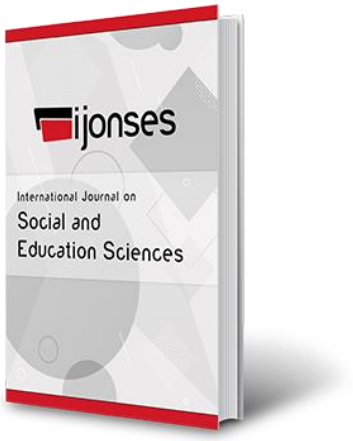

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A Study of the Learning Outcomes on Marine Education

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A Study of the Learning Outcomes on Marine Education

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Abstract

The major purpose of this study was to explore the learning outcomes on marine education for 3rd graders in Taipei. A quasi-experimental design with a single group was used in this study. Students in the experimental group (N=56) were given eight weeks of marine education activities and a one-day field trip at Tamsui River & Estuary Park in New Taipei city. Two research instruments were used in this study, including a Marine Education Achievement Test and an Attitude towards Marine Education Scale. The results were obtained by *t-test* analysis. The results of this study were (1) the Marine Education Achievement Test showed students in the post-test achieved higher scores than in the pre-test (t = 14.21, p < .001); and (2) the Attitude towards Marine Education Scale showed students in the post-test had higher scores than in the pre-test (t = 4.28, p < .001). Therefore, it can be concluded the marine education activities and field trip were effective for 3rd graders' learning on marine education in this study.

Introduction

The ocean covers 71% of the surface area of Earth. Haynes, Fundis, and Wiener (2019) pointed out we should appreciate, understand, and protect our ocean planet because we depend on the ocean to regulate the weather and climate; sustain the diversity of life; for maritime shipping and national defense; and for food, energy, medicine, and other essential services to humankind. If the marine environment is damaged, it will not only harm life in the ocean, but also greatly affect those living on land and the circulation of the environment. Therefore, in 1994, the United Nations (UN) announced the *United Nations Convention on the Law of the Sea*, appealing to all countries to follow. Later, Australia, the USA, Japan, the EU and other nations announced white papers on the ocean and engaged in the development and management of the economy, society, and culture of the ocean (Taiwan Ministry of Education, 2008).

Over the past few years, Taiwan has been facing huge marine crises, including damage and pollution of the marine environment, and a reduced number of marine organisms. Overfishing is the main reason, followed by damage to habitats, as well as pollution, eutrophication, and the invasion of foreign species, etc. With respect to strategies targeting marine crises, Chen (2005) pointed out the primary task is to enhance the public's knowledge of the ocean, which is also the basis for encouraging the public to take action. Considering the ocean is badly damaged, over the past few years, many researchers have engaged in research related to ocean and marine education in Taiwan (Chang & Lwo, 2014; Lai, 2010; Lai & Hsieh, 2013; Lai & Lin, 2011; Lai & Lin, 2013; Lwo, Chang, Tung, & Yang, 2013; Wang, 2012; Yang & Lee, 2012). In recent years, significant effort

has been made to incorporate more ocean examples into the Next Generation Science Standards (NGSS) and state science standards and to encourage the inclusion of ocean concepts in the current curricula (Haynes, Fundis, & Wiener, 2019). As more and more attention and concern has been given to marine-themed issues and marine education, Taiwan has been making all manner of efforts in recent years. Therefore, the major purpose of this study was to explore the learning outcomes on marine education for 3rd graders in Taipei.

Literature Review

Marine Education

The USA started to conduct marine education very early. Its marine education is defined as education related to the ocean, coastal currents, and the Great Lakes (Lwo, Lin, & Lee, 2005). With respect to the content of marine education literacy, Lwo, Chang, Tung, and Yang (2013) quoted the Ocean Literacy Network of the USA, which pointed out marine education literacy refers to "your understanding of your influence on the ocean and the ocean's influence on you", namely, the understanding that humans and the ocean influence each other. In 2008, the Taiwan Ministry of Education released the "Curriculum Guidelines for Topics of Marine Education", and specified formal implementation of the guidelines from 2011. The above guidelines specified different teaching fields should include marine education in their teaching scopes to strengthen elementary and secondary school students' perceptions and understanding of the ocean.

The major topic entitled Marine Education proposed in 2008 by the Taiwan Ministry of Education (Taiwan Ministry of Education, 2008) basically states Taiwan is encircled by the ocean, and its citizens should possess sufficient knowledge of the ocean, and an ability to utilize the ocean. Second, the Taiwan Ministry of Education (2008) emphasized marine education should strengthen the idea of an "ocean-land balance" which respects and is compatible with the natural environment and expands the education policies regarding the ocean, thus enabling all citizens to take Taiwan as a foothold, possessing the abilities to share and cherish the precious resources endowed by the ocean.

Through ocean leisure or participation in lively ocean-experience activities, students can be guided to share their experiences. In addition, getting close to the ocean through experience stimulates students' yearning and interest to explore their knowledge of the ocean. These activities and reflections will inspire students' love of the ocean, establish ideas of how to properly use and cherish various types of ocean resources and how to maintain the ecological balance of the ocean, actively conserve ocean resources, and maintain the harmony between humans and the ocean. Such a marine education curriculum also promotes students' respect for the ocean.

A number of research cases on marine education have demonstrated impressive instructional effects, such as enhancing students' learning achievements in relation to marine knowledge, and improving students' attitude and behavior towards the conservation of the marine ecosystem (Chang & Sheen, 2011; Chen, 2005; Guertin, 2016; Guertin & Clements, 2015; Hsieh & Hsieh, 2013; Jesus-Leibovitz, Faria, Baioa, & Borges, 2017; Jolley, Hampton, Brogt, Kennedy, Fraser, & Knox, 2019; Krauss & Lombardi, 2016; Lai, 2010; Lai & Hsieh, 2013; Lai & Lin, 2011; Lai & Lin, 2013; Lin & Lai, 2011; Riedinger & Burns, 2016; Tripler, Isakower, & Mott, 2016;

Tsai, 2008; Wu, 2010).

Lai and Lin (2011) found teaching activities related to the biological diversity of the intertidal zone (1) enabled students to achieve positive learning performance regarding the concepts of biological diversity of intertidal zones; (2) enhanced students' learning performance in a unit on marine life; (3) improved students' attitudes and behavioral performance regarding the conservation of intertidal zones. Lai and Lin (2013) pointed out after implementing teaching activities in marine education, students showed significant progress in learning performance regarding perceptions of marine education, and positive learning effects regarding their attitudes toward marine education. Additionally, their attitudes and behavior intentions toward the marine ecosystem conservation were improved. The implementation of teaching activities in marine education can effectively increase students' faith in recognizing and conserving the ocean, and the learning achievements and interactions between teachers and students surpass those of regular classroom teaching.

Jesus-Leibovitz, Faria, Baioa, and Borges (2017) presented a marine ecology inquiry-based activity implemented with primary school students, and used personal meaning maps (similar to mind maps) to assess the impact of the activity on students' ideas about the topics explored. The results revealed the fieldwork and exploration of real data were the aspects most emphasized by all participants in its study. Wedding, et al. (2018) designed a hands-on lab activity in mapping at the land-sea interface, and explained linking ecosystem services science through mapping efforts can help students learn methods for including the value of nature in climate adaptation decisions. The results showed students learn to apply ecosystem service concepts and easy-to-use, open source software to answer engaging questions within a real-world policy and planning context.

To summarize, with the increasing demand for better marine education literacy, enhancing elementary school students' perceptions and understanding the ocean as well as promoting marine education are important issues. Learning activities with an ocean theme must be conducted to promote students' experiences and learning, and thus further guide them to love and recognize the ocean. In other words, marine education is not simply about obtaining knowledge related to the ocean, but should guide students to establish appropriated values regarding marine life, encouraging them to understand how to properly utilize marine resources and conserve the marine environment, and allow them to realize we can coexist with the ocean.

Strategies for Marine Education

The curriculum and instruction framework of marine education for elementary and secondary schools can be divided into five major topics, namely, marine leisure, marine society, marine culture, marine science, and marine resources (Taiwan Ministry of Education, 2008). The Taiwan Ministry of Education (2008) indicated, to achieve marine education literacy, and cultivate life-oriented values, marine education in elementary and secondary schools should be centered on shaping an education environment of "being close to the ocean, loving the ocean, and understanding the ocean".

For improving the effectiveness of students' marine education learning, many researchers have offered

suggestions on marine education. Guertin (2016) suggested using the first day activities to students to challenge them to connect their course content ideas to the established Ocean Literacy Principles. Guertin (2016) further explained this approach immediately sets an expectation and model for collaborative and participatory learning, the desire for the instructor to receive student feedback, and shows students the connections of course material to a nationally recognized document on what every citizen should know about ocean science.

Chen and Tsai (2016) proposed a multimodal approach on improving marine knowledge and experience in marine-related activities, creating safe recreational spaces at the seaside, and reinforcing legal education. Krauss and Lombardi (2016) used literacy instruction which focused on applying decoding skills and comprehension strategies to informational text features. Krauss and Lombardi (2016) found the collaboration between the fields of ocean exploration and literacy intervention provided grades four and five general education and special education students' access to real-world science experiences and complex informational texts.

To enable students to get close to the ocean, more efforts for marine education are needed. Experience in marine-related activities and marine knowledge are important in fostering marine environmental awareness, particularly in regard to environmental behavior (Chen & Tsai, 2016). Among the implementation methods of firsthand participation and experience in science learning, inquiries and experiences raised through informal science learning have received an extremely high level of attention (Eshach, 2007; Falk & Dierking, 2011; Guilherme, Faria, and Boaventura, 2016; Kelly, Stetson, & Powell-Mikel, 2002; Knapp, 2000; Marcus, Haden, & Uttal, 2018; Pugh & Bergin, 2005; Riedinger & Burns, 2016; Subramaniam, Asim, Lee, & Koo, 2018; Vadeboncoeur, 2006; Zaragoza & Fraser, 2017).

Zaragoza and Fraser (2017) indicated students' learning in informal science learning environments was considerably more effective than in traditional classroom settings. Informal science learning is characterized as motivating, spontaneous, learner-centered, open-ended, and non-assessed (Eshach, 2007; Ramsey-Gassert, 1997; Vadeboncouer, 2006; Wellington, 1990). These characteristics of informal science learning are considered to be factors contributing to learning and interest in science by offering a new way to experience science, different from traditional classroom learning.

Abraham-Silver (2006) explains students in informal learning environments show increased attention and enthusiasm, as well as a willingness to observe, question, and discuss objects around them. Kim and Dopico (2016) indicated beside school science classrooms, informal science learning places such as science museums, science centers, botanic gardens, zoos, aquariums, and so forth can be effective venues to help learners acquire competence, knowledge, skills, and attitudes of science. Chang (2008) pointed out meaningful learning should be a process of experience and knowledge accumulation, and the ability to connect and apply learning content and experiences. Consequently, marine education should find ways to use informal learning resources, actively establish the educational ideas delivered, fully utilize educational resources and enable teachers and students to utilize rich learning resources to support one another, thus enhancing learners' marine education literacy and cultivating interest in lifelong learning.

Integrating formal learning at school with informal learning resources can create better learning outcomes. As to how to achieve good educational effects from informal teaching and field trips, many researchers have proposed important teaching strategies and suggestions (Miele & Adams, 2016; Subramaniam, Asim, Lee, & Koo, 2018; Summers, 2004). Lin and Schunn (2016) pointed out learners encounter science in a wide variety of contexts beyond the science classroom which collectively could be quite influential to student attitudes and abilities. Salmi and Thuneberg (2019) indicated the more autonomous students feel, the more likely it is that they will have intrinsic motivation in learning science. Jones (2018) suggested new learning resources can help science teachers embed ocean sustainability into the curriculum; try out the resources and take young people into the wild to learn about the science behind ocean sustainability.

Field trips are effective for students in encountering marine education learning (Miele & Adams, 2016; Subramaniam, Asim, Lee, & Koo, 2018). Subramaniam, Asim, Lee, and Koo (2018) indicated field trips refer to planned, structured, and adaptable ways of learning science outside the science classroom connected to the school science curriculum. Miele and Adams (2016) mentioned various topics discussed include materials used in this learning technique, field trips organized for learning about natural habitats, use of the 5E model of instruction and guidance given to students for completing their field assignment.

However, Rennie, Feher, Dierking, and Falk (2003) indicated out-of-school settings encompass several learning features that differ from classroom teaching. A spontaneous and voluntary learning model is necessary to meet the demands and satisfy the interest of the students. Therefore, when discussing off-campus teaching, it is necessary to carefully discuss the learning representations of learners, such as the role of learning motivation, displays of curiosity, the mechanism of choices and control, learning interest, and learning expectations.

Guilherme, Faria, and Boaventura (2016) demonstrated using activities included the exploration of an out-of-school setting as a learning context, and the results revealed most of the students acquired scientific knowledge related to biological diversity and adaptations to habitat. Moreover, their students progressively demonstrate greater autonomy, argumentative ability and decision-making. Guilherme, Faria, and Boaventura (2016) suggested elementary science curriculum could be better managed with inquiry project-based activities that explore different types of resources and out-of-school settings. Jolley, et al. (2019) emphasized in-field observations and instructor interviews identified key characteristics supporting a similar sense of place and experiences on all field trips: (1) consistent intended learning outcomes, (2) a carefully selected and immersive field area valued by instructors, and (3) an assessment connected to the landscape/field area with flexibility in its implementation, especially when faced with adverse weather conditions.

To summarize, how to enable students in getting close to the ocean is essential for marine education and informal science learning (field trip) is a good way to implement marine education. The informal science learning settings can serve as science classrooms that are secondary to classrooms in schools. Therefore, multiple teaching methods and strategies should be used, such as process skill inquiries, learning cycles, and role playing, with proper arrangement of the learning activities before, during, and after the visit, combining them with the aims of enhancing marine education learning.

Method

A quasi-experimental design (a pre-test and post-test) with a single group was used in this study. A total of 56 3rd graders at an elementary school in Taipei participated in this study. The students in the experimental group were given eight weeks of marine education activities and a one-day field trip at Tamsui River & Estuary Park in New Taipei city.

The learning and instruction focused on providing students with opportunities and shaping an educational environment of "being close to the ocean, loving the ocean, and understanding the ocean." Meanwhile, the learning and instruction also guided the students to reflect on their participation in marine education activities, inspire their love of the ocean, and establish ideas for properly utilizing and cherishing ocean resources, maintaining the ecological balance of the ocean, active conservation of ocean resources, and the harmony between humans and the ocean.

The learning objectives of the eight-week marine education were: (1) recognize the presence of salt in seawater and other marine resources; (2) establish a personal connection with the ocean through marine literature (a science trade book on the journey of a blue fin tuna) appreciation and marine art-making (sea-salt art-making); (3) participate in sea and water activities (exploration of the riverside coast through a boat tour, coastal ancient monument visits, factory tours, etc.) to cultivate students' love for ocean activities; and (4) to cultivate students' concern and care for the marine environment to encourage participation in marine conservation.

The study also integrated informal inquiries and experiences in real-world learning settings, and conducted a one-day field trip learning activity. The one-day outdoor teaching activities were mainly held on the banks of the Tamsui River, inside the river facilities, the coastal monuments of the town, on Ang Mo Fort, and on factory sites. During the river tour, students were arranged to take a one-hour boat ride from Guandu Wharf going to Tamsui. This allowed the students to take-in the "sea salt" air, and experience being close to the ocean. The coastal monument, Ang Mo Fort, is a building with great historical and cultural significance, which was used to overlook the estuary in ancient times. The factory tour consisted of two parts; the first part involved a guided tour in the exhibition hall, and the second part involved fish ball-making. The guided tour included different exhibitions such as "Ocean and Sea Fishing" which provided students with knowledge on Taiwan's marine fisheries, "A Fishball in a Small Town" which involved an old fish ball vendor narrating the history of Tamsui, and the "Time Story" which told the story of the development of Tamsui and its factories based on the perspective of time. Consequently, the fish ball-making allowed students to create their own fish balls after learning about Tamsui's fish ball industry through videos shown on-site. Through the one-day teaching and learning activities which included the river tour, site visits, and hands-on experience, students were able to learn about the ocean through direct and personal exploration.

Two research instruments were used in this study include a Marine Education Achievement Test and an Attitude towards Marine Education Scale. The Marine Education Achievement Test aimed to assess students' learning performance regarding concepts related to marine topics. The test was compiled by the researcher, and had 25

multiple choice questions, with KR_{21}=.68. The Attitude towards Marine Education Scale was aimed at assessing students' attitudes towards marine education. The scale was also compiled by the researcher, and had 30 items (five-point Likert type scale), with a *Cronbach's* α=.85. Both research instruments have good reliability. The validity of the research instruments was also examined by three researchers in marine education. The research instruments were confirmed to have good validity.

The research data collection covered students' marine perceptions and attitude tests, student worksheets, interviews with the students, and teachers' reflection notes on teaching. After the research data were collected, t-tests were conducted on the quantitative data, while triangulation and cross-case inductive analysis were conducted by three science education researchers on qualitative data (Bogdan & Biklen, 1982; Guba & Lincoln, 1999; Silverman, 2000). The tests and the analysis were conducted to confirm the reliability and consistency of the data analysis and the discoveries, before they were used to discuss the teaching feedback and learning performance.

Results and Discussion

Students' Outcomes of Marine Education Achievements Test

Learning outcomes on the Marine Education Achievements Test were collected, analyzed, and stated as follows. A total of 56 3rd graders participated in this study. The learning outcomes of the Marine Education Achievements Test are presented in Table 1.

Table 1. *t-test* Summary of Marine Education Achievements Test

	N	*Mean*	*SD*	*p*	*t*
Pre-test	56	15.05	5.28	14.21	.000***
Post-test	56	15.46	4.71		

*** p<.001

According to Table 1, the scores of the post-tests for the Marine Education Achievement Test were significantly higher than those of the pre-tests. The *t-test* shows t = 14.21, and p <.001, indicating after participation in the marine education teaching activities, the 3rd graders made significant progress in understanding the concepts and topics of marine education. After participating in the learning of marine content and marine education activities, students had a deeper understanding of the early salt industry. At the same time, with the creation of colored salt activities, students combined their marine resources knowledge with art and humanities courses to create a high level of interest and enthusiasm in marine education learning.

Students' Outcomes of the Attitude towards the Marine Education Scale

Learning outcomes on the Attitude towards Marine Education Scale were collected, analyzed, and stated as following. A total of 56 3rd graders participated in this study. The learning outcomes of the Attitude towards Marine Education Scale are presented in Table 2.

Table 2. *t-test* Summary of Attitude towards Marine Education Scale

	N	*Mean*	*SD*	*p*	*t*
Pre-test	56	126.6	15.44	4.28	.000***
Post-test	56	132.7	13.69		

*** p<.001

According to Table 2, the scores of the post-tests for the Attitude towards Marine Education Scale were significantly higher than those of the pre-tests. The *t-test* shows $t = 4.28$, and $p < .001$, indicating after participation in the marine education teaching activities, the marine education teaching activities conducted by this study significantly improved students' learning outcomes, and the promotion of students' attitudes towards marine education tends to be positive.

Feedback from the Students and the Teacher

During the teaching and learning activities, the traditional methods of salt-making and the several uses and importance of salt in daily life were introduced. Students' learning feedback on the activities is as follows:

Some students mentioned they thought the traditional salt-making method is laborious; Thomas noted, *"There are a lot of preparatory steps such as introducing sea water into the salt field, and evaporating the brine in the sun for quite a long time before harvesting the salt",* and Irene said, *"It is very hot when one makes salt in the sun; but the salt worker needs to endure it to harvest the salt. Moreover, heavy rains will dissolve the salt completely, so they need to cover the salt with cloth".*

These statements illustrate the students learned the early methods of harvesting salt and the traditional method of salt production was an arduous task involving hard-work. These show they obtained a deeper understanding of the history of the salt industry, which echoes the fourth unit of the project. In addition, this learning activity provided the students with an introduction to the salt industry which enabled them to integrate what they have learned in science class with the marine education provided in this teaching activity.

Two students were fascinated with the various uses of salt; Alexander stated, *"What impressed me most was how salt could be used as a preservative for milk and how it can be added to coffee to reduce its bitterness",* and Constance mentioned, *"What impressed me most was soaking the tofu in salt water can keep the tofu tender, and can prevent it from becoming sour. Salt really has a lot of uses that make life easier"*. Another two students found sea salt art-making interesting; Frederick stated, *"When we used the salt to create art, I saw how salt produced different colors. Not only did I have fun painting with it, I also managed to make salt give-off different colors"*, and Yvonne noted, *"That was the first time I learned we could paint with salt. I felt it was very interesting".*

Based on the statements of Alexander, Constance, Frederick, and Yvonne, it could be deduced the students were highly interested in the application of salt in daily life. In addition, the statements clearly indicate they enjoyed

the sea salt art-making activity. Each student was able to create an art piece using sea salt. Through the teaching activities used in this study, the students realized the knowledge learned from textbooks had practical applications in daily life, making them more interested in marine education courses.

Another teaching activity was the discussion of the science trade book concerning the journey of a blue fin tuna. The students also showed great interest in this activity, as manifested in the following feedback. One student, Raymond, said, *"Through this book, I learned the growth and the living habits of a blue fin tuna, as well as its importance as a sea creature. I also learned how humans catch a blue fin tuna".* Another student, Audrey said, *"This book enabled me to understand the life of a blue fin tuna. As it grows up, I learned it will swim along the Kuroshio to the western coast of the United States, and then swim back to Taiwan to reproduce. The little blue fin tuna in the story bravely journeyed and even in the presence of tremendous difficulties, it did not give up".*

Based on the feedback of Raymond and Audrey, it can be seen the students learned the life cycle of a blue fin tuna through the story. The arrangement of the plots allowed students to follow the blue fin tuna as it discovers the world. In this way, the students formed a clear picture of the problems and the dangers a blue fin tuna may encounter as it grows. The story also provided important information such as the blue fin tuna being a migratory fish that returns to its birthplace to fulfill its "sacred mission" which is to produce the next generation. Aside from this, the students also learned the virtue of not giving up and the importance of courage as one goes through life.

The off-campus teaching experience took place at Tamsui, Taipei, Taiwan. The unique geographical location and historical development of Tamsui helped the students understand its landscape, industry development, and culture. Several students expressed great appreciation for the off-campus activities. One student, Jerome, said, *"I found the waterfront of Tamsui very impressive. The ancient remains and constructions can still be seen in Ang Mo Fort. The teacher also made me understand its history"*. Another student, Gloria, said, *"I felt every activity I took part in today was very interesting. I appreciated the view during the boat tour, and the monuments at Tamsui District, Taipei. I also enjoyed making fish balls and watching the movies in the Dengfeng Fish Ball Museum".* The students also had the most fun during the fish ball-making activity as evidenced by the statements of Vincent, who said, *"I think today's activities were great fun. My favorite was making our own fish balls and tasting them. I used to think fish balls were made with only one kind of fish, but now I know they can be made with many different kinds of fish. I had fun eating the fish balls that I made myself",* and Kate who mentioned, *"In the Dengfeng Fish Ball Museum, we were allowed to make our own fish balls. This was my first time making them and I felt the experience was very special. Also, when we were on the boat, the sea breeze felt really cool on the skin. The off-campus teaching and learning activities were really interesting".* Moreover, a student named Hubert expressed enjoyment in the Ang Mo fort tour, as shown in his statements, *"Among the off-campus teaching places, I like Ang Mo Fort the most. It is not just an ordinary monument, but a building that prevented enemies from invading during ancient times. I saw many bronze statues, cannons, among other things, which are very attractive to me. I hope I will have another opportunity to visit again".*

The students' statements above illustrate the off-campus teaching activities done at Tamsui greatly appealed to them. Whether the exploration on the boat, the visit to ancient monuments, or the hands-on experience of making fish balls, all had fun and learned at the same time. In addition, the off-campus teaching activity left a great impression on them, and was still being talked about even after it ended. They felt the activities were meaningful and many hoped they would have the opportunity to visit Tamsui again.

The students' teacher, Tracy, observed the students truly enjoyed the off-campus activity based on their feedback and noted, *"When the marine education activities were being planned, they were arranged based on what the students have learned or will learn in their science class. Moreover, marine education was integrated into science teaching; therefore, aside from the information contained in the textbooks, the students acquired additional knowledge during the off-campus activity. The students enjoyed the activities, including the discussion of marine resources and sea salt, art-making with sea salt, the marine science trade books and the story of the blue fin tuna, as well as the discussion of marine environments and ocean conservation".* Moreover, the teacher believes the Ministry of Education's promotion of marine education, i.e. integration into the classes, is effective and feasible. She hopes other science teachers will integrate marine education into their science classes to deepen and broaden students' learning and to improve their knowledge of the ocean and their conservation.

Further, the students greatly appreciated the Dengfeng Fish Ball Museum because the tour was lively and interesting. In addition to the video presentations, the students took part in many interactive exhibitions, were allowed to taste several fish cakes and made and tasted the fish balls they themselves made. Although it took a lot of time and effort for the teacher to prepare the activities, such as contacting and coordinating with the Museum, the teacher felt it was worth the effort, especially after seeing the students highly enthusiastic in the activities, and happy to learn. The teacher also noted the students still remembered the activities the day after the event.

Based on the teacher's feedback, the integration of marine education activities into the students' science class enabled them to more deeply understand Taiwan's marine resources and salt industry. At the same time, the sea salt art-making enabled students to have a keen interest and considerable enthusiasm for science learning. The said activity facilitated the integration of natural knowledge and art and humanities courses. Moreover, through the field explorations, boat tour experience and riverside coastal landscape sight-seeing, historical building explorations, and hands-on fish ball-making, the students were able to use their five senses of hearing, sight, smell, touch, and taste, in practical learning.

The off-campus activities facilitated students' understanding of the interconnectedness of Tamsui's history and culture, Ang Mao Fort's historical significance, and the importance of the local economy, the riverside, and the coast. The students also had a wonderful experience in getting close to the ocean through the boat tour. Based on the feedback of the students and the teacher, it can be deduced they had a positive and supportive attitude to the teaching and learning activities for marine education. Moreover, fruitful and wonderful learning results were observed as a consequence of the off-campus activities.

Conclusion

The main findings of this study are summarized as follows: (1) the results of the Marine Education Achievement Test were students in the post-test achieved higher scores than in the pre-test (t = 14.21, p < .001); and (2) the results of the Attitude towards Marine Education Scale were students in the post-test obtained higher scores than in the pre-test (t = 4.28, p < .001). This findings indicating the marine education teaching activities conducted by this study significantly improved students' learning outcomes and their attitudes towards marine education. Moreover, according to the feedbacks of the students, it can be observed they hold positive and supportive attitudes to the marine education provided in this study. They felt the off-campus activities were meaningful and many hoped they would have the opportunity to visit Tamsui again. This finding indicated that integrating science class and off-campus activities did have great influential to students' marine attitudes and abilities. This finding also add support to the perspective that integrating off-campus marine environment activities into marine education learning can enhance students' understanding of marine concepts and attitudes toward marine education (Guilherme, Faria, & Boaventura, 2016; Jolley, et al., 2019; Jones, 2018; Kim & Dopico, 2016; Lin & Schunn, 2016; Miele & Adams, 2016; Riedinger & Burns, 2016; Salmi & Thuneberg, 2019; Subramaniam, Asim, Lee, & Koo, 2018, Zaragoza & Fraser, 2017). In addition, fruitful and wonderful results were achieved as a result of the marine education. Therefore, it can be concluded the marine education activities and the field trip were effective for 3rd graders' marine education learning in this study.

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References

Abraham-Silver, L. (2006). Valuing informal science learning environments. *The Science Teacher, 73*(1), 1-12.

Bogdan, R. C. L., & Biklen, S. K. (1982). *Qualitative research for education: An introduction to theory and methods*. Newton, MA: Allyn & Bacon.

Chang, C., & Lwo, L. (2014). Constructing the core value of marine education - Starting from the continuous rumors of marine disasters. *Taiwan Education Review, 3*(3), 118-123.

Chang, H. (2008, December). Reviewing informal science education in Taiwan. Paper presented at *The 2008 International Conference on Informal Science Education*. Taipei: National Changhua University of Education & National Taiwan Science Education Center.

Chang, L., & Sheen, S. (2011). The study of marine education of elementary schools in Kaohsiung city. *Chang Jung Christian University Journal, 15*(2), 33-48.

Chen, C.-L., & Tsai, C.-H. (2016). Marine environmental awareness among university students in Taiwan: A potential signal for sustainability of the oceans. *Environmental Education Research, 22*(7), 958-977.

Chen, K. (2005). Strategy of the public participation in conserving marine resources. *RDEC Bimonthly, 29*(4), 43-55.

Eshach, H. (2007). Bridging in school and out of school learning: Formal, non-formal, and informal education.

Journal of Science Education and Technology, 16(2), 171-189.

Falk, J. H., & Dierking, L. D. (2011, January). *Integrating formal and informal education*. Keynote speech at Public scientific literacy conference: Integrating formal and informal education to improve scientific literacy. Kaohsiung: National Sun Yat-sen University.

Guba, E. G., & Lincoln, Y. S. (1999). Establishing trustworthiness. In A. Bryman & R. G. Burgess (Eds.) *Qualitative research*. Thousand Oaks, CA: Sage.

Guertin, L. (2016). Starting students on the pathway to ocean literacy with a first day class activity. *Current: The Journal of Marine Education, 30*(2), 20-24.

Guertin, L., & Clements, N. (2015). Ocean literacy: Can students learn the essential principles? *Current: The Journal of Marine Education, 29*(3), 35-38.

Guilherme, E., Faria, C., & Boaventura, D. (2016). Exploring marine ecosystems with elementary school Portuguese children: Inquiry-based project activities focused on real-life contexts. *Education 3-13, 44*(6), 715-726.

Haynes, S. E., Fundis, A., & Wiener, C. (2019). Engage your students in ocean exploration science. *Science Scope, 42*(5), 6-9.

Hsieh, S., & Hsieh, T. (2013). The design and practice of oceanic liberal curriculum—Taking "ocean and medical life" as an example. *General Studies Journal, 2*(2), 179-206.

Jesus-Leibovitz, L., Faria, C., Baioa, A. M., & Borges, R. (2017). Exploring marine biodiversity through inquiry with primary school students: A successful journey? *Education 3-13, 45*(4), 437-449.

Jolley, A., Hampton, S. J., Brogt, E., Kennedy, B. M., Fraser, L., & Knox, A. (2019). Student field experiences: Designing for different instructors and variable weather. *Journal of Geography in Higher Education, 43*(1), 71-95.

Jones, K. (2018). From the classroom into our wild oceans. *School Science Review, 99*(369), 25-27.

Kelly, J., Stetson, R., & Powell-Mikel, A. (2002). Science adventures at the local museum. *Science and Children, 39*(7), 46-48.

Kim, M., & Dopico, E. (2016). Science education through informal education. *Cultural Studies of Science Education, 11*(2), 439-445.

Knapp, D. (2000). Memorable experiences of a science field trip. *School Science and Mathematics, 100*(2), 65-72.

Krauss, A., & Lombardi, M. (2016). A case study in exploration: A tiny fish with a big name sets the hook into grades 4-5 ocean literacy. *Current: The Journal of Marine Education, 30*(2), 25-33.

Lai, C. (2010). Promoting the theory and practice of marine education in primary schools. In C. Lai (ed.), *The theory and practice of the important agenda on the primary school curriculum guidelines*, (pp. 260-276). Taipei: National Taipei University of Education.

Lai, C., & Hsieh, E. (2013, December). A study on six-grade students' learning effectiveness of marine education. Paper presented at *The 29th International Conference on Science Education*. Chunghua, Taiwan: National Changhua University of Education.

Lai, C., & Lin, S. (2011). A study of the learning outcomes on biodiversity instruction at intertidal zone for 4th graders. *Journal of Humanities and Social Sciences, 7*(1), 15-24.

Lai, C., & Lin, Y. (2013, August). A study of 5th graders' science learning on marine education activities in

Taipei. Paper presented at *The Taiwan Education Research Association & Pacific Rim Objective Measurement Symposium 2013*. Kaoshiung: Taiwan Education Research Association.

Lin, P., & Schunn, C. D. (2016). The dimensions and impact of informal science learning experiences on middle schoolers' attitudes and abilities in science. *International Journal of Science Education, 38*(17), 2551-2572.

Lin, Y., & Lai, C. (2011, April). A study on the influence of marine education on children's attitude and knowledge -Taking the teaching of Pescadilla as an Example. Paper presented at *The Conference on the Application of Science Education and Sciences on Education*. Taipei: National Taipei University of Education.

Lwo, L., Chang, C., Tung, Y., & Yang, W. (2013). Marine science literacy and misconceptions among senior high school students. *Journal of Research in Education Sciences, 58*(3), 51-83.

Lwo, L., Lin, H., & Lee, H. (2005). Constructing a graduate curriculum and instruction with special oceanic features. *Oceanic Culture Journal, 1*, 181-200.

Marcus, M., Haden, C. A., & Uttal, D. H. (2018). Promoting children's learning and transfer across informal science, technology, engineering, and mathematics learning experiences. *Journal of Experimental Child Psychology, 175*, 80-95.

Miele, E. A., & Adams, J. D. (2016). Guided-choice learning in out-of-school environments. *Science Scope, 39*(6), 52-55.

Pugh, K. J., & Bergin, D. A. (2005). The effect of schooling on students' out-of-school experience. *Educational Researcher, 34*(9), 15-23.

Ramsey-Gassert, L. (1997). Learning science beyond the classroom. *The Elementary School Journal, 97*(4), 434-449.

Rennie, L. J., Feher, E., Dierking, L. D., & Falk, J. H. (2003). Toward an agenda for advancing research on science learning in out-of-school settings. *Journal of Research in Science Teaching, 40*(2), 112-120.

Riedinger, K., & Burns, K. (2016). Let's talk science: The implementation of discussion guides in out-of-school learning settings. *Current: The Journal of Marine Education, 30*(1), 5-12.

Salmi, H., & Thuneberg, H. (2019). The role of self-determination in informal and formal science learning contexts. *Learning Environments Research, 22*(1), 43-63.

Silverman, D. (2000). *Doing qualitative research*. Thousand Oaks, CA: Sage.

Subramaniam, K., Asim, S., Lee, E. Y., & Koo, Y. (2018). Student teachers' images of science instruction in informal settings: A focus on field trip pedagogy. *Journal of Science Teacher Education, 29*(4), 307-325.

Summers, S. (2004). Museums as resources for science teachers. *Science Scope, 27*(9), 28-29.

Taiwan Ministry of Education (2008). *Taiwan general guidelines of grade 1-9*. Taipei: Ministry of Education.

Tripler, A., Isakower, A., & Mott, B. (2016). Celebrate and take action for our ocean on World Oceans Day. *Current: The Journal of Marine Education, 30*(1), 25-28.

Tsai, C. (2008). Strategies for an integration system combining marine science research and educational development. *Educational Resources and Research, 85*, 1-18.

Vadeboncoeur, J. A. (2006). Engaging young people: Learning in informal contexts. *Research in Education, 30*, 239-278.

Wang, J. (2012). The teaching practice and transformation of the curriculum guidelines for marine education.

National Chiayi University Journal of General Education, 10, 191-219.

Wedding, L. M., Reiter, S. M., Verutes, G. M., Hartge, E., Guannel, G., & Good, L. H. (2018). Values at the land-sea interface: Mapping ecosystem services in the coastal environment. *Current: The Journal of Marine Education, 32*(1), 25-31.

Wellington, J. (1990). Formal and informal learning in science: Role of the interactive science centers. *Physics Education, 25*(5), 247-252.

Wu, G. (2010). Reviewing and restructuring the curriculum guideline of school marine education. *Educational Resources and Research, 92*, 25-46.

Yang, I., & Lee, S. (2012). An analysis of the current studies on marine education. *National Pingtung University of Education Journal of Physical Education, 15*, 501-510.

Zaragoza, J., & Fraser, B. (2017). Field-study science classrooms as positive and enjoyable learning environments. *Learning Environments Research, 20*(1), 1-20.

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