


Fostering Marine Science and Environmental Literacy Through Marine Education Activities in Science Museum

Yu-Hung Wang¹^a, Yi-Chen Chen¹, Jia-Ru Liou¹ and Tzu-Hsiang Ger²

¹*Division of Technology Education, National Science and Technology Museum, Kaohsiung, Taiwan*

²*Division of Secretariat, National Science and Technology Museum, Kaohsiung, Taiwan*

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Abstract: The purpose of this study was to understand changes in marine science and the environmental literacy of Taiwanese people through the use of questionnaires after their participation in marine education activities held by science museums, so as to further explore the effect of these activities. The results of this study showed that in terms of marine knowledge, although the correct answer rate of the knowledge items increased clearly after participation in marine education activities, this increase did not reach a level of significance. This indicates that the respondents already had a considerable understanding of basic marine knowledge, such as the development and application of marine resources and how to prevent marine pollution. The marine attitude variables and behavioral intention variables showed a significant increase after participating in marine education activities, indicating the marine education activities conducted in science museums are quite effective and could indeed improve individuals' marine science and environmental literacy.


1 INTRODUCTION

Ocean Literacy is a growing global education movement that aims to deepen the relationship between people and the ocean and to give people a better understanding of the ocean (Szczytko, Stevenson, Peterson, Nietfeld, & Strnad, 2019). Ocean literacy is defined as “an understanding of the ocean's influence on us and our influence on the ocean” (Cava, Schoedinger, Strang, & Tuddenham, 2005). An ocean-literate person should understand the fundamental concepts about the functioning of the ocean; can communicate about the ocean in a meaningful way; and is able to make informed and responsible decisions regarding the ocean and its resources. Ocean literacy not only increases public awareness of the ocean, but serves as a way to encourage more responsible and informed behaviour by all citizens and stakeholders about the ocean and its resources (UNESCO, 2005; NOAA, 2013; Santoro, Santin, Scowcroft, Fauville, & Tuddenham, 2017).

The use of education to understand the marine environment and protect the ocean is the simplest way to increase ocean literacy (Szczytko et al., 2019). Students should learn to understand the ocean from the earliest years of elementary school. Schools

should promote the inclusion of ocean-related topics in the school curriculum and train teachers to get professional knowledge of the ocean. In addition, cooperation with local aquariums, science centers, museums, and other informal educational institutions should be strengthened to promote ocean-themed activities (Mokos, Realdon, & Zubak C'izmek, 2020).

Taiwan is surrounded by the sea. Due to its geographical location, marine education has been actively promoted and popularized since 2000 in Taiwan. In schools, the development of marine education courses is actively encouraged, and teachers are trained to integrate marine issues into their teaching. In the new curriculum (junior and senior high school), five learning topics (marine leisure, marine society, marine culture, marine science and technology, and marine resources and sustainability) have been listed to encourage students to understand the ocean, get closer to the ocean, and learn how to protect the ocean (Wen & Lu, 2013). However, the knowledge background of most teachers is unrelated to the ocean, and they rarely have access to marine education courses in the process of teacher development and education. Therefore, in order to promote marine education, it is important to seek resources from non-formal

^a <https://orcid.org/0000-0001-8515-7303>

educational institutions. In Taiwan, schools of all levels often cooperate with two ocean-themed museums, namely, the National Museum of Marine Science and Technology (NMMST) and the National Museum of Marine Biology and Aquarium (NMMBA), to provide professional marine education equipment for peer-coaching and learning (Lee, Liu, & Yeh, 2019). The cooperation of schools with one another as well as the use of informal resources are the most effective means to implement high-quality marine education (Lee, Liu, & Huang, 2015; Chang & Lwo, 2016).

The purpose of this study was to develop a questionnaire to investigate the marine science and environmental literacy of Taiwanese people. The questionnaire was used to explore the changes in various variables, such as marine knowledge, marine attitudes, and behavioral intentions, before and after participating in the marine education activities and to further explore the effects of these activities.

2 MATERIALS AND METHODS

2.1 Marine Education Activities

The purpose of marine education activities is to build ocean literacy by transmitting and accumulating knowledge, thereby fostering ocean protection attitudes and behaviors. There are 10 large teaching aids in marine education activities, and the themes cover two parts. One part focuses on ocean energy and resources, including teaching aids of Wave Power Generation, Water Flow Power Generation, and Understanding Deep Ocean Water. These resources can increase people's understanding of marine renewable energy and resource development through interesting hands-on experiences. The other part focuses on the marine environment, including teaching aids related to Understanding Marine Waste, Ocean Defense Battle, and Taking Action to Protect the ocean, which can help people understand the seriousness of marine pollution and learn how to protect the ocean and make the ocean sustainable through learning methods such as interactive games and questions and answers.

According to the above literature discussion and the general public's awareness of the ocean in Taiwan, this study addressed marine science and environmental literacy, defined as including marine knowledge, marine attitudes, and marine behavioral intentions. The relevant definitions are shown in Table 1.

Table 1: Definitions of marine science and environmental literacy.

Domain	Subscale	Definition
Knowledge	Marine science and technology	Understand the structure of the ocean and the environment in which it is formed, including the cognition of ocean currents, sea waves, sea breezes, and other marine science connotations.
	Marine environment and resources	Understand the relationship between marine resources and life, as well as the impact of human activities on marine ecology.
Attitude	Concerns for marine resources	Develop a proper attitude and interest in the development of marine resources.
	A friendly attitude towards the marine environment	Gain the potential to think about the impact of the marine environment on human life.
Behavior Intention	Initiative and active participation	Actively engage in and explore ocean-related issues.
	Take actions to protect the ocean	Take active actions and be active in influencing others to protect the ocean.

2.2 Questionnaire Design

A structured questionnaire was used to measure the effectiveness of marine education activities, and pre- and post-tests were used to assess public learning outcomes. The questionnaire consists of three parts. Part 1 involves personal information, including gender, age, source of marine knowledge, frequency of seaside recreation. Part 2 covers marine knowledge questions presented as multiple-choice answers. Part 3 surveyed the marine attitudes and marine behavioural intentions items, scoring responses using a 5-point Likert scale.

Item discrimination, factor analysis and reliability analysis were used to test the research scale. When a marine education event was held at the National Science and Technology Museum (NSTM), a

questionnaire survey was conducted and 150 people who had participated in the event were selected. The sample size meets the requirements of pre-test analysis. The difficulty of Part 2 questions is between 0.66 and 0.79, and the correlation is significant, indicating that the difficulty of the questions is moderate and the discrimination is high. The third part deals with the marine attitudes and marine behavioral intentions project. The marine attitude items were divided into two sub-scales: concern for marine resources (six items) and a friendly attitude towards the marine environment (six items). The marine behavioral intention items were divided into two sub-scales: initiative and active participation (five items) and taking action to protect the ocean (nine items). In terms of factor and reliability analysis, five items related to attitude and two items related to behavioral intention were deleted. After deletion, the factor loadings were in the range of 0.76-0.93, and the Cronbach's alpha coefficient value for each variable was in the range of 0.92-0.94, which met the criterion of reliability above 0.70 proposed by Nunnally and Bernstein (1994). Therefore, the reliability of the scale is high and acceptable.

3 RESULTS AND DISCUSSION

3.1 Analysis of the Basic Information

The subjects of this study were Taiwanese citizens who participated in marine education activities held at NSTM. Before participating in the event, the public filled out a pre-test questionnaire. After filling out the questionnaire, they began to participate in marine education activities. Through the explanation of the instructor and hands-on operations, the respondents learned knowledge related to the ocean, with the expectation of enhancing their awareness of attaching importance to the ocean. After the activity, the respondents filled out the post-test questionnaire to measure the changes in their knowledge, attitudes, and behaviors after participating in the activities. A total of 360 questionnaires were distributed in this study, and 328 were returned. After deleting the invalid samples, 316 valid samples remained, and the effective recovery rate was 96.3%.

This study took adults with the age over 18 as the research subjects. Among the 316 questionnaires, in terms of the demographic data of the respondents, female was the most common gender (189 females, accounting for 59.81%); in terms of age, people aged 40 - 49 (125 people) and those aged 30-39 (122 people) were the most, accounting for 39.56% and

38.61% of the total, respectively. The question for the learning sources of ocean knowledge adopted the method of multiple choice. Among the respondents, 212 people (67.09%) believed that they usually learned relevant knowledge from museums, followed by 189 people (59.81%) who believed that they learned relevant knowledge from television media. This result indicated that museums and television media, which both can be seen as non-formal educational institutions, play an important role in promoting marine education. In addition, 237 people (75%) had participated in seaside activities one to five times in the past year, while only 49 people (15.51%) had not participated in any seaside activities in the last year. In terms of seaside activities, the most popular activity was coastal relaxation and recreation (209 people, accounting for 66.14%), followed by sightseeing at fishing ports or harbors (180 people, accounting for 56.96%). This result indicated that Taiwanese people often go to the seaside, and they are willing to get close to the ocean and engage in related leisure activities. The analysis of the related respondents is shown in Table 2.

Table 2: Basic data analysis table of the respondents.

Item	Category	Sample size (N)	Percentage (%)
Gender	Male	127	40.19%
	Female	189	59.81%
Age	18~29	37	11.71%
	30~39	122	38.61%
	40~49	125	39.56%
	50~59	10	3.14%
	Above 60	22	6.96%
Source of knowledge (Multiple choice question)	School	141	44.62%
	TV media	189	59.81%
	Newspaper and magazine	100	31.65%
	Film (film related to the ocean)	123	38.92%
	Social media (FB)	110	34.81%
	Museum	212	67.09%
	Instruction from the elder (parents)	23	7.28%
	Others	20	6.33%
Number of trips to the seaside in	Never	49	15.51%
	1-5 times	237	75.00%

the past year	6-10 times	16	5.06%
	More than 10 times	14	4.43%
Activities at the seaside (Multiple choice question)	Cleaning the beach	72	22.78%
	Intertidal observation and experience	123	38.92%
	Sightseeing in fishing ports or harbors	180	56.96%
	Coastal relaxation and recreation	209	66.14%
	Swimming	56	17.72%
	Snorkeling	44	13.92%
	Canoeing	7	2.22%
	Others	26	8.23%

3.2 Analysis of the Marine Knowledge Variable

There were two factors in the variables of marine knowledge. According to the statistical results shown in Table 3, the average score of the respondents in the pre-test of the overall factors of marine knowledge was 6.20 (a correct answer rate of 77.22%). After participating in marine education activities, the average score of the post-test was 6.29 (a correct answer rate of 78.48%), and the t-test value of the paired sample was 1.30 ($p=.194$). In terms of the overall factor or sub-factors, although the average score of the post-test was slightly improved, it did not reach a significant level. This shows that the respondents already had relevant marine knowledge before participating in marine education activities. For example, they had a good understanding of various energy developments, such as offshore wind power generation on the ocean and how to protect the ocean. After participating in marine education activities, there was no significant growth in their knowledge of the ocean. The detailed analysis results are shown in Table 3.

Table 3: Paired samples t-test results of the marine knowledge scores ($N = 316$).

Factors	Pre-test		Post-test		t-test (p)
	M	SD	M	SD	
Marine science and technology	3.72	1.21	3.76	1.16	.76 (.45)
Marine environment and resources	2.48	.73	2.53	.71	1.25 (.21)
Total scale	6.20	1.60	6.29	1.54	1.30 (.19)

3.3 Analysis of the Marine Attitude Variable

The pre-test average of the total scale for the ocean attitude variable was 4.54; after participating in the marine education activities held by the science museum, the post-test average was 4.59. The t-test analysis of the results indicated a significant difference ($p=.01$). In terms of the sub-factors, after participation in marine education activities, concern for marine resources and friendly attitude towards the marine environment both showed significant growth ($p=.04$ and $p=.01$). This result indicated that the respondents had a more positive and active attitude towards concern for marine resources and the marine environment after these activities. For example, they felt that it was interesting to discuss marine science issues, and they believed that maintaining the sustainability of the marine environment was a meaningful challenge. The detailed pre-test and post-test results for ocean attitude are shown in Table 4.

Table 4: Marine attitudes using the paired-samples t-test ($N = 316$).

Factors	Pre-test		Post-test		t-test (p)
	M	SD	M	SD	
Concerns for marine resources	4.47	.58	4.52	.55	2.03 (.04)
A friendly attitude to the marine environment	4.62	.52	4.68	.47	2.64 (.01)
Total scale	4.54	.51	4.59	.48	2.58 (.01)

3.4 Analysis of the Marine Behavioral Intention Variable

The pre-test average of the total scale for the marine behavioral intention variable was 4.50; after participating in the marine education activities held by the science museums, the post-test average was 4.56. The t-test analysis of the results indicated a significant difference ($p < .01$). In terms of the comparative analysis of each sub-factor, initiative and active participation showed significant growth after the respondents' participation in the marine education activities ($p < .01$), indicating that the respondents intended to actively pay attention to news or events related to marine issues after these activities. However, there was no significant difference in taking action to protect the ocean, such as not throwing garbage into the ocean or not destroying the marine ecology, after participating in marine education activities ($p = .29$). This study speculated that the respondents already had the behavior intention to protect the ocean before participating in the marine education activities, therefore this factor would not change after their participation. The detailed pre-test and post-test analysis results for marine behavioral intentions are shown in Table 5.

Table 5: Marine behavioral intentions using the paired-sample *t*-test ($N = 316$).

Factors	Pre-test		Post-test		<i>t</i> -test (<i>p</i>)
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	
Initiative and active participation	4.27	.67	4.39	.60	3.87 (<.01)
Take actions to protect the ocean	4.65	.49	4.68	.47	1.05 (.29)
Total scale	4.50	.50	4.56	.46	2.89 (<.01)

4 CONCLUSIONS

The main objective of this study is to develop a survey scale of Taiwanese marine science and environmental literacy. In addition, a questionnaire survey was conducted through the marine education activity of the science museum to explore the relationship between various variables among the scales, and to further explore the effect of the activity. In terms of questionnaire preparation, according to the preliminary test results of item discrimination,

exploratory factor analysis and reliability analysis, after deleting inappropriate items, the scale has good reliability and validity.

Taiwan is surrounded by water, and the general public has many opportunities to access the ocean. In addition, through publicity in schools and the media, the public has acquired a basic concept of protecting the ocean. This study found that the respondents already had a considerable degree of marine science and environmental literacy before participating in marine education activities. However, after participating in these activities, the attitude and behavioral intention of the respondents towards the ocean could still be effectively improved. In terms of marine knowledge, the respondents had a correct answer rate of about 77% for questions related to marine science and environmental knowledge before participating in the marine education activities, and this grew to 78% after the activities. Although their understanding of relevant knowledge was improved, it did not reach a significant level, indicating that the public in Taiwan already has a considerable understanding of basic marine knowledge, such as the development and application of marine science and technology, as well as the prevention of marine pollution.

In terms of marine attitudes, the comparison of the results showed that the respondents' concern for the ocean had a significant increase after participating in marine education activities. These activities are held in science museums, and they contain many interactive teaching aids related to marine science. Therefore, such activities could promote people's interest in marine science research. For example, the respondents showed great interest in understanding wave power generation, observing ocean tide changes, and even discussing the topography of Taiwan's coastline and its causes. In addition, participation in related activities has a considerable impact on people's attitudes towards the marine environment. The results indicated that after participation in such activities, people believe they can help reduce harm to the ocean by preparing their own reusable bags or reducing the amount of waste they produce.

Marine behavioral intentions contained two factors, namely, initiative and active participation, and taking action to protect the ocean. Among these two factors, initiative and active participation showed significant growth after participating in marine education activities. The questionnaire results indicated that the public will take the initiative to pay attention to marine education activities and will actively participate in them after these activities.

Therefore, participation in activities held by science museums could help people understand the importance of the ocean and increase their interest in participating in related activities. In general, in terms of taking action to protect the ocean, people in Taiwan already have a sense of protecting the ocean, and this is shown through not carelessly throwing away garbage and by showing respect for marine life. People in Taiwan do these things to protect the ocean, and such actions show a close connection with these marine education activities.

In terms of the survey and analysis of the basic data, the respondents had experienced being close to the ocean and enjoyed going to the seaside for leisure and recreational activities, indicating that people in Taiwan attach increased importance to the sustainable development of the ocean. In addition, in terms of the source of marine knowledge, most of the respondents believed they could get marine knowledge from museums, and sometimes, museums play an even more important role than schools. Taiwan currently has two ocean-themed museums, and they spare no effort to promote marine education. Moreover, the research focus of this study was the science museum in southern Taiwan. In response to ocean conservation policies, the museum conducts promotional activities for marine education and encourages the public to participate in these experiences, further demonstrating its influence in promoting marine education. The findings of this study also proved that people could indeed improve their marine science and environmental literacy by participating in promotional activities for marine education.

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