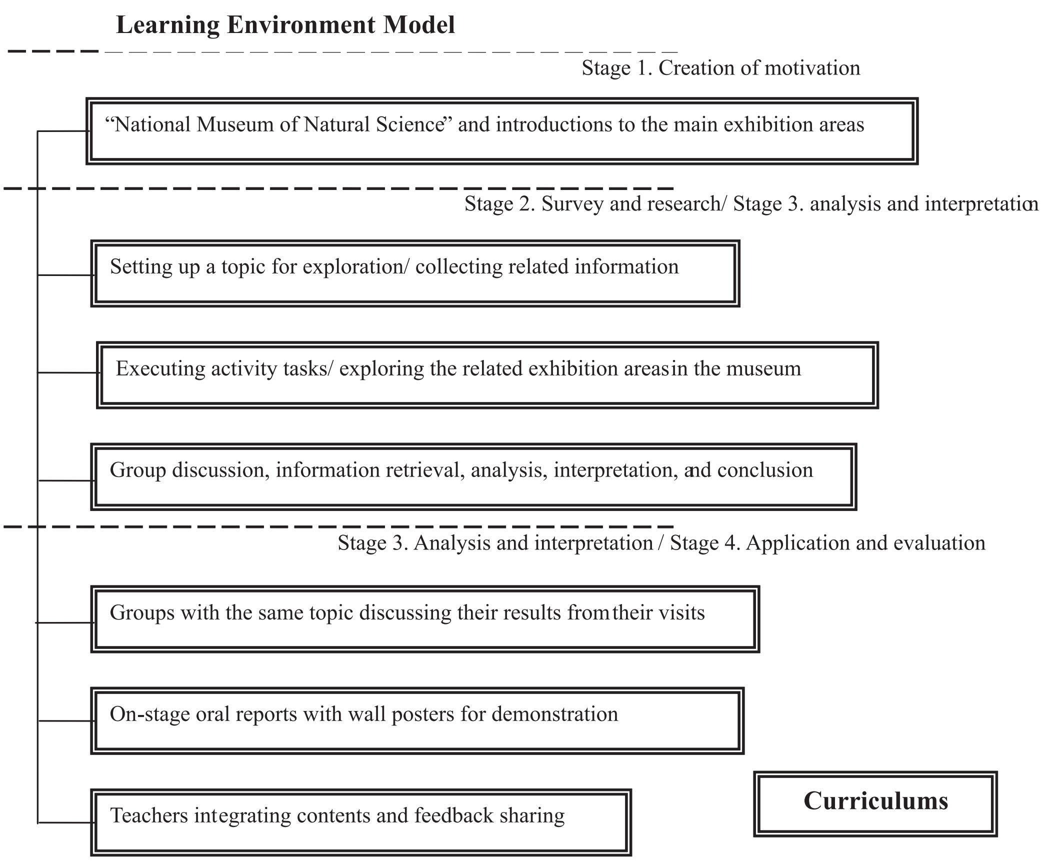

Figure 2: The design and planning for the teaching strategies and 4-stage learning cycle.

Results of Research

Table 1 shows the descriptive statistics before and after a SMiLE test.

Table 1. The descriptive statistics of a SMiLE (unit: question).

n=34	Expected		Actual		Difference between the expected value and the actual value	
	Average	S.D.	Average	S.D.	Average	S.D.
SMiLE pre-test (30 questions)	3.70	0.41	3.06	0.47	0.64	0.66
Degree of integration with the curriculum (6 questions)	3.90	0.55	3.10	0.63	0.80	0.76
Interpersonal relationship learning (6 questions)	3.61	0.57	3.12	0.61	0.50	0.62
Knowledge of learning goals (8 questions)	3.71	0.52	3.13	0.53	0.59	0.81
Preparation (5 questions)	3.21	0.54	2.94	0.54	0.27	0.70
Usage of relation assisting tools (5 questions)	3.76	0.64	2.98	0.57	0.78	0.76
SMILE post-test (30 questions)	3.82	0.36	3.43	0.40	0.38	0.35
Degree of integration with the curriculum (6 questions)	3.87	0.48	3.47	0.45	0.41	0.43
Interpersonal relationship learning (6 questions)	3.72	0.43	3.48	0.41	0.24	0.42
Knowledge of learning goals (8 questions)	3.92	0.50	3.49	0.51	0.43	0.43
Preparation (5 questions)	3.28	0.62	3.33	0.58	-0.05	0.52
Usage of relation assisting tools (5 questions)	3.91	0.40	3.36	0.62	0.55	0.66

S.D. = standard deviation

The tables, from Table 2 to Table 6, show the results of the paired sample t-tests performed for the differences between expected perception and actual perception of the experiences in a SMiLE. Cohen's effect size index *d* (1988, p. 20) was also used to illustrate the degrees to which the difference in the pre–post-test mean is present for each measure. This value of Cohen *d* is not between 0 – 1, which was indicated on page 8 by Chang (2004).

Table 1 shows the pretest average expected perception of a SMiLE (3.70) and the average actually perception of a SMiLE (3.06). For all the learning environment aspects except for "preparation," there are statistically significant differences between the perception of a SMiLE expected and those actually experienced by the students, which means the students expect a SMiLE to be better than a SMiLE they actually experience.

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Table 2. The paired sample t-tests performed for the differences between expected perception and actual perception of the experiences in a SMiLE in the pretest.

n=34	MD(SD) Expected value – actual value	*t value*	*P value*	*Cohen's d*	$CI_{95\%}$
SMiLE pre-test	0.64(0.45)	5.61*	.000	1.33	(0.41, 0.87)
Degree of integration with the curriculum	0.80(0.77)	6.10**	.000	1.14	(0.53, 1.07)
Interpersonal relationship learning	0.50(0.59)	4.67**	.000	1.16	(0.28, 0.71)
Knowledge of learning goals	0.59(0.52)	4.25**	.000	1.03	(0.31, 0.87)
Preparation	0.27(0.54)	2..24	.032	0.54	(0.02, 0.52)
Usage of relation assisting tools	0.78(0.60)	5.95**	.000	1.47	(0.51, 1.04)

*Overall * $p < 0.05$ Aspect ** $p < 0.01$ MD: difference between both averages SD: standard deviation of both averages*

After experiencing the ESSMIM (Table 3), there is still a significant difference between the average of the students' expected overall perception of the experience in a SMiLE (3.82) and the average of their actual perception of the experience (3.43). Both the students' expected overall perception of the experience in a SMiLE and their actual one have increased, which means the ESSMIM has a positive influence on both the students' expected overall perception of the experience in a SMiLE and their actual perception of the experience.

Table 3. The paired sample t-tests performed for the differences between expected perception and actual perception of the experiences in a SMiLE in the posttest.

n=34	MD(SD) Expected value – actual value	*t value*	*p value*	*Cohen's d*	$CI_{95\%}$
SMiLE post-test	0.38(0.38)	6.35**	0.000	1.54	(0.26, 0.50)
Degree of integration with the curriculum	0.41(0.46)	5.56**	0.000	1.37	(0.56, 0.56)
Interpersonal relationship learning	0.24(0.42)	3.28**	0.002	0.80	(0.09, 0.38)
Knowledge of learning goals	0.43(0.50)	5.85**	0.000	1.46	(0.28, 0.57)
Preparation	-0.05(0.60)	-.524	0.604	0.13	(-0.23, 0.14)
Usage of relation assisting tools	0.55(0.51)	4.853**	0.000	1.23	(0.32, 0.78)

*Overall * $p < 0.05$ Aspect ** $p < 0.01$ MD: difference between both averages SD: standard deviation of both averages*

Table 2 and 3 shows that both the students expected perception and actual perception of their experience in a SMiLE in the posttest are higher than those in the pretest. It is inferred that the perception of the experience in the ESSMIM SMiLE is significantly different than that of the previous experience in science museum teaching.

Table 4. The paired sample t-tests performed for the differences in the expected perception of students' experiences in a SMiLE.

n=34	MD(SD) Expected value – actual value	*t value*	*p value*	*Cohen's D*	$CI_{95\%}$
SMiLE	0.12(0.39)	2.23*	0.031	0.57	(0.01, 0.22)
Degree of integration with the curriculum	-0.03(0.51)	-.28	0.784	0.07	(-0.25, 0.19)
Interpersonal relationship learning	0.10(0.50)	1.01	0.318	0.24	(-0.10, 0.31)
Knowledge of learning goals	0.21(0.51)	2.45	0.020	0.87	(0.03, 0.38)
Preparation	0.08(0.34)	0.72	0.476	0.27	(0.14, 0.29)
Usage of relation assisting tools	0.15(0.53)	1.49	0.145	0.36	(-0.06, 0.36)

*Overall * $p < 0.05$ Aspect ** $p < 0.01$ MD: difference between both averages SD: standard deviation of both averages*

About the changes in the students' expected perception, Table 4 shows that the average of the students' expected overall perception of the experience in a SMiLE (3.82) in the posttest is significantly higher than that in the pretest (3.70). This means after experiencing a SMiLE, the students' expected perception of the experience in a SMiLE gets higher.

Table 5. The paired sample t-tests performed for the differences of the actual perception of the experiences in a SMiLE.

n=34	MD(SD) Expected value – actual value	*t value*	*P value*	*Cohen's d*	$CI_{95\%}$
SMiLE	0.37(0.44)	3.77*	0.001	0.90	(0.17, 0.57)
Degree of integration with the curriculum	0.36(0.55)	2.80**	0.008	0.67	(0.10, 0.63)
Interpersonal relationship learning	0.36(0.52)	2.84**	0.008	0.65	(0.10, 0.62)
Knowledge of learning goals	0.37(0.52)	2.82**	0.008	0.40	(0.10, 0.63)
Preparation	0.39(0.56)	3.26**	0.003	0.80	(0.15, 0.64)
Usage of relation assisting tools	0.38(0.59)	2.89**	0.007	0.71	(0.11, 0.64)

*Overall * $p < 0.05$ Aspect ** $p < 0.01$ MD: difference between both averages SD: standard deviation of both averages*

Table 6 shows that the difference between the expected perception and the actual perception of experience in a SMiLE in the posttest (0.38) is smaller than that in the pretest (.64). It is found from the statistical analysis that the difference between the expected perception and the actual perception of experience in a SMiLE in the posttest is smaller than that in the pretest. This means, the difference between the expected perception and the actual perception of experience in a SMiLE is reduced through the ESSMIM teaching.

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Table 6. The paired sample t-tests performed for the differences between the expected perception and the actual perception of experience in a SMiLE.

n=34	MD(SD) Expected value – actual value	*t value*	*p value*	*Cohen's d*	$CI_{95\%}$
SMiLE	-0.26(0.53)	-2.61*	0.014	0.70	(-0.46, -0.06)
Degree of integration with the curriculum	-0.39(0.62)	-3.11**	0.004	0.78	(-0.65, -0.14)
Interpersonal relationship learning	-0.26(0.53)	-2.29	0.028	0.56	(-0.49, -0.03)
Knowledge of learning goals	-0.16(0.65)	-1.20	0.239	0.30	(-0.44, 0.11)
Preparation	-0.32(0.62)	-2.43	0.021	0.60	(-0.58, -0.05)
Usage of relation assisting tools	-0.22(0.79)	-1.87	0.070	0.41	(-0.47, 0.02)

*Overall * p < 0.05 Aspect ** p < 0.01 MD: difference between both averages SD: standard deviation of both averages*

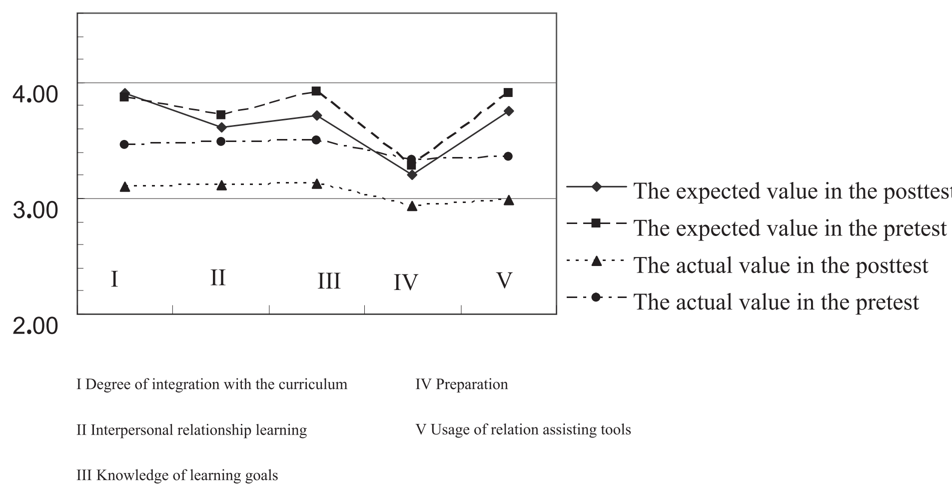

Figure 3: The averages of the aspects of a SMiLE.

Figure 3 shows the average values of the aspects. For most of the aspects: the expected value in the posttest > the expected value in the pretest > the actual value in the posttest > the actual value in the pretest. However, in the aspect of preparation: the actual value in the posttest > the expected value in the posttest > the expected value in the pretest > the actual value in the pretest.

Discussion

This study aimed to investigate students' expected and actual perceptions of a SMiLE during students' learning by ESSMIM in 11th grade earth science classes. The results showed that the averages of this aspect are similar to the first experimental teaching class. The actual value in the posttest is higher than the expected value in the pretest, and the expected and actual values in the pretest are the lowest in all the aspects. This means the students barely did any preparation in their previous experiences in a SMiLE. Through the module, the students learn to collect related information before their visits. And during their visits, they can integrate the information with the information provided in the museum. Results shown by this method are found to be in good agreement with the previous opinion (Hein, 1998; Roberts, 1997). In cases where the number of our convenience sampling in the data are relative small, any inferences made may be more reliable with small-sized for future effort, and hence the effect that the explanatory variables are expected to have on the response probability could be valid. Finally, the research limitation is that gender, and age were not related to any of the outcome variables.

The result of demonstrating the effectiveness of the ESSMIM is not surprising, since the outdoor ESC, with plenty of materials to choose from, should have some positive impacts on student achievement. Moreover, the ESSMIM, which integrated the hardware and software into ESC and instruction, would certainly provide some excellent narrative guidance for students through the available media resources, therefore, leading to considerable score gains on student achievement. Several students have expressed optimism towards this type of simple and portable instructional approach after they experience the kind of outdoor teaching module of earth science. It can be drawn, as a result of the study, that the development and integrative use of SMiLE with interactive whole-class teaching was successful in improving student achievement and attitudes towards the subject matter. It is therefore suggested that this type of teaching approach could serve as a significant alternative in teaching basic science concepts.

In order to situate students in real-world learning environments, which refers to direct experiences that take place within the context of practice, it is significant to place the students in a series of learning activities that include both real and virtual-learning environments. Real-world learning environments aim to develop such a learning environment to provide students with real-world experiences and knowledge (Chang et al., 2007; Chiou et al., 2010). The results show the ES is useful in achieving museum learning experiences. Furthermore, the results of a posttest survey revealed that most students' testing scores improved significantly, further indicating the effectiveness of the ESSMIM; these results are also backed by a previous study (Chen & Huang, 2012). It is concluded that the innovative approach is helpful to the students to utilize the learning resources and achieve better learning efficacy, both more effectively and efficiently (Chiou et al., 2010).

Conclusions

It is found that there are "positive" changes in the students' expected perception and actual perception of the experience in a SMiLE after going through the ESSMIM. The change in the aspect of "preparation" is rather large. However, the aspect of learning perception is the lowest among all the aspects.

The Ministry of Education promotes "actively exploring and studying" as part of the 10 fundamental abilities required for the nine-year compulsory educational system in Taiwan. Indeed, past science curricula in the high-schools around the world mainly focused on traditional classrooms. This research contends that the science curriculum should be taught in union with a SMiLE. The resultant statistical analysis shows solid agreement: that the ESSMIM reached objectives for increasing students' flexibility in terms of applying academic knowledge into their daily lives. The questionnaire survey also showed that the proposed approach was able to provide more interesting learning scenarios to high school students, fostering a positive attitude toward learning that improved significantly.

This empirical study has several limitations. First, sampling was conducted only in one Senior High School of Taichung City, an area in central Taiwan. We recommend that the scope of future studies be expanded to include more people, genders as well as other races to avoid the concerns that resulted from this sample. Second, we should consider having two classes, one experimental and one control group, to examine in this research. Finally, further statistical analysis of this study is recommended.

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Chun-Yen Chang	Ph.D., Research Chair Professor of National Taiwan Normal University (NTNU), Adjunct Professor of Graduate Institute of Science Education & Department of Earth Sciences, No. 88, Sec. 4, Ting-Chou Rd., Wenshan Chiu, Taipei, 116, R.O.C., Taiwan. E-mail: changcy@ntnu.edu.tw
Yu-Ching Huang	FWU-SHAN Junior High School, 215 Chung Shin Road, Kaohsiung, Taiwan.
Chen-Yuan Chen	Department and Graduate School of Computer Science, National Pingtung University of Education, Taiwan. E-mail: peterchenyuanchen@gmail.com