How to Motivate Individuals to Take Responsible Ocean Action: the Mediate Effect of Attitude Towards the Ocean

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Abstract

When considering how to improve public literacy and behavior related to specific themes, top priority is usually given to strategies to enhance knowledge and understanding. However, recent evidence has shown that attitude could be an important factor in the development of behavior. The aim of this study is to explore the relationships among ocean knowledge, attitude towards the ocean, and intention to take responsible behavior in the marine setting. After recruiting a total of 266 volunteers, participants' ocean knowledge, their attitudes towards the ocean, and their intention to behave responsibly were evaluated using questionnaires. The results indicate that attitude may be more important than knowledge in terms of the effect on intention, and a person's attitude towards the ocean may indeed be the full mediator between ocean knowledge and their intention to show responsible marine behavior. Based on these results, the development of marine policy and public education should consider the importance of attitude in achieving the primary aim, of ensuring that people engage in responsible ocean behavior. At the same time, it is noted that appropriate knowledge provides people with insights that may determine the correctness of their behavior.

Introduction

The oceans cover over 70% of the Earth's surface and play a crucial role in providing social, economic, and environmental benefits to the earth's growing population. According to the OECD's 2017 Green Growth and Sustainable Development Forum on "Greening the Ocean Economy", the oceans support activity with an annual economic value in the range USD 1.5-2 trillion. In 2017 the OECD estimated that the value of the ocean economy could have more than doubled by 2030 [1]. However, marine resources are in rapid decline due to the destruction of habitat, overfishing, pollution, and global change. The promotion of ocean literacy and the encouragement of citizens to behave in environmentally responsible ways have been regarded as challenging yet fundamental elements for minimizing the negative environmental impacts of human activity [2]. In the pursuit of this goal, a series of ongoing ocean education research projects at international and national levels has been proposed within the Sea Grant Program (US National Oceanic and Atmospheric Administration), the EU Blue Growth program (European Commission), and the Ocean Literacy Program (Japan), among others.

Around the world, current developments in scientific education have placed a strong emphasis on scientific literacy, which has now emerged as a clear common theme [3–5]. Marine education is presently evolving along the same path, as marine educators work towards the goal of integrating ocean literacy into classroom activities. Ocean literacy is a broad concept that encompasses a number of educational themes that have shifted over time. Many institutions and individuals have tried to define what is meant by ocean literacy. As part of a project supported by the National Geographic Society, the Centers for Ocean Sciences Education Excellence, the National Marine Educators Association (NMEA), the US National Oceanic and Atmospheric Administration, and the College of Exploration, Cava, et al. [6] developed a framework for the Essential Principles and Fundamental Concepts of Ocean Sciences. In

their report, ocean literacy is defined as a means to “understand the essential concept, communicate about the ocean in a meaningful way, as well as make informed and responsible decisions regarding the ocean”.

Following the development of initial principles and concepts with respect to ocean literacy, some adjustment is still ongoing due to the wide range of meanings and variety of goals of ocean literacy. The development of ocean literacy is similar to the development of scientific literacy, due to the plethora of visions of scientific concepts, processes, the nature of science, procedural skills, and affective and motivational development, both for general and local education purposes, all of which should be included in the notion of scientific literacy [4,7]. In the public realm, teachers and researchers generally acknowledge that scientific literacy encompasses cognitive, affective, and practice domains (NGSS). Therefore, in line with scientific literacy, ocean literacy should also include, albeit not exclusively, marine conceptual understanding, procedural skills, and affective and motivational development, its ultimate aim being the development of responsible behavior regarding the ocean (Cava et al., 2005).

Given that human-induced modifications have been the dominant detectable threat to the global marine environment [8], the improvement of public understanding and individual/collective responsible behavior regarding the ocean is important for the conservation and sustainable use of the ocean’s resources. In recent years, there has been a growing interest in studies of ocean literacy, with a primary focus on investigating the level of knowledge of ocean science [2,9]. This recent surge in interest relates largely to the essential principles and fundamental concepts of ocean sciences, with a focus on the development of ocean knowledge, and only rarely on the shaping of attitudes. Despite increased investment in ocean literacy in many countries, a critical question has emerged of which constructs of ocean literacy are the main factors that influence responsible ocean behavior, in terms of knowledge and attitude. Few analyses evaluate explicitly the impact of knowledge and attitudes on responsible behavior towards the ocean. However, an understanding of the cognitive mechanism of responsible behavior regarding the ocean may help government agencies and educators learn how to develop policy and procedure for enhancing sustainable development of the oceans. The aim of this study is to fill this gap by considering these important questions.

Although previous authors have recognized knowledge and attitude as the antecedents of responsible environmental behavior (REB), there is at present no agreement among researchers which of the variable appears to be the more strongly associated with REB. Many scholars have suggested that knowledge should be thought of as the main influence of REB in ocean literacy. According to Steel, et al. [10], improving citizens’ knowledge should be the first step in establishing a nationwide effort to preserve the oceans in the USA. McKinley and Fletcher [11] identified lack of knowledge as a major factor in public non-involvement in environmental activities, and Hines, et al. [12] argued that knowledge is a prerequisite of action in this regard. In a similar study, Umuhire and Fang [13] highlighted that a lack of knowledge can limit participation in ocean-related action.

Researchers generally acknowledge that knowledge is not the sole determinant of environmental behavior [12,14]. A number of studies have shown that attitude towards environment is more important than knowledge in governing environmentally responsible behavior. Meinhold and Malkus [15] examined the relationships among adolescent environmental behaviors, knowledge, and attitudes, and found attitudes to be better predictors of environmental behaviors than environmental knowledge. A similar finding was also reported by Pe'er, et al. [16] in 765 students in Israel, where attitudes correlated with environmental behavior more strongly than knowledge.

In recent studies in social psychology there have been some attempts to explore the relationships among knowledge, attitudes, and behavior; however, the model of behavior regarding the ocean environment is still not clear. A number of studies on psychological theories reveal that knowledge may play a key role in its direct impact on attitude and behavior [17]. For example, to construct a model of environmentally responsible behavior among tourists, Cheng and Wu adopted the "cognition-affection-attitude-behavior" model [18], suggesting that environmental knowledge can be key to the development of environmental sensitivity and environmentally responsible behavior. In contrast, Ajzen, et al. [19] indicated that the effect of knowledge on behavior could be indirect, and mediated largely by attitude and intention. Kallgren and Wood [20] assessed attitudes towards environmental conservation, by measuring attitude-relevant knowledge before proposing another model in which attitudes were better predictors of environment-related behavior when they are based on greater amounts of knowledge. In sum, there may be a path model for the relationship among ocean knowledge, attitude, and behavior. Given that empirical evidence indicates an inconsistent direct impact of knowledge on behavior [19,20], a mediate relationship between knowledge and behavior may exist. In this study, we hypothesize that conceptions of the ocean may be influenced by both attitude and behavior, and attitude may play a mediating role between knowledge and behavior.

Purpose of the study

Characterization of the ocean literacy of citizens is the first stage in longitudinal, cross-sectional, and causal research that forms part of the investigation of the relevant responsible behavioral mechanisms. Information gained from this study is vital in view of its potential for promoting marine policy and the development of marine education programs. The aim of this article is to characterize ocean literacy, including ocean knowledge, attitudes towards the ocean, and intentions towards responsible marine behavior. We also attempt to examine a model of intentions towards responsible marine behavior.

Methodology

Participants

Recent decades have seen growing efforts to improve marine education around the world. Taiwan is one of only a few nations to have promoted marine education into the national curriculum. For the purpose of

fostering ocean literacy among its citizens, the Ministry of Education has mandated marine education to be introduced to the national curriculum guidelines for secondary education since 2008 [21]. This means that all citizens under 24 years old in Taiwan have received a basic ocean education at middle school. It is possible that we may fail to estimate the impact of ocean knowledge on behavior if the population has a general lack of basic knowledge about the ocean. Indeed, this could be one of the reasons for the inconsistent results of the knowledge-attitude-behavior studies mentioned above. Therefore, those aged less than 15 or more than 24 were excluded from the present study. A total of 266 volunteers, comprising 136 males and 130 females, were recruited from three major geographical regions in Northern, Central, and Southern Taiwan. All study participants provided informed consent.

Evaluation of Scientific Literacy

To measure subjects' ocean literacy in terms of their conceptual understanding, their attitudes towards the ocean, and their intentions regarding responsible marine environmental behavior, we devised and developed the Ocean Conception Instrument (OCI), and employed the Attitudes towards the Ocean Inventory (AOI) and the Intention to Take Responsible Marine Action Instrument (ITRMAI). These are explained in more detail below, and sample questions are shown in Table 1.

Ocean Conception Instrument (OCI)

The OCI is a 75-question multiple-choice test designed to measure subjects' conceptions of the ocean. The core conceptions are defined based on Ocean Literacy-The Essential Principles and Fundamental Concepts of Ocean Sciences for Learners of All Ages [22] and the Marine Education Curriculum Guidelines of Taiwan [21]. The NOAA's version of ocean literacy comprises seven essential principles with 45 fundamental concepts: (1) The Earth contains one large ocean with many features, (2) The ocean and life in it shape the features of Earth, (3) The ocean is a major influence on weather and climate, (4) The ocean makes Earth habitable, (5) The ocean supports a great diversity of life and ecosystems, (6) The ocean and humans are inextricably linked, and (7) The ocean is largely unexplored. In contrast, the Marine Education Curriculum Guidelines of Taiwan comprise five topics: Marine leisure, Marine society, Marine culture, Marine science and Technology, Marine resources and Sustainable Development. The item pool was reviewed extensively by a panel of six marine science and marine education professionals, instructors, and graduate students for validity.

Attitudes towards the Ocean Inventory (AOI)

Research on attitudes related to science and education mostly consists of the perception, value, self-belief, interest, and motivation of science and education [23–27]. In order to measure subjects' attitudes towards the Ocean, we developed the AOI, which is a five-point Likert type scale that consists of 26 items, divided into five categories. These include: Support for Marine Science (items 1–4), Self-Confidence in Learning about the Ocean (items 5–8), Interest in Learning more about the Ocean (items 9–12), and Motivation for Learning about the Ocean (items 13–17).

Intention to Take Responsible Marine Action Instrument (ITRMAI)

The Intention to Take Responsible Marine Action Instrument comprises 10 items used to assess the extent to which individuals are willing to engage in actions to protect the ocean environment (eco-management, consumerism, persuasion, and civic actions). These items were generated from the literature [28–31] using a five-point Likert-type scale.

CFA

To establish the validity of the AOI questionnaire, we conducted a Confirmatory Factor Analysis (CFA) by AMOS to re-establish whether attitude can be constructed by measuring five indicators (perception; value; self-belief; interest; motivation). Our standard of factor loadings was 0.5. The criteria listed below were used to assess the model fit: the value of χ^2/df must be less than 3.0 [32]; the comparative fit index (CFI) must be more than 0.90 [33]; the root-mean-square error of approximation (RMSEA) must be less than 0.08 [34,35].

Tests for mediation

In recent years, the bootstrapping approach has replaced the causal steps approach [36] as a more mainstream method for testing mediation hypotheses [37–39]. To examine the hypothetical model presented in Fig. 1, the SPSS PROCESS macro was utilized to carry out a path analysis [40].

Results

The results of OCI

Prior to the evaluation of subjects' understanding of ocean literacy, the internal consistency of the OCI items was established using a Cronbach's α coefficient (α = 0.86). The results of the descriptive analysis showed a mean score for the entire sample of 45.05 (*SD* = *10.25*). Our data also indicate that the following principles had the greatest level of misconception: the major mechanism of global sea level rise (passing score: 12%); the reason why Kuroshio is known as the black current (28%); the major energy source for typhoons is warm ocean water (29%); whale sharks are fish, rather than mammals like whales (30%); the classification of ocean animals (34%); and tiny white fish (whitebait) consist of immature fish of a number of different species (35%).

Mediation test via a path model

Firstly, a confirmatory factor analysis was undertaken to identify an attitude model that consisted of five indicators (perception; value; self-belief; interest; motivation). The results revealed a model with an

adequate fit to the data χ^2 = 532.70; df = 289; p < .001; χ^2/df = 1.84; CFI = 0.94; RMSEA = 0.06). Specifically, the value of χ^2/df was less than 3.0 [32], the comparative fit index (CFI) was more than 0.90 (Bentler, 1990), and the root-mean-square error of the approximation (RMSEA) was less than 0.08 [35].

Secondly, a process macro output for the mediation test was obtained as presented in Table 2. The results suggest that attitude is a significant mediator between ocean knowledge and intention to take responsible marine action (ITRMA). The coefficient of indirect effect along the a-path (knowledge-attitude) was 0.013 with $p < 0.001$; for the b-path (attitude- ITRMA) it was 1.13 with $p < 0.001$. The direct effect of the relationship between knowledge and ITRMA (c'-path) was insignificant. The total effect of knowledge on ITRMA, mediated by attitude, was $R^2 = 0.59$; $F(2, 263) = 191.15$; $p < 0.001$.

Discussion

Subjects' levels of ocean literacy

The initial question related to the promotion of responsible behavior in marine matters was related to which constructs of ocean literacy are the main influencing factors. To characterize ocean literacy in terms of knowledge, the OCI questionnaire was undertaken to evaluate explicitly seven essential principles regarding the ocean. The results reveal that even though Taiwanese subjects received education about the ocean at an early stage, the conceptual knowledge of the ocean exhibited by them is nevertheless flawed and fragmentary. One striking example is the mechanism of storm surge. Despite the fact that Taiwan is located in a subtropical zone affected by storm surge, and global warming has dramatically increased the impact of storms on Taiwan, subjects' conceptions are still inconsistent with those of teachers and scientists.

The data also reveal that the subjects struggle to comprehend long-term, abstract concepts that cannot be observed directly, such as global change, the principles and phenomena of the ocean, and ocean environmental issues. This finding is similar to those from a previous study on misconceptions in Environmental and Earth Science Education [41–43]. Learners often experience cognitive overload in learning, they develop misconceptions, and cannot integrate this knowledge into their behavior in daily life [44]. To foster learners' conceptual understanding of ocean literacy, their learning must entail integration of multiple displays of data, such as graphs, models, and other figures. In this regard, new teaching materials and strategies are required to meet the learning needs of students. For instance, students usually face a considerable challenge in learning ocean environmental issues due to their long temporal and/or large spatial scales. Game-based and situated learning over periods of a few hours have been shown to facilitate learners in experiencing longer timescales. Furthermore, visualization techniques are also recommended when these offer a realistic representation of the processes to be explained, facilitating a deeper comprehension of dynamic systems and providing a greater motivation to learn about them [45,46].

Mediation effect of attitude between knowledge and intention to take responsible marine action (ITRMA)

The main aim of the present study is to address questions that have remained unanswered for some time, namely whether attitude towards the environment is more important than knowledge in the prediction of ITRMA, or whether knowledge plays a key role in attitudes and behaviors. As hypothesized, the results of the mediation test suggest that attitude is a significant mediator between knowledge and ITRMA. A number of studies have also revealed that despite broad understanding of the impact of climate change, and knowing that taking responsible action has an important role in mitigating against the effects of climate change, people tend to ignore and trivialize the responsible action [47]. Besides this, it has repeatedly been reported that environmental knowledge is not sufficient to promote the development of responsible environmental behavior [48–50]. Specifically, in line with evidence produced by Ajzen et al. (2011), the effect of knowledge on intentions toward behavior is indirect, and mediated by attitude. Moreover, the correlation coefficient between knowledge and behavior reported by Ajzen, et al. [19] is similar to our result. This finding is also aligned with previous studies indicating that attitude is a better predictor of behavior than environmental knowledge [15,16]. It is noteworthy that one of the implications of the enhancement of intention towards behavior is related to the mediation effect of attitude on the correspondence between knowledge and behavior. This study provides statistical evidence that cultivation of one's attitude might be a more efficient means of promoting responsible behavior, rather than treating environmental knowledge as the sole predictor.

However, the implementation of government policies has tended to focus on ocean knowledge rather than attitude. For instance, although the Next Generation Science Standard (NGSS) adopted seven principles developed by the National Marine Educator Association (NMEA) in order to facilitate citizens' ocean literacy and encourage responsible behavior, the importance placed on attitude in the guidance is far less than that placed on environmental knowledge. Therefore, based on the results of this study, the formulation of environmental policies and educational instruction should weigh the contribution of attitude in achieving the primary aim of engaging people in ocean responsible behavior. It is generally accepted that attitude comprises three components: cognitive, affective and behavioral [51]. People's attitude toward the ocean environment could be triggered by personal experience, self-belief, environmental values, or perceived social norm [52,53]. Therefore, for policy development, it is important to guide public understanding of moral behavior, engage the public in ocean-related hands-on and reflective activities, heighten awareness of social concerns about marine issues, promote behavioral control in the marine environment, all of which could form the basis for the development of ocean-related attitudes.

Although environmental knowledge does not emerge as a significant predictor of ITRMA, it should not be taken that knowledge is irrelevant to the development of responsible behavior. It is a matter of fact that environmental knowledge underlies the quality of a person's behavior. Acquisition of appropriate knowledge provides people with correct insights into the understanding of environmental problems and thus supports them within the decision-making process. A lack of adequate knowledge may alternatively induce a series of erroneous behaviors, made worse by the fact that the ocean is inextricably connected with natural phenomena and all related earth systems science. In summary, the usefulness of efforts to promote citizens' intentions to take responsible marine action by guiding their attitudes has been

confirmed in the present study. The quality of behavior is also a crucial issue and could be enhanced by encouraging people to pass on knowledge to others. These findings reveal that not only is the establishment of environmental knowledge imperative to the adjustment of environmental policies and educational instruction, but attitude also serves as a primary influencing factor towards the development of responsible behavior for the benefit of the ocean.

Declarations

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Author contributions statement

Guang-Ying Liu contributed to the study’s conception and design, data analysis, and drafted the article. Yi-Chen Lin contributed to the study’s data analysis, and revised the manuscript. Ting-Kuang Yeh contributed to the study’s conception and design, data analysis, drafted and revised the article, and approved the final version to be submitted.

Additional information

None of the authors declare any potential financial conflict of interest to this report.

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Tables

Table 1
Examples of AOI and ITRMAI

Instruments	Constructs	Examples
AOI	Acknowledge the importance of Ocean Exploration (Values)	• It is essential for the government to provide an annual budget for researchers to explore the ocean. • Ocean exploration is important because it helps us understand the natural environment around us.
	Self-belief towards Learning Ocean (Self-belief)	• I can easily understand the ocean-related knowledge provided in school courses. • If there are some ocean-related concepts that I don't understand, I can always collect relevant data and perform analyses to figure out the right answer.
	Interest in ocean (Interest)	• I am always delighted to discover new knowledge about marine matters. • I am interested in outdoor experiments related to marine matters.
	Willingness to seek information about the Ocean (Motivation)	• I find the ocean-related course provided at this stage very helpful, because it will help me greatly with my future career. • I hope to pursue an ocean-related career.
	Responsibility towards ocean resources and environments (Perception)	• Marine ecology is closely related to my daily life. • It is our duty to protect the beach and seashore.
ITRMAI		• I would like to participate in coastal clean-up activities. • I would like to take time to think about how to maintain the sustainable development of the ocean.

Table 2
Results of mediation test via process macro. ITRMA: intention to take responsible marine action.

Consequent								
	Attitude				ITRMA			
Antecedent	path	Coeff.	SE	*p*	path	Coeff.	SE	*p*
Knowledge	a	0.013	0.003	< .001	c’	-0.001	0.003	.818
Attitude					b	1.132	0.060	< .001
Constant	i1	2.973	0.136	< .001	i2	-0.646	0.222	< .01

Figures

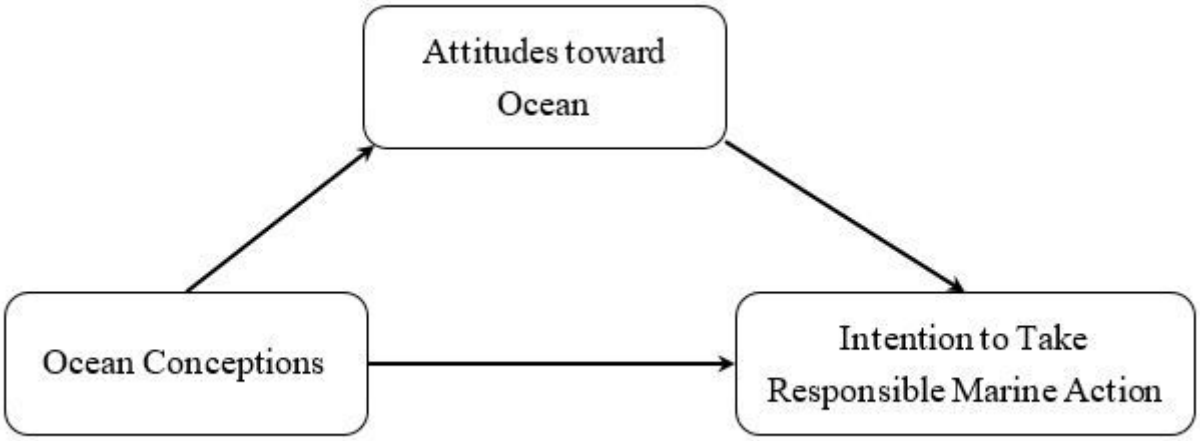

Figure 1

The hypothesized mediation model.