THE EFFECTS OF THE TRIP MODEL ON STUDENTS' SCIENCE READING ABILITY AND MARINE CONSERVATION LEARNING INTEREST

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Abstract. *This research sought to improve students' science reading comprehension ability and marine ecological conservation learning interest through the implementation of an inquiry-based learning course. A Triggered situational interest-Reading-Inquiry-Presentation (TRIP) model was proposed to guide the course design. The quasi-experimental design was adopted in this research. Experimental teaching activities were conducted with two classes of second graders (50 students in total) in southern Taiwan. One class served as the experimental group, and the other served as the comparison group. The Science Reading Comprehension Test (SRCT) and Marine Ecology Conservation Learning Interest Scale (MECLIS) were used as instruments. Data were analyzed using the Johnson-Neyman Technique, analysis of covariance, and qualitative analysis. The results showed that the students with lower pre-test scores on the SRCT in the experimental group had better scores on the post-test than those in the comparison group, while the students in both groups with higher pre-test scores on the SRCT had no difference in their post-test scores. Furthermore, the experimental group students had better MECLIS scores than the comparison group students, and the difference had a moderate effect size. Overall, this research suggests that the TRIP model may assist science teachers in designing science reading courses.*
Keywords: inquiry-based learning, learning interest, reading comprehension, reading literacy.

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Introduction

Reading science books can help students learn specific vocabulary and improve their understanding of science. Therefore, reading literacy is valued by science research domain around the world (Cervetti et al., 2006; Patrick et al., 2013) and viewed as a key ability for students in contemporary society (Mullis et al., 2017; Organization for Economic Co-operation and Development [OECD], 2010; Strietholt & Rosén, 2016). Reading ability refers to the consciousness and ability of individuals to understand and apply various appropriate strategies when processing texts (OECD, 2010). Reading comprehension covers the basic decoding of text, including its grammar, language, and textual structure, in order to gain knowledge about the world. The pictures in science books may help students learn and overcome the limitations of their education. In recent years, the most well-known reading literacy assessment tests have been the Programme for International Student Assessment (PISA) and the Progress in International Reading Literacy Study (PIRLS) (Strietholt & Rosén, 2016). The PIRLS is conducted every five years, and the test targets are fourth graders. Taiwan ranked 8th among the countries whose students participated in the 2016 PIRLS. The PISA is conducted every three years and measures 15-year-old students' competencies (Cansiz & Cansiz, 2019). Taiwan ranked 23rd on the 2009 PISA and 2015 PISA, below Singapore, China, Hong Kong, and other Asian countries, and these results have attracted the notice of educators in Taiwan.

In recent years, the value of marine education has been acknowledged by a number of scholars and countries (Chang & Zhang, 2018; Lu & Liu, 2015; Wen & Lu, 2013). However, several studies (Chang & Zhang, 2018; Tsai et al., 2017) have noted various problems with existing marine education efforts, such as the difficulty of implementing effective educational efforts and the lack of public understanding of the ocean. Furthermore, Markos et al. (2017) found that educational research has rarely focused on the teaching and learning of marine science concepts. Although the attitudes of students toward scientific learning are important, most researchers have paid greater attention to the cognitions of students regarding marine education (Tsai et al., 2017).

Wen and Lu (2013) found that school curriculums are not the main force in fostering primary school students' attitudes towards marine environmental protection. The above review of past studies shows that marine education is a complex and multifaceted issue. Relatedly, raising awareness of the marine environment and associated issues requires the development of appropriate learning strategies (Lu & Liu, 2015).

As primary school students are interested in everything around them, teachers should encourage them to engage in close observation and develop their explanation skills (National Research Council [NRC], 1996). In addition, schools are important places for learning about marine environment protection (Wen & Lu, 2013). Therefore, it is important to implement marine education in schools. According to the above discussion, the existing marine science courses and teaching may not be sufficient for students to achieve the goals of marine education. As such, teachers may want to allow students to read marine biology picture books and combine their school learning with daily life. Therefore, this research sought to design marine education courses in order to propose relevant teaching strategies. In addition, Taiwanese students' unsatisfying performance in reading literacy and science learning on the PISA (OECD, 2010, 2016) has given Taiwan's educators cause for concern. Therefore, this research sought to improve students' science reading comprehension ability and marine ecological conservation learning interest levels with the aforementioned strategies.

Literature Review

Reading Literacy and Science Education

The PIRLS defines reading literacy as the ability of individuals to understand meaning through texts and to use the knowledge gained thereby in daily life (Mullis & Martin, 2016; Strietholt & Rosén, 2016). The PISA definition of reading literacy is the ability to understand, use, reflect on, and engage with written texts in order to achieve personal goals and develop one's knowledge and potential. In these definitions, 'understand' refers to the ability to construct meaning and comprehension from a given text; 'use' means applying the information and ideas in the text directly to a task or goal; 'reflect on' means connecting with the content and experience read about, or making judgments on the text; and 'engage with' refers to having the motivation to read (OECD, 2010). Combining the reports for the PIRLS and PISA shows that understanding and using texts is the key to reading literacy.

Children's literature has proven to be an effective tool for cultivating children's understanding of scientific concepts (Hsiao & Shih, 2016). Using stories in science courses can help children to better understand and emotionally identify with how scientific concepts connect to the world around them. The practice of scientific process skills also allows children to reflect on and apply the concepts they have learned and to cultivate their emotional value (Hsiao & Shih, 2016). If science language is used systematically in a course and language and writing are applied to science, even lower achievers can have appropriate discussions with peers (Cervetti et al., 2006). For example, Chen et al. (2015) found that primary school students could understand the scientific concepts in picture books, ask scientific questions, and enjoy scientific inquiry. Hsiao and Shih (2016) found that picture books could enhance children's understanding of concepts related to the environment, such as concepts concerning the reuse and recycling of resources.

As the above discussion makes clear, educators can use picture books to design marine education courses for lower grade students and guide them in learning scientific concepts. In addition, scientific inquiry can be applied in these courses to strengthen students' ability to understand and use such concepts in order to improve their reading literacy.

Reading Literacy and Learning Interest

Interest in a particular subject or the associated reading materials may be an important factor in determining whether students concentrate and work hard on reading comprehension (Lee, 2009; Soemer & Schiefele, 2019). Students may first become interested in a topic and then have a strong attitude towards learning about it (Blankenburg et al., 2016). According to the literature, interest can be divided into two types: individual interest and situational interest. Individual interest consists of relatively stable emotions regarding certain topics, while situational interest is a relatively short-term psychological state that allows individuals to maintain their focus, curiosity, and positive emotions in specific situations (Huang, 2013; Hidi & Renninger, 2006).

Hidi and Renninger (2006) have asserted that there are four phases in the development of interest: (1) Trig-

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gered situational interest refers to the transient interest changes caused by emotional and cognitive processing, including those in group learning, problem solving, and other learning environments. (2) Maintained situational interest refers to the psychological state that occurs after triggered situational interest, which requires concentration and persistence, including topic-oriented learning and group cooperation. (3) Emerging individual interest refers to the sustained interest generated by external support, including support from peers, experts, etc. (4) Well-developed individual interest refers to an individual's mental state and relatively persistent tendencies, including persistence in work or problem solving. The fact that students process texts at a deeper level is one of the powerful indicators of reading intrinsic motivation (Huang, 2013). Individual interest allows students to be highly involved in challenging materials and reading activities. For students with low reading achievement, individual interest plays an even more important role (Soemer & Schiefele, 2019).

Previous studies have found a positive correlation between topic interest and reading comprehension (Lee, 2009; Soemer & Schiefele, 2019). Topic interest has been characterized as being composed of both individual and situational interest and is clearly influenced by individual interest (Renninger & Hidi, 2016; Soemer & Schiefele, 2019). This is because the specific topic of a given text is related to individual interest (Soemer & Schiefele, 2019). Topic interest may also be situational in the case of readers who have not yet formed a stable individual interest. For example, Lee (2009) found that topic interest was an important factor affecting reading comprehension, and that students who are learning foreign languages should be provided with attractive reading materials so that they can understand the text. In another research, Huang (2013) found that all the participating students said that reading books related to individual interests was more interesting than reading textbooks, in addition to finding that low achievers also participate in critical reading as a result of individual interests.

According to the above discussion, interest, especially individual interest, is a key factor affecting reading comprehension. Teachers should thus aim to cultivate individual interests so that students can participate in challenging reading activities. Before students develop individual interests in teaching materials, appropriate situations should be arranged to arouse the students' situational interests, and then related activities should be undertaken to support the students' individual interests. Therefore, the teaching strategy used in this research was to encourage the students involved to participate in the arrangement of the learning contexts, so that they had a situational interest in marine education. The students were then guided to read related picture books in order to learn scientific concepts, conduct inquiry activities, and gradually form individual interests. With these strategies, it was expected that the students might increase their interest in learning and then participate in the reading activities and improve their reading comprehension.

Reading Literacy, Learning Interest, and Scientific Inquiry

Science experience in early childhood is the basis for future science learning and understanding (Shillady, 2013). If children have good learning experiences in kindergarten or early primary school, those experiences will have a positive impact on their later behavior and cognitive skills (Lin & Chen, 2015). Among science learning experiences, inquiry-based learning can help students understand the nature of science and relevant concepts in different scientific disciplines, rather than independent concepts (Patrick et al., 2013).

Inquiry-based learning can increase students' interest in learning, and interest is an important predictor of students' intention to select courses (Blankenburg et al., 2016). Students' interest can be enhanced through various learning contexts or activities, and educators can connect science lessons with students' daily lives. For example, Wang, Wu, Yu, and Lin (2015) found that students' motivation and interest in science learning increased after they participated in inquiry-based instruction. Blankenburg et al. (2016) found that sixth graders were most interested in surveys and hands-on activities in all situations. Lu and Liu (2015) found that younger students and lower achievers were given more confidence during learning activities and gained course knowledge with the help of augmented reality technology. In addition, Patrick et al. (2013) expressed the belief that the combination of science reading, writing, and inquiry activities can develop important literacy and scientific skills in younger students. They found that combining science reading with inquiry activities allowed children to score higher on literacy and science tests than their counterparts of the same race. Liston and Hennessy (2018) found that the combination of oral expression, reading, writing, and inquiry activities could effectively improve the literacy, scientific thinking, reasoning skills, and understanding of scientific concepts among children aged 6-8 years. However, they also found that many teachers lacked the necessary professional development or related resources and did not use an integrated approach in teaching their classes.

According to the preceding discussion, teachers can conduct science teaching by combining reading, writing, and inquiry activities and effectively trigger students' situational interest within a teaching environment by giving them appropriate support and encouragement. Individual interests can gradually develop after the triggering of situational interests. Furthermore, after students have formed their individual interests, they can participate in reading comprehension and inquiry activities spontaneously, and they can also exhibit better learning results through presentations.

The TRIP Teaching Model

Science learning should focus on different subject-related contexts and activities, rather than just content and concepts (Blankenburg et al., 2016). It is also important to provide science courses that integrate children's literature (Liston & Hennessy, 2018). Therefore, a Triggered situational interest-Reading-Inquiry-Presentation (TRIP) teaching model was proposed in the current research in order to integrate science reading and inquiry skills. The strategy with regard to the *triggered situational interest* consisted of guiding students to arrange appropriate learning situations and letting the students know what topics they were about to learn. The strategy with regard to *reading* consisted of having them read picture books to improve their background knowledge. The strategy with regard to *inquiry* consisted of allowing the students to use the scientific knowledge they had learned to explore scientific issues. The strategy with regard to *presentation* consisted of encouraging the students to integrate and report on the scientific concepts and attitudes they had learned.

The *triggered situational interest* strategy is based on the notion that transient psychological changes are caused by emotions and cognitions. Situational interests occur in specific contexts and can be generated by environmental or textual stimuli. It has been found that learning environments such as group work and problem solving environments can arouse situational interest (Hidi & Renninger, 2006; Huang, 2013). Therefore, hands-on activities and work exhibitions can be combined together. This allows students' situational interests to be briefly stimulated and changed by setting up different contexts in classrooms, which in turn stimulates students' learning motivation. Such activity is consistent with the view that students may have an individual interest and a positive attitude toward a subject (Blankenburg et al., 2016).

The *reading* strategy relies on the use of stories in science lessons to connect students to the world around them and to allow them to apply the concepts they have learned. This can help students develop scientific processing skills and learn important concepts to cultivate emotional value (Hsiao & Shih, 2016; Liston & Hennessy, 2018). Reading can also serve to provoke doubts in students about scientific topics, spurring them to ask and explore related questions (Cervetti et al., 2006). Since the mind map is a visual tool, constructing a mind map requires remembering and organizing the learned concepts. A mind map can be used to guide groups to construct, monitor, and evaluate the knowledge development of individuals and the groups themselves (Stokhof et al., 2020). Therefore, the teacher can guide students to pay attention to the scientific vocabulary mentioned in a picture book and in forming the keywords on a mind map. Then, the teacher can guide students to draw the connecting lines between the keywords and associated cards with color pens, and the students can improve their understanding of the relevant scientific concepts by reading the picture books. Such activity is consistent with the view that understanding and inquiry strategies involving reading can help students in making judgments and drawing conclusions (Cervetti et al., 2006).

The *inquiry* strategy is based on the notion that students develop knowledge and understanding of scientific concepts through learning activities. Inquiry learning activities include observing, questioning, designing experiments, analyzing and interpreting data, explaining and predicting, communicating results, etc. (NRC, 1996, p. 23). Teachers may ask questions and guide students to design experiments and collect, analyze, and interpret data to verify the concepts they have learned. At the same time, teachers or peers may ask questions to encourage more in-depth inquiry that helps students to reflect in different situations. Students apply concepts and develop scientific process skills, and develop individual interests to maintain their learning persistence. Such activity is consistent with the view that inquiry-based learning can increase interest and cause students to continue learning (Blankenburg et al., 2016; NRC, 1996, p. 23).

The *presentation* strategy relies on the application of writing to display learning outcomes. According to Cervetti et al. (2006), the application of writing to science learning enables students to engage in appropriate discussions when engaged in scientific learning. The teacher can design a science study sheet to provide students with the opportunity to discuss and share the language they encounter in reading picture books and conduct-

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ing inquiry activities, with such discussions including opportunities to ask questions, observe records, and draw conclusions. In addition, teachers can design study sheets to facilitate students in presenting the results of their reading comprehension, including the scientific concepts they have learned from picture books and mind maps of picture books. Such activity is consistent with the view that combining spoken expression and writing can improve students' scientific literacy (Liston & Hennessy, 2018; Patrick et al., 2013).

As indicated by the above discussion, each teaching strategy included in the TRIP teaching model continually develops the next learning activity in order, that is, the previous teaching activity can be regarded as the beginning of the next activity. The scientific background knowledge and skills of most students in the lower grades are quite limited, and it is thus quite difficult for teachers to conduct inquiry activities with such students directly. However, by starting with their familiarity with hands-on activities, the teacher can arrange a suitable learning environment to stimulate their situational interest. After the students have a basic understanding of the subject, the teacher can then encourage them to read related picture books and improve their background knowledge. In order to achieve the desired effects, such picture books may have exaggerated stories. Teachers can use this to guide students in thinking about and in stimulating their doubts about the content. Then teachers can arrange related inquiry activities as a test so that students can reflect on whether the concepts they have learned are correct. Finally, writing activities are conducted to guide students in recording their knowledge in order to test the learning outcomes on their own, and to facilitate teachers in monitoring and evaluating the knowledge development of individuals and groups.

Research Questions

A TRIP teaching model was proposed by the research team that conducted this research, and a curriculum designed according to the TRIP model was used to improve the reading comprehension ability and marine ecological conservation learning interest of second graders in primary school. Based on the above research purpose, the following research questions were addressed:

1) Did the TRIP model cause differences in students' performance of science reading comprehension?
2) Did the TRIP model cause differences in students' learning interest in marine ecological conservation?

Research Methodology

Design and Contexts

This research adopted a quasi-experimental design that was mainly based on quantitative data analysis supplemented by qualitative data analysis. Through the TRIP model course, the researchers expected to improve the science reading comprehension ability and marine ecological conservation learning interest of the participating second graders. There were three phases in the research.

The first phase consisted of the research team discussing the marine biology inquiry course, including the selection of marine biology picture books and the design of related scientific inquiry activities. The researchers used the Science Reading Comprehension Test (SRCT) and Marine Ecology Conservation Learning Interest Scale (MECLIS) (see *Research Instruments* section) to measure the starting behaviors of the students in both the experimental and comparison groups before conducting teaching activities. In the second phase, the teacher guided the students to set up the learning environment, and then conducted the teaching activities. In this phase, the students in the experimental group learned with the TRIP model, while the teacher for the comparison group used the lecture teaching method to teach the students. In the third phase, after all the teaching activities were completed, post-tests were conducted to determine and compare the changes in the SRCT and MECLIS of the students in the two groups.

There were 10 lessons conducted as the experimental activity, with each of those lessons being 40 minutes long. Regarding learning content, the unit *Gift of the Earth* (3 lessons) introduced dewdrops, autumn, farm, and nature notes. The unit *Wonderful Water* (2 lessons) introduced the characteristics of water, the use of water, and the sinking and floating of objects in water. The unit *Beautiful Nature* (3 lessons) introduced rivers, the sunset, and preferred places. The unit *Making Friends with Small Animals* (2 lessons) introduced the concepts of learning about, caring for, and respecting small animals.

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Participants

The participants in this research consisted of the second graders in two classes of a primary school in Southern Taiwan. This primary school was located in the city center, and the academic achievement of students attending the school was slightly higher, on average, than that of students in other areas in Taiwan. There were 25 students in the class, including 14 boys and 11 girls. There were also 25 students in a comparison group class, including 14 boys and 11 girls. Since primary schools in Taiwan underwent normalized placement in the first grade, the backgrounds of the comparison group students were comparable to those of the experimental group students. The teacher of the experimental group (Ms. O) had 29 years of teaching experience, majoring in science education. Her usual teaching model was inquiry teaching. The teacher of the comparison group (Ms. Y) had 21 years of teaching experience, majoring in visual arts education. Her usual teaching mode involved the use of narration, questioning, group discussions, and related videos. These two teachers discussed the teaching process before beginning the current research and controlled all the teaching factors besides the use of the TRIP teaching strategies. The proposal for this research was reviewed by the Ministry of Education of Taiwan, and the informed consent of all participants and their guardians was obtained before the course was conducted.

Educational Design

The TRIP model was used to guide the educational design of the teaching activities for the experimental group, including setting up the classroom learning environment and reading picture books, conducting inquiry activities, and presenting the learning outcomes. The *triggered situational interest* strategy consisted of arranging the learning environment. Using this strategy, the teacher instructed the students to make representations of marine life from stained glass, and then displayed their work on the classroom windows. Through this creative process, the students could recognize the characteristics of marine life and their interest in learning was stimulated.

The *reading* strategy consisted of guiding the students' metacognitions based on the scientific concepts mentioned in the picture book (*The Song of Clams*). First, the teacher guided the students to find the keywords of the picture book. In this activity, the students needed to put the keywords and the picture cards in the appropriate place, and then draw the connecting lines between the two cards with different colored pens to complete the mind map. Finally, the students were asked to evaluate what they needed to improve, and the mind map was used to summarize the content and integrate the relevant concepts. In a previous research, the process of mapping mind maps was found to enable students to 'focus on and retrieve', 'make inferences', 'interpret and integrate', and 'evaluate and critique' in the PIRLS reading comprehension process (Mullis & Martin, 2016, p.13). Relatedly, in this research, the students had to use the skill of 'focus on and retrieve' to find information from the picture book, and then use the link to connect two or more messages to 'make inferences'. In the end, the students were expected to 'interpret and integrate' and 'evaluate and critique' to extract the knowledge they had learned in order to express the message of the picture book, and to criticize it.

The *inquiry* strategy consisted of guiding the students to explore the scientific concepts mentioned in the picture book. For example, the content of the picture book mentioned that 'when clams hit each other, the living and dead clams will make different sounds'. The teacher explained this as follows: 'If there was a lot of sand in the shell of the clam, or the clam had broken, it would make a different sound.' Then, the teacher let each student tap various clams gently with a fresh clam, listen carefully, and verify the learned concepts. Finally, the teacher asked questions to encourage the students to think further about this issue before conducting experiments. For example, 'What other methods could we use to prove that clams are fresh?' When the students knew how to conduct an appropriate experiment, the teacher would let them explore.

The *presentation* strategy consisted of letting the students present their learning outcomes. After the students carried out the experiment, they had to complete a scientific inquiry study sheet in order to integrate the scientific concepts they had learned in the scientific inquiry activities. In addition, the students had to present their reading comprehension results with a mind map.

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Instruments

The Science Reading Comprehension Test (SRCT). Since the participants in this research were second graders, their reading comprehension ability was obviously different from that of the participants in the PISA (that is, 15-year-old students). Therefore, the reading literacy framework proposed by the PIRLS was used in this research (Mullis & Martin, 2016).

Table 1
The framework of the SRCT

Scale	Processes of Comprehension	Item numbers
Straightforward process	Focus on and Retrieve Explicitly Stated Information	2, 8, 9, 10
	Make Straightforward Inferences	1, 3
Evaluating process	Interpret and Integrate Ideas and Information	4, 5
	Evaluate and Critique Content and Textual Elements	6, 7

There are 10 items in the SRCT worth a total of 10 points as shown in Table 1. Before the formal test, another 119 second graders were selected for validation of the SRCT, and Tester for Windows 3.0 (Yu, 2012) was used to analyze the test. The correct answer rates for the individual items in this instrument ranged from .54 to .89, meaning that each of the items was answered correctly by more than half of the students. The difficulty coefficients ranged from .45 to .85, with an average difficulty of .68. The discrimination coefficients of the individual items ranged from .28 to .78, which showed that the test items could be used to distinguish the students' varying levels of science reading comprehension ability. The internal consistency reliability value for the overall test was .75. In terms of validity analysis, the correlation coefficients between each of the individual items and the total score of the test ranged from .43 to .66. In terms of the diagnostic analysis of the test items, it was found that each item was suitable for the measurement of the students' performance, and could be used to distinguish the difference between the low and high achievers (Yu, 2012). In addition, the correlation between the 'Straightforward process' scale and the 'Evaluating process' scale was .62 ($p < .001$), which was a moderate correlation. This result shows that the two sub-scales had discriminant validity. Based on the above analysis, it reveals that the SRCT had acceptable reliability and validity, and was suitable for measuring the science reading comprehension ability of the participating second graders.

The Marine Ecology Conservation Learning Interest Scale (MECLIS). The MECLIS, which was developed in a previous research (Chen et al., 2017), was used in this research. The MECLIS includes three sub-scales that are all 5-point Likert scales and contains a total of 15 items worth a total of 75 points. The Cronbach's alpha value of the total scale was .92. The first subscale is 'interest in marine knowledge' (five items), which was found to have a Cronbach's alpha value of .77. An example item from this subscale is 'I like to learn marine knowledge.' The second subscale is 'interest in marine creatures' (five items), which was found to have a Cronbach's alpha value of .85. An example item from this subscale is 'I like to know marine creatures.' The third subscale is 'interest in protecting the ocean' (five items), which was found to have a Cronbach's alpha value of .85. An example item from this subscale is 'I like to learn to protect the ocean.' In the current research, the reliability of the total scale was found to be .88.

Scientific inquiry study sheet. The scientific inquiry study sheet was designed according to the nature of each inquiry activity. The students conducted inquiry activities through mentoring and recorded the data for the sheet based on the results of their research. The unit about 'knowing clams' serves as an example (Table 2). After the first inquiry question, the students in both groups cooperatively discussed the variables of the second inquiry. The teachers, based on the actual teaching situation, then guided the students to explore through the experiment according to their own ideas.

Table 2
Evaluation standards for scientific inquiry ability in the study sheet

Scientific inquiry abilities[1]	Example question from study sheet and evaluation criteria
Explain phenomena scientifically - Recall and apply appropriate scientific knowledge. - Make and justify appropriate predictions.	• Inquiry question: Do you think the clams in the bags are still alive? Why? Criteria: Apply scientific knowledge to explain or predict based on observations.
Evaluate and design scientific enquiry - Identify the question explored in a given scientific study. - Propose a way of exploring a given question scientifically.	• Inquiry question: ( ) will affect the speed of clam spitting? Criteria: Explain the factors that affect the speed of clam spitting. • Inquiry question: Soak the clams in fresh water, 3% salt water, and 6% salt water, and observe their spitting. Criteria: Experiment based on different variables.
Interpret data and evidence scientifically - Analyze and interpret data and draw appropriate conclusions. - Evaluate scientific arguments and evidence from different sources.	• Inquiry question: What kind of water does the clam spit the most? □ fresh water □ 3% salt water □ 6% salt water Criteria: Draw conclusions based on data.

Note: [1]Related abilities were referenced from the PISA 2015 assessment framework (OECD, 2016a, p24-25).

The students' performance in terms of their scientific inquiry abilities were judged according to the assessment framework proposed by the PISA (OECD, 2016a). As shown in Table 2, observing the marine life of clams and explaining the observed phenomena in the scientific inquiry study sheet relates to the competency of 'Explain phenomena scientifically'. The discussion on evaluating and designing methods to explore the factors affecting the speed of clam spitting relates to the competency of 'Evaluate and design scientific enquiry'. Explanation factors regarding the speed of clam spitting in the inquiry activities relates to the competency of 'Interpret data and evidence scientifically'. The students could learn about these competencies from the contents of the scientific inquiry study sheet.

Data Collection and Analysis

The qualitative data collected included interview data, the scientific inquiry study sheets, and other observational data. The qualitative data labels were coded as follows: student (parent) number, date, source (sheet, interview, or others). Regarding the research analyses, the analysis aimed at answering the first research question sought to analyze the students' SRCT scores before and after the TRIP learning activities by using analysis of covariance (ANCOVA) and the Johnson-Neyman technique (D'Alonzo, 2004). The analysis aimed at answering the second research question sought to analyze the students' MECLIS scores before and after the TRIP learning activities by using ANCOVA.

Research Results

Students' SRCT Performance

First, a homogeneity test of the regression coefficients for the two groups was performed. The test reached significance and did not meet the basic assumptions ($F = 13.32$, $p = .001$). The Johnson-Neyman technique was then adopted as an alternative to the ANCOVA. The results are shown in Figure 1. Among the students whose SRCT pre-test scores are lower than 7.56, SRCT post-test scores of those in the experimental group are better than those in the comparison group. Meanwhile, the SRCT pre-test scores for those in the two groups whose SRCT scores are between 7.56 and 10.00 do not differ statistically. Since the students' scores are all integers, these results reveal that the experimental group students who had a pre-test score of 7 or less had better post-test scores than the comparison group students who had a pre-test score of 7 or less.

Figure 1
Johnson-Neyman technique test for two groups
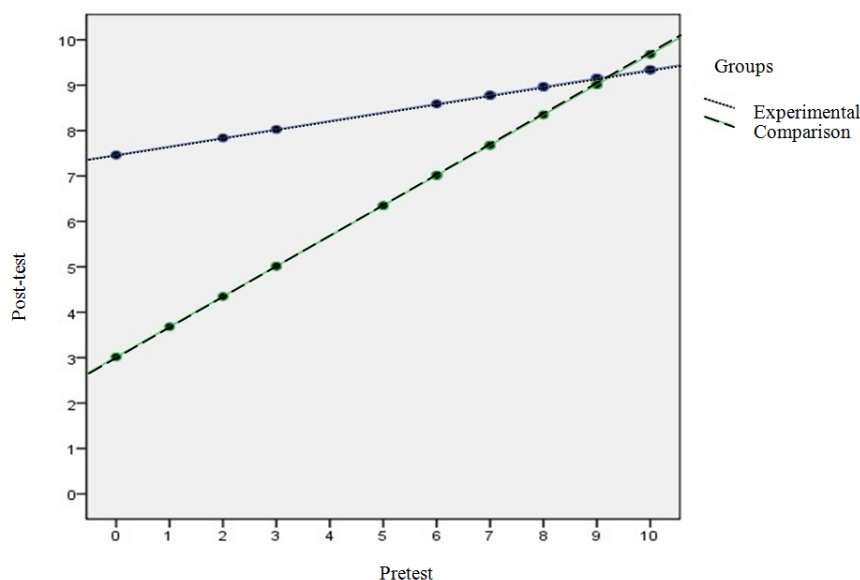
In the experimental group, the students whose reading comprehension ability was lower than the mean by one standard deviation were classified as low achievers (that is, those with a score of less than 6 points). As a result, four students (16%) in the group were classified as low achievers. After analyzing the post-test results, it was found that only one of those students (4%) had a score of 6 points. This student's pre-test score was 2 points, meaning that the post-test score of the student represented an increase of 4 points. The above results show that the TRIP model can effectively improve students' science reading comprehension ability.

With respect to the analysis of the qualitative data, an article about 'Good Friends' in nature was introduced to the students. After reading this article, the students could spontaneously discuss different forms of marine life to provide examples of good friends. It reveals that the students' reading comprehension ability had improved significantly and that they could apply the scientific knowledge they had learned to appropriate situations. This was, in effect, the 'Interpret and Integrate Ideas and Information' ability, that is, the ability of the students to extract their own knowledge in order to connect with messages that are not clearly expressed in a text (Mullis & Martin, 2016).

> st9: Corals and symbiotic algae are good friends, and symbiotic algae provide coral with nutrients. If symbiotic algae die, then corals will be bleached.
> st18: Water is a good friend of fish! Fish live in water.
> st5: Clownfish and anemones are good friends. Anemones protect clownfish, and clownfish clean away dirty things from anemones. (other_20190313)

Finally, from the contents of the students' study sheets, it was found that 18 of the students (72%) could correctly write down three of the marine concepts they had learned from the picture book of their choice.

> If the coral is bleached, there is no place for the fish to live (st4_20181229_ sheet).
> Kelp is the food of marine animals, so you can't just take away all the kelp in the sea (st19_20181229_ sheet).
> I learned how to distinguish between good and bad clams. If the clams used for inspection are bad, then any good clams will also mistakenly be judged as bad (st25_20181229_ sheet).

Fifteen students (60%) were able to correctly abstract the contents of the picture books onto mind maps and then use their own words to introduce the story and criticize the picture book content.

Corals need a place where the seawater is clean, ... and warm sunshine (st5_20181229_ sheet).

This book was talking about sharks polluting the ocean, and the ocean became very dirty ... (st16_20181229_ sheet).

This story was about two clams colliding, some were good, some were bad ... Therefore, the clams we used for inspection would affect the results of the inspection (st24_20181229_ sheet).

Students' MECLIS Performance

First, a homogeneity test of the regression coefficients within each group was performed, and the results did not reach significance ($F = 2.224$, $p = .143$). The above result meets the basic assumptions of the test and indicated that the MECLIS results could be analyzed by ANCOVA. Table 3 shows the mean, standard deviation (SD), and adjusted mean of the post-test regarding the students' interest in marine ecological conservation learning. The mean score of the experimental group increases to 69.64 points (out of 75 points) on the post-test, and the adjusted post-test mean is 68.97 points. The mean of the comparison group increases to 63.61 points on the post-test, and the adjusted post-test mean is 64.34 points. The ANCOVA results indicate that the performance of the two groups is different ($F = 4.576$, $p = .038$), and that the experimental group outperforms the comparison group. The test has a medium effect size (Cohen's $f = .32$) (Cohen, 1988; Richardson, 2011).

Table 3

Students' MECLIS performance results

Group	Mean of Pre-test (SD)	Mean of Post-test (SD)	Adjusted Mean of Post-test (SE)
Experimental	64.16(8.48)	69.64(4.61)	68.97(1.48)
Comparison	60.92(11.04)	63.61(10.62)	64.34(1.54)

Note: SE = standard error

If the MECLIS pre-test score of a student in the experimental group was more than one SD below the average, then that student was categorized into the low achiever group. Twenty percent of the students had a mean score lower than 55 and were thus categorized in the low achiever group. After analyzing the post-test scores of the students in the experimental group, it was found that the scores of all the students were higher than 60 points. In addition, three students' post-test scores (12%) had improved by more than 20 points, while five students' post-test scores (20%) had improved by more than 10 points. Not only had all of the students' scores improved, but the results also indicated that the TRIP model had effectively improved the marine learning interest of the low achiever group. The interview data, which was based on the four-phase model of interest development (Hidi & Renninger, 2006), was reported as follows:

Phase 1 - triggering situational interest:

T: Do you like the stained-glass activities? Why?

St14: Yes, it's fun! We can also meet many marine animals. (st14_20181122_interview)

St17: Yes, I made a beautiful clownfish! The classroom has become so beautiful! (st17_20181122_interview)

Phase 2 - maintaining situational interest:

T: Do you like to do the experiment? Why?

St7: Yes, we can learn a lot by doing experiments! (st7_20181229_interview)

St25: Yes, it is fun to do marine experiments! (st25_20181229_interview)

Parent21: I think it's great to conduct science experiments in lower grades! They like it now, and they won't be afraid of science class in the future. (parent21_20190330_other)

Phase 3 - emerging individual interest:

Parent19: My daughter did not like to drink kelp soup. Now, after the teacher taught about kelp, she likes it! (parent19_20190220_other)

Parent17: My daughter does too! (parent17_20190220_other)

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Parent06: My son likes the ocean classes. He said that the kelp buds that the teacher taught the students to cook are delicious! (parent06_20190220_ other)

Parent21: Their stained glass is so creative and well done! (parent21_20190330_ other)

Phase 4 - well-developed individual interests:

Homework: What other things should be noticed when observing small animals?

St18: Don't throw garbage into the ocean, otherwise small animals will eat it. (st18_ 20190430_ interview)

Parent25: Teacher, my daughter is looking forward to your marine course. (parent25_201900509_ other)

T: Do you think you can protect the ocean?

St14: Yes, don't litter, so the ocean will be clean. (st14_ 20190520_ interview)

From the above qualitative data, it was revealed that engaging in marine biology projects and setting up classrooms can trigger students' situational interest; for example, 'You can know many marine animals' (st14_20181122_interview). Then, the teacher used this situation to conduct inquiry activities, so that the students had a meaningful connection to maintain their situational interest; for example, 'Doing ocean experiments is fun!' (st25_20181229_interview). The parents' support for and affirmation of the course were the key to arousing individual interest; for example, 'It's great to take science experiment classes in a lower grade class!' (parent21_20190330_other). After the intervention, the students formed individual interests; for example, 'Do not throw garbage into the ocean' (20190430_st18_interview) and 'Don't litter' (st14_ 20190520_interview). This shows that the students could think of ways to solve problems after learning.

Discussion

Although several scholars have discussed the effects of the integration of reading, writing, and inquiry on scientific learning (Liston & Hennessy, 2018; Patrick et al., 2013), there is still limited literature indicating appropriate integration models for improving students' science reading ability and learning interest. Therefore, in order to improve students' reading comprehension ability and marine conservation learning interest, the researchers in the current research proposed a TRIP teaching model. This model provided innovative contributions in the field of marine science education research. The research team designed a course based on the TRIP model and obtained promising results. The research demonstrated that simple activities could be used to motivate the participating students to develop the interest in topics they were not familiar with. First of all, the teachers used novel materials to guide the students in setting up learning environments and let the students know what topics they were about to learn in order to enhance their situational interest by creating a learning environment. Secondly, related picture books and marine science concepts were selected to improve the students' reading ability and, in turn, their ability to understand marine science. Third, common marine ingredients were used to conduct inquiry activities to provide the students with opportunities to apply marine science concepts. The teacher gave encouragement and support to enhance the students' individual interests. Finally, the students were encouraged to fill out a science inquiry study sheet in order to organize and share scientific concepts.

Although the typical courses for second graders in Taiwan mention related ocean concepts, they do not guide students to learn deeply. It is difficult for students to appreciate the need to protect nature based on the existing teaching materials, and it is not easy for teachers to achieve the relevant teaching goals. Interest can predict the performance of reading comprehension (Lee, 2009; Soemer & Schiefele, 2019). Therefore, if students' reading comprehension abilities are expected to improve, their interest in the subject of marine education should be enhanced first. A larger increase in later academic performance of teenagers who perform well in early learning was expected (Lin & Chen, 2015). In addition, Soemer and Schiefele (2019) have argued that existing individual interests will influence topic interests when reading. Before individual interests are formed, meanwhile, topic interests may be influenced by situational interests. In this research, a topic of marine education that the students were unfamiliar with inspired their situational interest first. The students used stained-glass materials to create simulations of marine life, so that they could understand the characteristics of marine life. Then the designed works were used to set up a marine education learning environment. As the stained-glass project represented the students' first exposure to this material, each student felt that the subject was novel, and they were interested in and focused on the project. Therefore, the strategies laid out in the learning environment achieved positive results and successfully improved the interest of all the students. This result was in line with the work of Lin and Chen (2015). Lin and Chen (2015) found

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that placing students in a well-designed learning environment was conducive to their development of cognitive skills, as well as to increasing their reading interest and inquiry abilities. However, situational interest belongs to a short-term psychological state, and other activities may be added and supported in order for students to form long-term individual interests and achieve the teaching goals of marine education.

In addition, scholars have found that students' concepts about marine science are insufficient and that some are even wrong (Chang & Zhang, 2018; Tsai et al., 2017). Blankenburg et al. (2016) pointed out that students should pay more attention to different activities in science learning and enhance their interest through specific situations or activities. Linking science lessons to everyday life can help students to develop practical scientific abilities. Therefore, the TRIP teaching model allows students to understand the relevant scientific concepts by reading appropriate picture books to acquire more scientific concepts and by conducting related inquiry activities using common ingredients. Finally, in analyzing the post-test results regarding marine conservation learning interests, it was found that all of the students in the experimental group had scores of higher than 60 points on the MECLIS. That is, each student scored an average of more than 4 points on each item, and their performance on each 5-point scale was thus relatively positive. In addition, 12% of students improved their scores by more than 20 points from the pre-test, and 20% of the students improved their scores by more than 10 points from the pre-test. These results revealed that the TRIP model can effectively improve the learning interest of most students with respect to marine ecology conservation, especially low-achieving students. Scientific inquiry is a good way to acquire new knowledge (OECD, 2016b), and the results of the current research were consistent with the idea that inquiry-based learning can increase student learning interest (Blankenburg et al., 2016; Wang et al., 2015).

Based on the results of the current research, teachers devoted to science education are encouraged to use the TRIP teaching model as their course design framework. Teachers can use novel materials to set up learning environments and inspire students' situational interests. Next, teachers can guide their students through the relevant picture books or stories to learn scientific concepts, and integrate the relevant activities into scientific inquiry. In this way, the relevant scientific concepts can be closely integrated with daily life experiences. Through the support of parents and teachers, students may gradually develop their individual interests, enhance their reading comprehension and marine ecological conservation learning interest, and achieve the teaching goals of marine education.

Conclusions

A TRIP teaching model was developed in this research based on a previously proposed theory and the effect of this model on students' reading comprehension and marine conservation learning interest was measured. It has been found that this model could improve the participating students' reading comprehension and marine conservation learning interest. The students used their own marine biology projects to set up a learning environment, and their situational interest was enhanced. The teacher selected related picture books and marine science concepts to improve the students' reading comprehension. Common marine ingredients were used to conduct inquiry activities, successfully integrate inquiry activities with daily life, and then integrate the relevant marine science concepts. In addition, the teacher and parents provided timely encouragement and support to the students, and also enhanced the students' individual interests. Finally, the research results confirmed the effectiveness of the TRIP teaching model with respect to enhancing the students' reading comprehension and marine conservation learning interest.

There were several limitations in this research. The scope of marine education on marine life was focused on in this research. As such, it may not be appropriate to make excessive inferences about the possible performance of students on other topics based on the results of this research. Secondly, in consideration of the habits and safety of marine animals, only clams were selected as the subject of the marine animal investigations conducted as part of the research, while other marine animals were not included. Furthermore, the use of different teachers for the experimental group and the comparison group may have biased the research results. This limitation necessitated that the research team coordinate these two teachers' approaches in order to control other teaching factors. Finally, there were only two classes that participated in the research (n = 50). The students in both classes participated in related research and teaching when they were in the first grade and had similar learning experiences. Therefore, the generalizability of the results of this research to students in other classes remains to be examined further. It is suggested that related future studies increase the number of research subjects involved and conduct longer-term research, as doing so may yield more detailed data to illustrate the benefits of the TRIP model.

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