



Evaluating the impact of interactive marine wildlife programs on student conservation attitudes in coastal communities

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Abstract

The study aims to assess the success of an online interactive marine wildlife program in enhancing the knowledge and conservation attitudes of students in the coastal communities. The quasi-experiment pre-test- post-test with a mixed-methods design was used on a sample of 198 students aged between 10 and 16 years. The intervention consisted of a 2–4-week web-based intervention including virtual simulations, sessions with the expert, and interactive modules. Data were collected using structured questionnaires of knowledge and conservation attitudes. Statistical analyses were paired t-tests, Cohen's d, and regression. The findings indicated that the knowledge scores improved significantly by 46.2% (± 10.5) during the pre-test and 78.6% (with a standard deviation of 9.2) during the post-test ($t = 24.87, p < 0.001$). The score of attitudes towards conservation also improved by 3.12 (0.58) to 4.08 (0.47). The effect sizes were large ($d = 1.85$ and $d = 1.42$, respectively, in the case of knowledge and attitudes), which demonstrates a high practical value. The regression analysis indicated that the change in attitude was greatly predicted by knowledge gain ($\beta = 0.68, R^2 = 0.62, p < 0.001$). The research has shown that online learning with an interactive program proves very successful in promoting marine conservation awareness and attitudes among learners. These results indicate the significance of experiential digital learning to promote

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environmental responsibility and uphold the incorporation of such courses into the educational system.

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Introduction

Marine ecosystems are among the most ecologically valuable and biologically diverse environments to be found on Earth, sustaining a wide range of flora and fauna and being important sources of ecosystem services, including coastal protection, fisheries, and climate regulation. However, the pressure imposed on these ecosystems by humans is increasing, including pollution, overfishing, destruction of habitats, and climate change. Coastal communities, which directly depend on marine resources, are particularly at risk of these changes. It is observed that education is an essential resource to help grow environmental awareness and encourage sustainable practices (Talib *et al.*, 2023). While traditional experiential styles of learning such as physical field visits and direct hands-on interaction have long been the focus of attention (Winks *et al.*, 2020), there is an increasing need to adapt these experiences into the digital realm. The goals of these programs are not only to enhance the knowledge, but also to develop the attitudes and behaviors related to conservation, especially those of students as the future stakeholders and decision-makers. Interactive marine wildlife projects or programs, such as virtual simulations and expert-led digital modules, offer scalable way to close the gap between the knowledge in books and the reality of environmental issues (Portman and Camporesi, 2020).

The main aim of the research is to assess the performance of interactive

marine wildlife programs in helping to mould the student attitude towards marine conservation amongst the coastal communities. The aim of the research is to analyze the effect of experiential learning techniques, including firsthand exposure to marine organisms, field-based learning activities, on knowledge and awareness of marine biodiversity and perceptions of the students. It will also test the potential of such programs to bring about positive attitudinal development and reinforce behavioral intentions towards viable practices and conservation efforts among students.

Despite the fact that environmental education has been recognized as significant to cause conservation awareness, there is a lack of studies regarding the implementation of interactive and experiential marine learning programs, whereas most studies are based on classroom-based and theoretical approaches to teaching (Tagulao *et al.*, 2022). Moreover, there is a lack of empirical research on the effectiveness of such programmes in the coastal communities, particularly where human dependence on the marine environments is very high, especially in the developing regions. Most of the previous research is also on short-term learning of the knowledge and fails to investigate deeper issues such as attitudinal change, emotional engagement, and behavioral change. In turn, there is an urgent necessity for

detailed research that can assess the impact of direct contact with marine wildlife on the conservation attitudes of students in practice (Sakurai *et al.*, 2020).

The hypotheses of this study are as follows: interactive marine wildlife programs play a significant positive role in the conservation attitudes of students (Mascovich *et al.*, 2023). Some hypotheses that are made are that students who are exposed to such experiential learning activities will exhibit better awareness, more positive attitudes towards marine conservation, and intentions to engage in environmentally responsible behaviors than their counterparts who do not. On the other hand, the null hypothesis is that the difference between the attitudes of students who are exposed to interactive programs and students who are not, in terms of conservation, is not significant.

The study will also assist in improving current research on the topic of environmental education that has been expanding in recent years by providing an empirical investigation of the significance of interactive and experience-based learning in the establishment of the marine conservation awareness of students. It offers a comprehensive measure that integrates the cognitive, attitudinal, and behavioral aspects and therefore transcends the traditional knowledge-based measurements. The results will help in coming up with viable education systems in which practical marine education is integrated into the school curricula, especially in the coastal areas. Besides, the research holds importance to policymakers, educators, and environmental organizations in the

development of specific conservation programs and also to provide area-specific information that can shape sustainable community interaction strategies.

The article is well organised to provide a thorough assessment of an online interactive marine wildlife education course. It starts with an introduction in section 1, describing the significance of marine ecology and the value of learning through experience in conservation education. Section 2, the literature review examines the literature on marine education and determines gaps in the research. Quasi-experimental design, sampling, intervention, and analysis methodology are given in Section 3. The results in Section 4 are given, where both quantitative and qualitative results are given, and in Section 5, a discussion of their interpretation is provided. Finally, the conclusion in section 6 provides the summary of the key findings, implications, and the method of future research, and the impact of interactive digital learning on the stimulation of marine conservation awareness is effective.

Literature Survey

Marine conservation education is currently a highly significant tool in combating the escalating threats to coastal and marine ecosystems. The importance of educational activities, in particular those involving work with young learners, has been demonstrated to improve ocean literacy, environmental attitudes, and activities oriented towards conservation. The role of organized and practical learning interventions in enhancing knowledge of marine ecosystems and interest in conservation

work among students remains an important topic in the literature on this topic in different geographical settings.

A number of studies have highlighted the usefulness of the integrated educational programs in enhancing the knowledge as well as attitude towards marine conservation. As an example, intervention with Greek students indicated that organized programs related to coastal lagoons had a positive impact on ecological awareness and a positive attitude towards marine conservation in students (Kevrekidis *et al.*, 2024). Similarly, charismatic conservation education interventions involving sea turtles have shown positive outcomes in children's awareness and pro-conservation attitudes, notably via interactive and engaging pedagogy (Frame *et al.*, 2021). These results indicate that it is possible to develop emotional attachment to species-based and place-based education, which has no monetary value in changing behavior in the long term.

Ocean literacy has been mentioned among other factors that play a significant role in conservation behavior. Pro-environmental attitudes and behavior in a study carried out on a group of university students in China have been demonstrated to be directly impacted by a higher level of ocean literacy, indicating that knowledge is a predecessor of action (Wang *et al.*, 2025). In line with this, the reviews of various scholars worldwide have indicated that the perceptions about the ocean are usually low among the masses, and special educational treatment is needed to close the gaps to promote sustainable practices (Jefferson *et al.*, 2021).

Field-based or experience-based learning models, such as marine tourism and outdoor education programs, are becoming a growing focus of study in terms of the effect on conservation attitudes. While historical data emphasizes physical field-based learning, recent advancements suggest that digital "virtual experiences" can serve as a vital bridge when physical access is restricted (Hofman *et al.*, 2022; La Manna *et al.*, 2020). Community-based and extension programs are also significant alongside formal education as far as distributing marine conservation awareness is concerned. Decades-long projects involving Brazilian schoolchildren showed that the positive ecological awareness results would last even ten years, presenting the significance of constant involvement (Netto *et al.*, 2025). In the same way, the programs based on the combination of the local ecological knowledge with problem-based learning and teaching methods proved to be efficient in empowering the conservation attitudes of students through the approach of making the learning process more relevant and culturally rooted (Damopolii *et al.*, 2024).

The Mangrove and coastal ecosystem education programs have also yielded positive results in the students' comprehension and attitude towards conservation. An investigation conducted in Malaysia and China found that educational interventions that target educational awareness of students positively affected their understanding of the ecological significance of mangroves (Kamaludin *et al.*, 2022). In addition, environmental education is a powerful

shaper of community attitudes to conservation, including in mangrove conservation and marine recreationists (Jadin and Rousseau, 2022).

Young people are the central aspect in studies where it is noted that their views of marine problems, including the problem of marine debris, are formed by formal and informal learning (Canosa *et al.*, 2021). Additionally, the socio-cultural and geographical environmental factors may influence the problem of environmental concern and attitude towards marine life, and the fact that the education strategies must be context-dependent means that they should be context-specific (Chen and Martens, 2023). Voluntary conservation programs also mean that personal values, motivation, and personal engagement are critical to sustaining conservation practices (Shum *et al.*, 2023).

Though the body of research is increasing, more complex frameworks need to be introduced to combine interactive, experiential, and community-based methods of learning. Recent research presents the concept of outdoor environmental education as a nature-based approach, which can solve educational and environmental issues simultaneously, especially in coastal communities (Hsu, 2025). These methods work very well in coordinating with interactive marine wildlife programs that are a combination of direct learning, emotional involvement, and knowledge learning, which can impact conservation attitude.

In general, the literature suggests that the interactive and experiential types of marine education programs are very successful in promoting knowledge,

attitude, and behavior of students in regard to conservation. Nonetheless, there are still missing links in determining how such programs affect the community in the long run, particularly in the context of varied coastal communities. This shows the need to conduct additional research on interactive marine wildlife programs and how they can help in ensuring the practice of sustainable conservation attitudes among the students.

Methodology

Research Design

The research design adopted in this study is the mixed-methods quasi-experimental research design involving an online pre-test: the pre-test involves administering an online questionnaire to participants before the implementation of the programme to assess the pre-test results on the student conservation attitudes. The design will integrate a quantitative method of analysis of survey results with a qualitative method of interpreting the responses given by the participants to give a complete picture of the cognitive and behavioral changes. The quasi-experimental method will be suitable in this case because it will enable the evaluation of the effects of interventions in actual educational conditions without the possibility of random assignment.

Study Population and Sampling Technique

The population under study will be composed of school students between the ages of 10 and 16 years and located in coastal areas. The recruiting methods used are online sources, such as school networks, educational forums, and online outreach to recruit participants. A

stratified random sampling method is used to guarantee equal representation of the age groups, gender, and academic levels. The initial sample size was 210 students, of which 198 completed both the pre-test and post-test surveys, resulting in a high retention rate of 94.3%. The final sample ($n=198$) was distributed across three age groups like 10-12 years, 13-14 years, 15-16 years.

It is a large population such that the Cochran formula is used to find the sample size:

$$n_0 = \frac{Z^2 \cdot p \cdot (1 - p)}{e^2} \quad (1)$$

In equation (1), n_0 is the original sample size, Z is the Z -score at the desired level of confidence, p is the proportion in the population being estimated, and e is the margin of error. In the case of finite populations, the sample size is compensated to increase the level of accuracy:

$$n = \frac{n_0}{1 + \frac{(n_0 - 1)}{N}} \quad (2)$$

Equation (2) ensures statistical adequacy and representativeness of the sample.

Intervention Design

The intervention is an online, two-to-four-week interactive learning program focused on marine wildlife. The program will integrate face-to-face expert classes, computer simulations, taped examples of marine ecosystems, and interactive learning courses that will help reinforce ocean literacy and ocean conservation awareness. Digitally interactive, the content is crafted to promulgate an experiential learning experience through establishing an emotional connection or a cognitive understanding of marine biodiversity and conservation issues.

Data Collection Procedure

The entire data collection is carried out using online questionnaires specifically designed for the target demographic of school students (ages 10–16). At first, baseline knowledge and conservation attitudes of the participants are tested with the use of a pre-test questionnaire. After the educational intervention is complete, a post-test is done on the same instrument, which is used to assess changes in responses. Also, open-ended questions are used to gather qualitative data to include the perceptions, thoughts, and experiences of the participants. The online structure provides access and scalability as well as effective data management.

Measurement of Variables

The knowledge score that measures marine knowledge is defined as the ratio of the correct responses to the total number of questions. An attitude score that uses a Likert scale measures conservation attitudes based on the mean of item responses. These measures will offer uniform measures of comparison of pre- and post-intervention results and the success of the program.

Reliability and Validity

The internal consistency of the attitude scale is assessed using Cronbach's alpha:

$$\alpha = \frac{k}{k - 1} \left(1 - \frac{\sum \sigma_i^2}{\sigma_t^2} \right) \quad (3)$$

In equation (3), where k is the number of items, σ_i^2 is the variance of a single item, and σ_t^2 is the total variance. The reliability consideration is to have a value of 0.7 or more. Expert evaluation of the questionnaire guarantees content validity, and the support of construct validity is guaranteed by the adaptation of the developed instruments to the marine

studies of the education conducted in the past.

Data Analysis Techniques

Quantitative data are processed with the help of statistical software to provide descriptive and inferential statistics. The data are summarized with the help of mean and standard Deviation, and a paired sample t-test is employed to identify the importance of differences between the pre-test and post-test scores:

$$t = \frac{\bar{d}}{s_d/\sqrt{n}} \quad (4)$$

The variables used in equation (4) are \bar{d} , the mean difference between paired observations, S_d , the standard Deviation of differences, and n , the sample size. The effect size is also determined to measure the amount of change that occurred, and the regression analysis is carried out to examine how the knowledge gain is related to the change in conservation attitudes. In order to analyze qualitative statistics, the thematic analysis is used to identify the frequent trends and learnings about the student engagement and perception change.

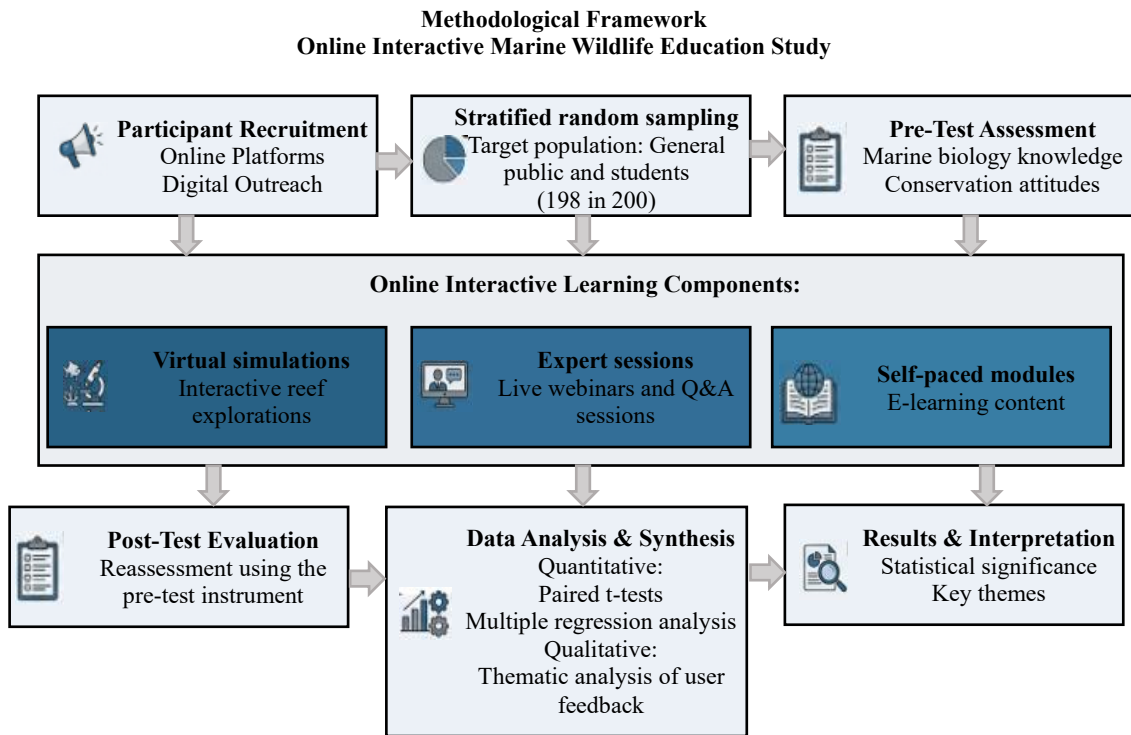


Figure 1: Methodological framework of the online interactive marine wildlife education study.

The figure 1 displays the general workflow of the study methodology, involving the recruitment of the participants, sampling approach, pre-test, online interactive intervention implementation, post-test evaluation, and data analysis processes. It visually displays the adoption of the quantitative and the qualitative methods in a

quasi-experimental pre-test-post-test design.

Ethical Considerations

Upon the study, ethical approval is obtained, and informed consent is taken digitally among the study participants and their guardians. Confidentiality and anonymity are maintained in the research process with the assistance of safe data storage and the lack of personally

identifiable information. Participation is voluntary, and respondents are allowed to withdraw at any stage without any consequences.

Limitations and Bias Control

There is an attempt to reduce the risks of possible biases related to online data collection through randomized order of presentation of questions, attention-check questions, and validation of responses. These have been used, but limitations such as self-report bias and access differences to digital resources are identified, and their potential influence on the outcome of the study is considered in the analysis.

Results

Participant Characteristics

The overall sample size was 210 students, with 198 of them completing the pre-test and post-test survey, giving a retention rate of 94.3% of the total population. They classified them into three age groups, including: 10-12 years (34.8%), 13-14 years (33.3%), and 15-16 years (31.9%). There was a relatively equal distribution of gender; 51.5 percent of the respondents were male, and 48.5 percent

were female. The majority of the respondents have been exposed to some form of basic environmental education, but only 27.2% of the respondents knew anything about marine ecosystems.

Pre-test and Post-test Knowledge Scores

The comparison of pre-test and post-test knowledge scores revealed a substantial improvement following participation in the online interactive marine wildlife program. The mean knowledge score increased from 46.2% (± 10.5) in the pre-test to 78.6% (± 9.2) in the post-test, indicating a significant enhancement in students' understanding of marine biodiversity and conservation concepts.

Comparison of the knowledge rating between pre-test and post-test showed that there was a significant increase in knowledge after attending the online interactive marine wildlife program. The average level of knowledge rose to 78.6% (± 9.2) in the post-test as compared to the pre-test of 46.2% (± 10.5), and this is a significant improvement in the knowledge of the students concerning the concepts of marine biodiversity and conservation.

Table 1: Comparison of knowledge scores before and after intervention.

Measure	Mean (%)	Standard Deviation (\pm)	t-value	p-value
Pre-test	46.2	10.5		
Post-test	78.6	9.2	24.87	<0.001

The table 1 will show the comparison of the knowledge scores of students prior to and after the intervention. The post-test improved significantly in the mean score as compared to the pre-test, which was 46.2% (± 10.5), leaving behind the mark of 78.6% (± 9.2). The t-value (24.87) and statistically significant p-value ($p < 0.001$) confirm that this difference is significantly high. In general, the findings indicate that the online

interactive marine wildlife initiative was very efficient in improving the knowledge of students.

Changes in Conservation Attitudes

The conservation attitudes of students significantly changed towards being positive following the intervention. The general attitude measurement score rose by a pre-test score of 3.12 (± 0.58) to a post-test score of 4.08 (± 0.47) on a

5-point Likert scale. This increase indicates better environmental interest, the desire to take up conservation

activities, and the emotional attachment to marine life.

Table 2: Changes in conservation attitude scores.

Measure	Mean Score	Standard Deviation (±)	t-value	p-value
Pre-test	3.12	0.58		
Post-test	4.08	0.47	18.63	<0.001

The changes in the scores of conservation attitude in students prior to and after the program are indicated in table 2. An improvement of a clear nature in attitudes was seen in the mean score of 3.12 (±0.58) in the pre-test, and 4.08 (±0.47) in the post-test. The t-value (18.63) and the statistically significant

p-value ($p < 0.001$) validate that this is not a result of chance. On the whole, the findings indicate that the program was very successful in creating a positive impact on the conservation attitudes of the students with regard to marine environmental protection.

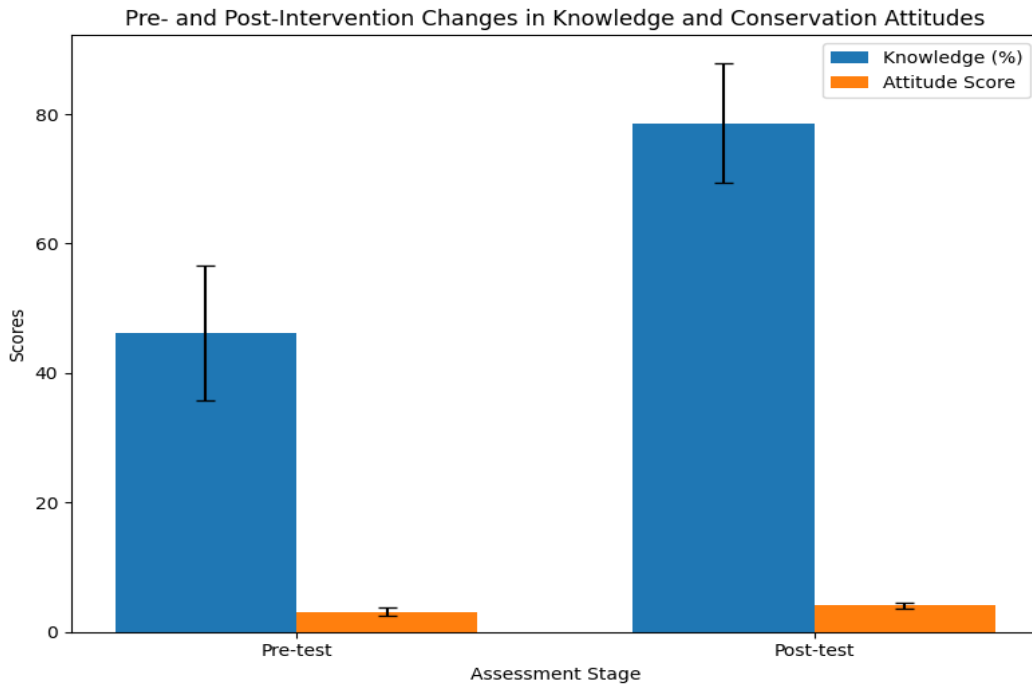


Figure 2: Pre- and post-intervention comparison of knowledge and conservation attitude scores.

The comparison of the scores of knowledge and conservation attitude of students with respect to pre-intervention and post-intervention is shown in figure 2. They both have significant improvement in their post-test values, with a significant improvement after the program. The error bars are the standard Deviation, which points out the disparity in the responses of the participants.

Effect Size of the Intervention

Cohen's d was used to determine the extent of the impact of the intervention. Knowledge improvement effect size was determined as 1.85, and attitude change effect size was 1.42. These values represent a high impact, and they prove that the program had a strong practical influence on both cognitive and affective learning outcomes.

Relationship Between Knowledge Gain and Attitude Change

The regression study found that there was a positive correlation between the increase in knowledge and alterations in conservation attitudes. The model

displayed that knowledge gain was a significant predictor of attitude gain ($R^2 = 0.62$, $p < 0.001$), with the positive result meaning that more knowledge on the marine ecosystems led to more positive conservation attitudes in the students.

Table 3: Regression analysis of knowledge and attitude change.

Variable	β Coefficient	Standard Error	t-value	p-value
Knowledge Gain	0.68	0.07	9.71	<0.001
Constant	1.12	0.21	5.33	<0.001

The table 3 shows the outcomes of the regression analysis of the relationship between the increase in knowledge and the shift in conservation attitudes. The results show that knowledge improvement has a significant and positive impact on attitude improvement, which is statistically significant ($\beta = 0.68$, $p < 0.001$). This indicates that the more students acquired information on marine ecosystems, the more chances they had to

attain positive conservation attitudes. The model describes a significant amount of the variation in change of attitude ($R^2 = 0.62$), and the role of interventions based on education in the formation of the environmental outlooks. The constant value is also noteworthy ($p < 0.001$), as it shows that there is an underlying level of attitude change that occurs without knowledge acquisition.

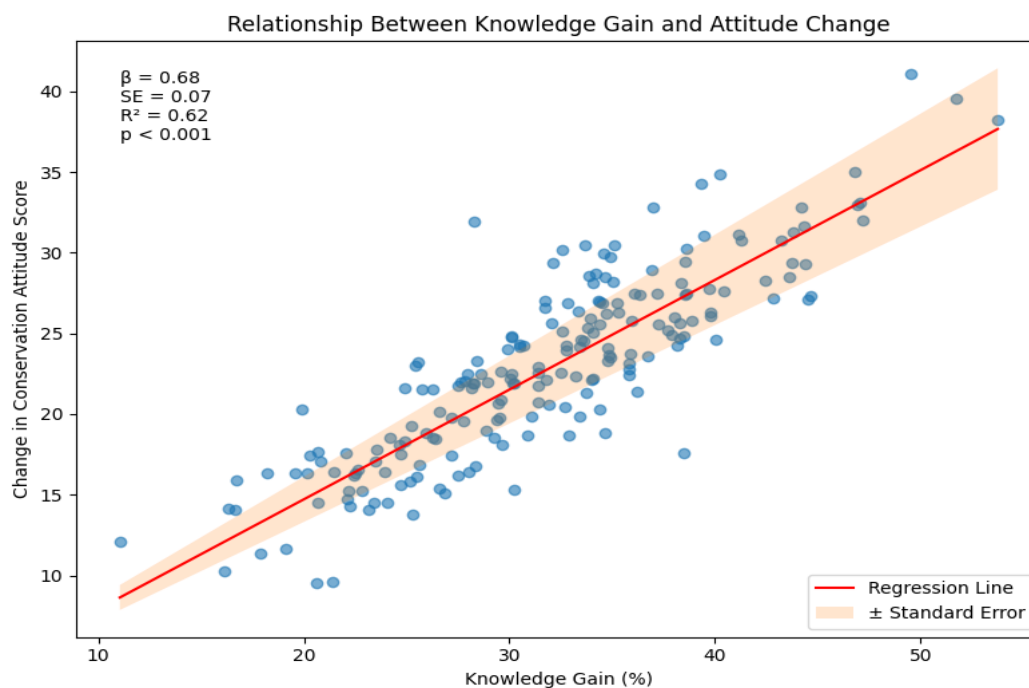


Figure 3: Relationship between knowledge gain and change in conservation attitudes.

The figure 3 depicts the positive correlation between the increase in knowledge among the students and the change in conservation attitudes after the

intervention. The regression line indicates that higher knowledge improvement is associated with greater enhancement in conservation attitudes,

while the shaded region represents the standard error, reflecting the reliability of the model estimate ($R^2 = 0.62$, $p < 0.001$).

Qualitative Insights from Participants

Open-ended responses identified via qualitative analysis yielded a number of common themes associated with the learning experience of students. The participants regularly reported that they had become more aware of marine biodiversity, that they had been able to develop a stronger emotional connection to marine organisms, and that they had become more responsible for protecting the environment. Many students discussed the interactive parts of the programs, such as virtual simulators and live classes, and the majority of them reported that they became more engaged and remembered these parts better. Furthermore, a number of the interviewees mentioned that they would be receptive to the idea of going green, such as reducing plastic use and raising awareness in their communities.

Overall Program Effectiveness

Both the quantitative and the qualitative results show that the online interactive marine wildlife program was quite effective in enhancing the level of knowledge in the students and their attitude towards conservation. All the statistically significant improvement increments, the substantial effect sizes, and the positive participant comments all indicate that interactive and experiential pedagogical approaches, even in a virtual setting, may play a crucial role in spreading knowledge about marine conservation to coastal populations.

Discussion

This study demonstrated that students who participated in the online interactive

marine wildlife program had made significant knowledge and conservation attitude gains. The mean knowledge score (46.2% (± 10.5) to 78.6% (± 9.2)) and conservation attitude scores (3.12 (± 0.58) to 4.08 (± 0.47)) were increased. They were statistically different ($p < 0.001$), and t-values were high (24.87 and 18.63, respectively). The magnitude of effects of the intervention was also large (Cohen's $d = 1.85$ in knowledge and 1.42 in attitudes), which implies that the practical effect is high. Moreover, the regression analysis revealed that there was a strong positive correlation between knowledge gain and attitude change ($\beta = 0.68$, $R^2 = 0.62$, $p < 0.001$). My findings suggest that an online learning approach based on an interactive and experiential methodology is rather effective in enhancing cognitive and affective learning regarding marine conservation. The correlation between the knowledge acquisition and the attitude change is high and proves that the more a person is informed about the marine ecosystems, the more he or she appreciates the environment. This supports the fact that learning is a crucial parameter in determining pro-environmental behavior, particularly when taught in appealing and interactive methods. These results highlight the potential of online learning websites to create environmental awareness and marine conservation, which could be used especially in coastal communities. Such large effect sizes suggest that this type of program is capable of producing significant educational results in quite a limited period of time. This can be significant to policymakers, educators, and conservation agencies aiming to identify scalable and cost-effective ways of instilling environmental stewardship in young learners. However, despite these

good results, there are limitations with this study. Depending on self-reported data could be associated with a bias in responses, and a completely randomized control group should be considered to make a causal conclusion. Access to digital resources may have also contributed to the participation of the participants. Longitudinal designs should be used in the future to determine the long-term effects of such interventions on behavior. Causal conclusions would be strengthened with the inclusion of a randomized control group. It is also possible that further studies can be conducted with the aim of incorporating a sophisticated technology like virtual reality to make it more engaging. It would be better to generalize the study to other geographical areas and socio-economic groups, and real-time behavioral data would help gain further insight into real conservation activities.

Conclusion

This research was in response to a necessity to determine the effectiveness of online interactive marine wildlife programs in enhancing the level of knowledge and conservation attitudes among students, especially in coastal communities where there is a high level of environmental awareness. Using a quasi-experimental pre-test- post-test design, the research question sought to identify whether digital, experiential learning methods had any statistically significant effect on cognitive and behavioral aspects of environmental education. The findings are clear in demonstrating that the intervention was highly effective. The knowledge of students also increased significantly, 46.2% (± 10.5) to 78.6% (± 9.2), and the conservation attitude score also went up, from 3.12 (± 0.58) to 4.08 (± 0.47). These

improvements were statistically significant ($p < 0.001$) and were supported by large t-values. Besides, the effect sizes (Cohen's $d = 1.85$ and 1.42 , respectively) are too high, which implies the effect is very realistic. Regression analysis also revealed that the knowledge gain was strongly correlated with attitude change ($\beta = 0.68$, $R^2 = 0.62$), which confirms the substantial influence of knowledge on the attitude change. Overall, the study brings to light the fact that interactive digitally-based educational programs could be successfully applied to increase the level of marine conservation awareness and provide a positive change in the attitude of the students. These lessons include the requirement to integrate the application of experiential learning techniques, such as simulations and expert interactions, to improve engagement and learning outcomes. To further enhance learning activities, future research should consider long-term behavioral influences, the use of a more diverse group of people, and the use of new and enhanced technology, such as virtual or augmented reality. The possibility of increasing such programs on a grand scale might be crucial to ensuring sustainable environmental practices and conservation awareness in many countries around the world.

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