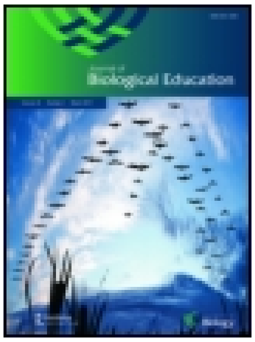

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Using ethological techniques and place-based pedagogy to develop science literacy in Hawaiʻi's high school students

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ABSTRACT

This high school-level, place-based, inquiry-driven laboratory module familiarises students with techniques used to analyse animal behaviour while facilitating the development of the observational skills highlighted by the Next Generation Science Standards (NGSS). Throughout the module, students observe, quantify, and discuss local invertebrate behaviours in the classroom. While field-testing the module with Hawai'i high school students, we administered anonymous, online surveys before and after participation to examine whether the use of animals and language from the local environment and cultural landscape unique to Hawai'i helped to connect students with the ecology surrounding them and emphasise the relevancy of scientific observations beyond the classroom. Survey responses indicated increased content understanding, increased confidence in scientific skills, and more positive attitudes towards marine science among participants. Utilising ethological techniques within a place-based framework provides an adaptable platform for students in any location to develop the science literacy skills at the core of NGSS.

KEYWORDS

Animal behaviour; place-based education; hypothesis testing; experimental design; authentic scientific inquiry; experiential learning; student-centred; NGSS

Introduction

The combined abilities to notice details, recognise patterns, or communicate clearly are critical for developing scientific literacy. Although applicable to almost any discipline, these skills are heavily featured in the Next Generation Science Standards (NGSS). The NGSS are research-based K-12 science content standards that seek to help students develop 'an in-depth understanding of content and develop key skills – communication, collaboration, inquiry, problem solving, and flexibility' (www.nextgenscience.org). As of November 2019, '20 states and the District of Columbia (representing over 36% of the students in the U.S.) have adopted the [NGSS] and are working to implement them in districts and schools' (ngss.nsta.org). Our programme in the State of Hawai'i is located among these participating states, where the Hawai'i Board of Education (HI BOE) has required all of its public schools to fully implement the NGSS by the 2019–20 school year (Hawai'i State Department of Education, 2016). Further, in collaboration with the Hawai'i State Department of Education (HI DOE), the HI BOE also seeks to integrate local curricula with 'uniquely Hawaiian values and sense of place' (www.hawaiiplublicschools.org), creating in 2015 an Office of Hawaiian Education and system-wide educational framework that honours the qualities and values of the Hawaiian language and culture while maintaining inclusivity of all cultures. Here, we report the use of a NGSS-compliant curriculum that utilises place-based pedagogy within a Hawaiian cultural framework.

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Place-based education (PBE) is a pedagogical approach that deliberately integrates place as a multidimensional construct within a curriculum (Gruenewald, 2003). PBE has been described as 'education grounded in local phenomenon' (Samaniego 2012, 3), and an experiential and interdisciplinary way of learning (Semken and Freeman 2008). Some scientific content areas, such as biology, ecology, or environmental science, present an easy platform for integrating place-based pedagogy with rigorous scientific methodology. Our programme has developed several place-based marine science modules which emphasise ecological relationships, biological processes, and anthropogenic effects (Fox et al. 2013; Gorospe et al. 2013; Haverkort-Yeh et al. 2013; Tamaru et al. 2014). All of our modules emphasise NGSS Science and Engineering Practices (e.g., Analysing and Interpreting Data), Crosscutting Concepts (e.g., Cause and Effect), as well as Disciplinary Core Ideas specific to the content of each module (e.g., the physics of marine bioacoustics to illustrate DCI LS4.A: Wave Properties). Ethology (the study of animal behaviour) provides the methodological framework for the module we describe here and presents a useful platform for students to hone their observational and data-taking skills while employing both qualitative and quantitative research methods. The module utilises the same observational and data collection techniques used by scientific researchers to examine animal behaviour in diverse marine systems ranging from: scalloped hammerhead sensory transduction (Ambrosino, 2012), elasmobranch foraging in a magnetic field (Hutchinson et al., 2012), and marine mammal auditory perception (Au, 2014).

Our laboratory classroom, located on a small offshore island within a bay on O'ahu, Hawai'i, is surrounded by a protected tropical coral reef ecosystem that provides a home for many marine animals considered economically and culturally important to the Hawaiian people. In 2018, our research unit also became the lead agency for the most recently established National Estuarine Research Reserve (NERR), collaborating on research and education efforts with the numerous community partners to integrate traditional and contemporary strategies to sustainably manage the estuary. Our state-of-the-art facilities combined with an unique location, close proximity to estuarine, coastal and offshore environments, and connection to numerous watersheds, promotes the integration of cutting-edge laboratory experimentation, rigorous fieldwork, Hawaiian natural history and science education that is unparalleled by other marine science research institutes. While referencing perceptual, sociological, ideological, political, and ecological experiences, PBE has the capacity to give a voice to colonised lands and peoples, and has thus provided a platform for developing indigenous education frameworks such as those found in Hawai'i (Kana'iaupuni and Kawai'ae'a 2008). Native Hawaiian students face high rates of attrition and low representation in STEM (science, technology, engineering, and maths) academic and career pathways, but PBE that is culturally grounded, relevant, responsible, and sustainable helps to empower these underrepresented students (Kana'iaupuni and Kawai'ae'a 2008). With such a unique setting, we strive to incorporate place-based pedagogies to better engage our local students, a large proportion of whom are Native Hawaiian, Filipino and other Pacific Islanders, ethnicities underrepresented in STEM fields. The study of animal behaviour provides ubiquitous opportunities to students in any location for developing observational skills and teaching students to think critically about their environments.

In accordance with an emphasis on place-based education (PBE), the main organism we use for observation is an endemic Hawaiian animal, the Hawaiian bobtail squid, or *Euprymna scolopes*, although the concepts and methods described here can easily be adapted to other locally available organisms. Beyond using a Hawaiian animal, the use of a cephalopod has further connections to our facility's location within the He'eia *ahupua'a* (Hawaiian land division). *He'e* (squid) feature in many *ōlelo no'eau* (Hawaiian proverbial sayings), the name He'eia may refer to the abundance of *he'e* in our bay, and a kraken-type creature is said to have lived in the waters surrounding our classroom. Most research on *E. scolopes* focuses on its unique symbiosis with a bioluminescent bacterium (e.g., Boettcher, Ruby, and McFall-Ngai 1995; Lee et al. 2009), but like the closely-related cuttlefish, *E. scolopes* is easily housed in aquaria and has a repertoire of complex behaviours making it an ideal organism for behavioural study (Huffard 2013). In preparation for their laboratory activity, students practice creating ethograms (behavioural inventories) and observe and describe simple animal behaviours. While visiting our facilities, the students use frame-by-frame digital video analysis to quantify the activity of *E. scolopes* in controlled laboratory settings.

Here, we describe the module wherein students participate in several NGSS Science and Engineering Practices: 1) planning and carrying out investigations, 2) analysing and interpreting data, and 3) obtaining, evaluating, and communicating information. The module also incorporates NGSS Disciplinary Core Ideas (LS2.D: Social Interactions and Group, LS4.C: Adaptation, LS1.A: Structure and Function, and HS-LS2-8 Ecosystems: Interactions, Energy, and Dynamics) and Crosscutting Concepts such as the recognition of patterns within a biological system. A detailed list of relevant standards is available in the Appendix.

The primary objective in developing this module was to provide a unique scientific inquiry experience that was place-based and culturally framed, one that Hawai'i students would be more prone to engage in relative to a standard textbook lab on ethology. However, the delivery of the module during student field testing also afforded us to explore questions as to whether the experience with culturally significant animals and language unique to the Hawaiian Islands would affect participant attitude and content understanding. Thus, we also describe the results from questionnaires administered before and during the module for examining student understanding of content and attitudes towards marine science.

Materials and methods

There are three main components in this laboratory module: (1) background reading, classroom lecture, and preparatory observations, (2) recording and analysing data, (3) discussion, and scientific writing. To assess student content understanding, attitudes towards marine science, and feedback on the overall experience, we also administered a brief (12 question), anonymous, online survey before and after participation in the module via i> clickers®. We present a summarised form of the module components here. Although originally designed for high school students and an endemic Hawaiian organism, we have successfully adapted this laboratory for use with middle school students, undergraduate and graduate students, as well as for use in teacher professional development workshops and utilising a variety of locally sources organisms.

Component 1: background reading, classroom lecture and preparatory observations

The NGSS framework encourages the use of phenomena to drive student learning through science lessons. Thus, during the first part of this module, students are introduced to the scientific study of animal behaviour and learn pertinent ethological vocabulary through discussion of the anchor phenomenon: a short, slow-motion video of a sepiolid hunting. The full lesson plan also includes descriptions of the techniques ethologists use to describe and quantify behavioural data and examples from the research currently conducted by scientists at our facilities. To practice making behavioural observations, the teacher may lead students in the simple example activities listed in the lesson plan to the behaviours of readily available animal subjects (e.g., birds, crickets, etc.).

After grounding students with a discussion about our location within the Native Hawaiian land division system (including a *mo'olelo* (story) about how our *ahupua'a* (land division) is named after a cephalopod), a brief introduction to *E. scolopes* biology and behaviour is included to familiarise the students with our model organism. In order to guide their research design, students conduct a literature search on their specific animal subject chosen for laboratory observations to become familiar with the commonly described behaviours or previously recorded research. To further assist in discussions about ethological concepts and the students' literature review of the animal subject, we also utilise the following guiding questions:

- Can the squid learn over time? Will its reaction time to the same stimulus get faster and faster?
- How can you determine if a behaviour is defensive or aggressive?

- Will all animals react to the same stimulus the same way? Will one animal react the same way in each experiment? How might size of the animal affect burying or hunting rates and success?
- What senses are most important to nocturnal animals, like the bobtail squid? How can you determine if the squid is aware of changes to its environment?
- What factors might influence the squid to change the colour of its chromatophores, or to use its light organ?
- Do squid see the same colours that humans can?

Component 2: recording and analysing data

The second component of this module consists of hands-on science activities that allow students the flexibility to design their own research questions and experimental framework, then collect data, and analyse their results. This is a teacher-guided process and resulting experiments are highly variable; some students will come up with very simple research questions and experimental designs, while others maybe more sophisticated or complex.

To better engage our target students, the lesson we teach at our facilities centres around *E. scolopes*, an organism endemic to the Hawaiian Islands. However, as these observational techniques may be applied to any organism, teachers are encouraged to adapt the module by using another easily obtained, unregulated invertebrate (e.g., the house cricket, *Acheta domesticus*). If we are unable to collect *E. scolopes* due to weather conditions, we simply substitute small shrimp, crabs, brittle stars, etc. to provide students an actively mobile subject.

During this activity, students should be divided into groups of about three or four students. This component is composed of four main tasks. Task 1 includes collection of the laboratory animals and is typically prepared by the instructor before class time. Tasks 2 through 4 focus on the students designing their observations, collecting their data, and analysing their results. Regardless of the complexity of the research questions students devise, the materials below are generally needed for all experiments.

Animal collection and housing materials

Euprymna scolopes

- 2.5-gallon or partitioned 5-gallon glass aquaria
- Small nets
- Live shrimp or crabs
- Black plastic mesh

Laboratory or classroom materials

- Pen/pencil
- Paper/notebook
- 500 mL beakers
- Varieties of aquarium rocks/sand
- Live shrimp and dried shrimp or fish food (or appropriate food for study organism)
- Rulers
- Laptops
- Digital cameras with camcorder function (e.g., Olympus TG-830 HIS Digital Camera)
- QuickTime Player software (Apple Inc., Version 10.5 (935.3))
- Image-analysis software (e.g., ImageJ or Fiji (imagej.net))

Task 1 – Collection of animals for observation

Because *E. scolopes* are nocturnal and need time to adjust to laboratory aquaria, our instructors collect the animals approximately two weeks before the students arrive. The animals are collected in shallow, calm water over sandy substrates about an hour after sunset. Flashlights are used to attract plankton, which in turn attract *E. scolopes*. Once spotted, the animals are gently scooped up with small hand nets into a bucket for transportation to the laboratory classroom. Once in the classroom, the squid are individually housed (to prevent mating and/or fighting) in 2.5 or 5 gallon aquaria with electric filter systems. Larger aquaria are partitioned with black mesh to prevent animal interactions before experimental observations. The animals are fed small crabs and shrimp to satiation daily.

Task 2 – Student experiment design

Before selecting their animal for observation, the student groups discuss and write down their observational experimental design. We guide the students towards appropriate stimuli to use in their observations and give examples of the types of behaviours they might witness (such as burying or feeding behaviours, which *E. scolopes* readily demonstrate). If inclement weather or uncooperative organisms prevent the use *E. scolopes* for observation, we have also successfully utilised small shrimp, crabs, sea cucumbers, file clams, or other small marine invertebrates. When choosing a subject for observation, students should keep in mind the relative complexity of the animal's nervous system. A sepiolid such as *E. scolopes* with a highly organised central nervous system will display more multifaceted behaviours (e.g., hunting behaviour incorporating colour change, orientation, approach-attack-capture motor patterns). An echinoderm such as a sea cucumber with a loosely organised nerve net may demonstrate simplified behaviours or reflexes such as directional response to light or contracting feeding tentacles when touched. However, behaviours should not be undervalued based on perceived complexity – students should bear in mind that classic neurological concepts were developed by observing the limited reflexes of 'simple' invertebrates (e.g., Mpistos and Collins 1975).

Some examples of previous student designs include feeding the animal, placing *E. scolopes* over different coloured or textured substrates, placing two *E. scolopes* in a tank able to view each other through a plastic barrier, etc. An example research design might include:

- Five minutes acclimation
- One minute observation of *E. scolopes* at rest
- One minute observation after introduction of *Palaemon debilis* (feeble shrimp)
- One minute observation of *E. scolopes* at rest or feeding
- One minute observation after introduction of second *P. debilis*
- One minute observation of *E. scolopes* at rest or feeding

The students may also attempt to sex their squid by looking for the presence or absence of the hectocotylus, a specialised arm used by males to transfer sperm packets to females (Figure 1). Although a specific species might have a typical behavioural repertoire, there are often behavioural differences between individuals, between sexes, or between size classes.

While conducting these experiments, students should be shown how to treat their test subjects with care and respect, as a professional researcher would do. We remind the students that respect for non-human animals is also emphasised in Hawaiian culture. Students should take care not to assign anthropomorphic traits to the animals (e.g., the shrimp is hiding because he is 'scared'). If an animal appears to be in distress (e.g., frantic swimming, inking, etc.), the instructor should pause the activity to allow the animal to rest, or stop the experiment entirely. Another important lesson for students is that they will get their best behavioural data from non-stressed and healthy animals.

Task 3 – Collection of data: digital video recording

Once they have developed their experimental design, the students choose their animal and set up digital cameras to begin recording their animal's behaviour. *E. scolopes* are transported to observation tanks in 500 mL beakers and allowed to acclimate for at least five minutes before observations begin. Students should only record about five minutes of digital video, or else they will face tedious video analysis afterwards. We encourage our students to be respectful of their colleagues and their experiments by remaining as quiet as possible while recording is happening in the classroom. Extra

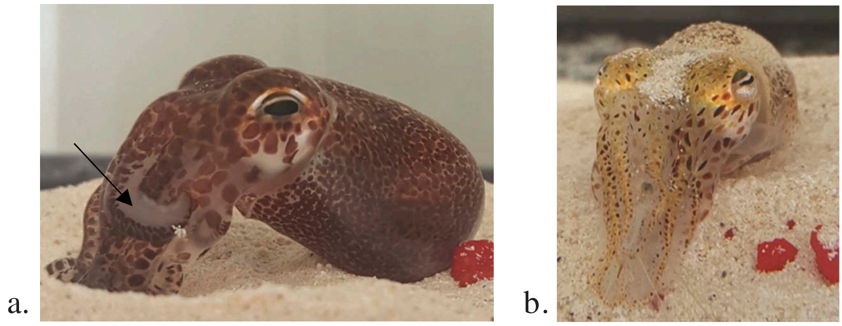

Figure 1. Images of male (a) and female (b) *Euprymna scolopes*. Note the prominent hectocotylus of the male sepiolid highlighted by the black arrow. Interindividual colouration should not be used to differentiate organisms or sexes as each *E. scolopes* can shift from pale yellow-white to deep red by contracting or dilating its chromatophores. Photo credit: Kyle Landers.

Table 1. An example of a student ethogram of *E. scolopes* burying behaviour. Note that the description of behaviour does not include any emotional or conscious intent by the animal.

Phase	Behaviour	Description
Pre-Burying	Alert position	Stands on bottom substrate with its arms pointing vertically down, and resting top of mantle on substrate
	Resting position	Lays on bottom substrate with arms curled ventrolaterally, and resting mantle on substrate
Burying Phase 1	Push and rock (PnR)	Contracts and expands mantle to rock into substrate
Burying Phase 2	Arm sweeps	Uses two arms to gather sand and throw it on mantle; The arms work simultaneously, anterior to posterior
Post-Burying	Siphon blow	After burial, blows excess sand out of its siphon

movement or noise outside the aquaria might affect the animals' behaviour and distort any behavioural observations.

Task 4 – Video analysis and ethogram development

Once the students have completed recording their animals' behaviours, they download the digital video onto laptops for analysis. Using QuickTime (QuickTime Player, Version 10.4 (855)) or ImageJ (ImageJ 1.42q, (Rasband, n.d.)) for frame-by-frame analysis, students should be able to compose an ethogram and/or time budget of *E. scolopes'* behaviour (for an example ethogram, see Table 1; accompanying video of behaviour is available as an online supplement). An ethogram is a behavioural inventory used by animal behaviour scientists to categorise discrete behavioural quanta, similar to how an educational researcher might code instances of classroom behaviour. A time budget reports how long an animal spends doing a particular behaviour, which may give insights to the animals' trophic level or lifestyle.

Component 3: discussion and scientific writing

Communicating science effectively is a critical scientific literacy skill. Once the students have analysed their video data, instructors should lead a general discussion of the students' findings. Student groups may compare their observational data and note any similarities or differences they found. The observational research produced by this module should lead to the generation of additional research questions or hypotheses the students may wish to test. The instructor should note that the scientific method is based on a dynamic cycle of observing, questioning, and hypothesis-testing and does not necessarily end when the experiment ends. Unexpected or surprising results can facilitate discussion on how scientific knowledge is built upon evidence and open to change or revision (another NGSS Science and Engineering Practice).

After the class discussion, students should be encouraged to present their research in a written and/or oral lab report. The report should follow standard scientific formatting and include a title, introduction, materials and methods, results, and discussion sections. Ideas from students for integrating the laboratory content or methods in other subjects or beyond the classroom in their home communities should also be encouraged.

Results

In this paper we primarily sought to share a novel scientific inquiry idea with science educators who might adapt our module to their own settings and classrooms. However, during the development of this activity, we field tested the module with 10 classes comprising 197 students and took the opportunity to collect data on the students' experiences. To assess student gains in content understanding, opinions on developed scientific inquiry skills, and changes in attitudes towards marine science, we administered survey questions before and during the module using i> clickers®. We utilise this instrument to conduct student assessments due to the interactive, instant feedback that provides our instructors with real-time readings of student understanding and participation. Use of i>clickers® also allows our instructors to share results with students as part of a collaborative, group-learning process. We emphasise to the students that responses are anonymous to encourage honest answers for the evaluation questions. We also review the correct answers to each of the content questions to address any misunderstandings the students may have. Responses from the surveys reveal increased content understanding (Figure 2), increased self-reported confidence in hypothesis generation and testing (Figure 3), and more positive attitudes towards marine science (Figure 4) after participation in our module.

Discussion

The simple structure and interdisciplinary nature of this module has made it appealing to non-STEM teachers and STEM teachers alike. Although the animals used were wild-caught and untrained, the observations are not recorded in their native habitat, but rather in a controlled 'laboratory' environment (aquaria). However, the students are taught to use the same tools and techniques utilised by ethologists in the field to record, describe, and analyse animal behaviour. Observation and communication skills are critical for students of any subject, and scientific literacy is just one part of the general literacy spectrum. By learning to describe and quantify data, students also learn that science is flexible and that nature does not always fit into neat categories. For example, during the experiments, students may decide to change their focus from the behaviour of the hunting *E. scolopes* to the behaviour of the fleeing prey. The students, as scientists, have to take charge of their research and make determinations when collecting, analysing, and reporting their data. While any organism could be used for developing observational skills, our conscious decision to choose an animal unique to the Hawaiian environment aims to further engage students who might not otherwise be interested in participating in activities utilising unfamiliar Eurocentric or continental US models. Our instructors' connection with their local place and our model organism also transformed during the development of this module. In reviewing the literature on *E. scolopes*, and in talking with local fishermen and cultural practitioners, we could not find any cultural documents referencing this secretive sepiolid. In Hawai'i, there is an increasing effort to provide names to organisms which do not appear in historical literature, and we wanted to be part of this effort. We worked closely with Hawaiian language scholars to develop a name we felt was appropriate for this small organism which skilfully camouflages and can be difficult to find: *mūhe'e huna*, the hidden squid. With a meanginful Hawaiian name, we hope to emphasise the contribution *E. scolopes* has made to our educational and scientific endeavours, and to provide a cultural connection for our students.

Among those who visit our programme at our research institute, many are students from marginalised demographics who often lack confidence in their scientific literacy and some additional encouragement and guidance is needed to build their knowledge and skills. In our experience, these students will choose the path of least resistance and conduct the most simple and cursory

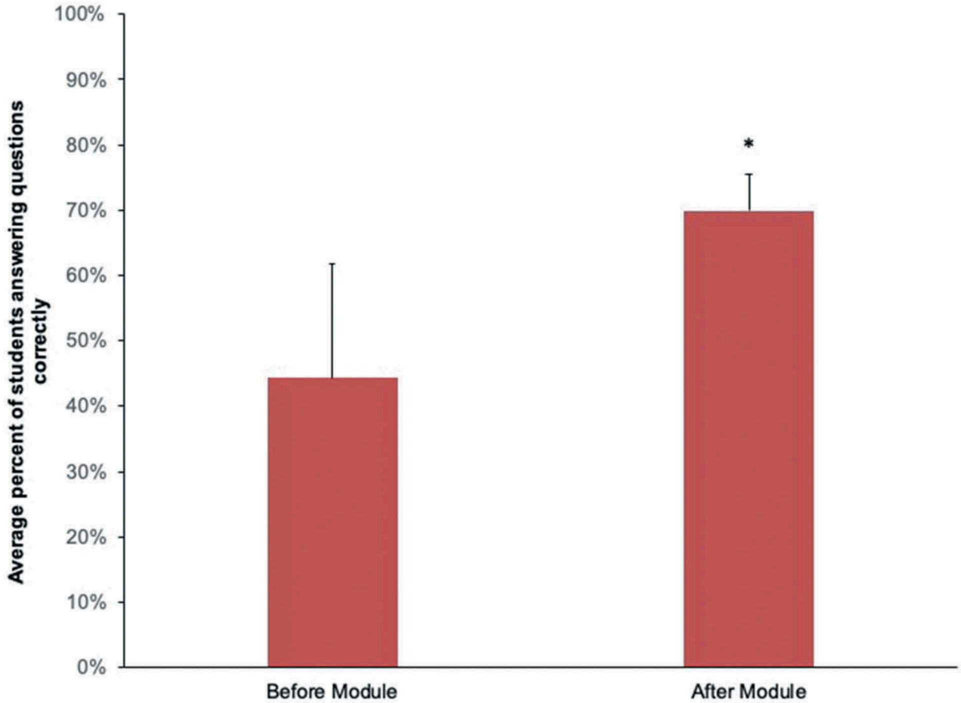

Figure 2. Graph showing student average correct response to i> clicker® content questionnaire before and after participation in the laboratory module. (N = 105; $p \leq 0.05$ for two-tailed, paired Student's t-Test).

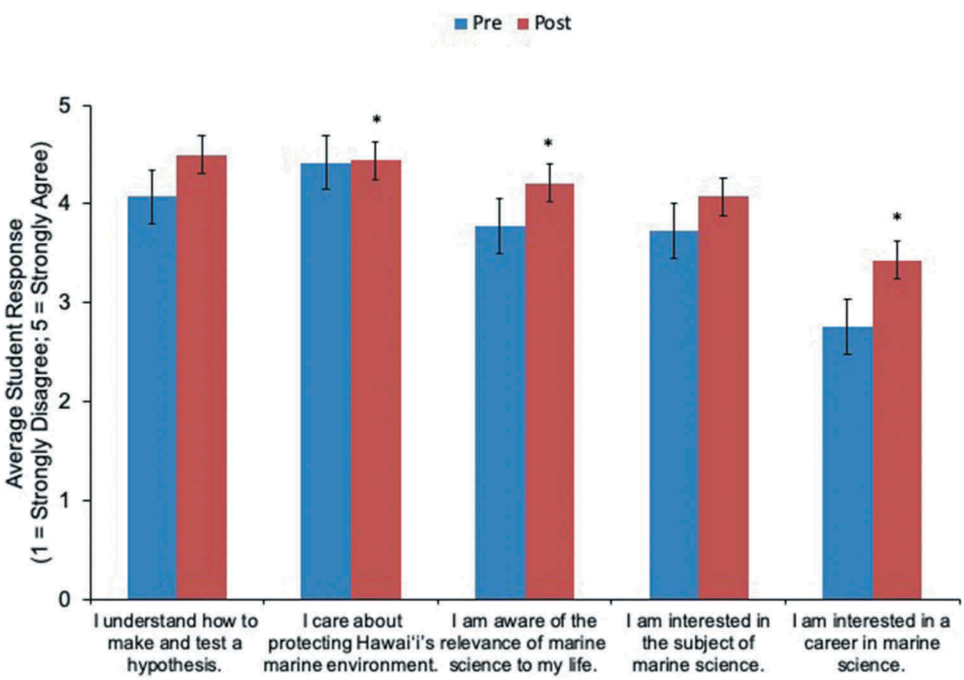

Figure 3. Graph comparing student responses from anonymous online survey before and after participation in module. Question responses were on a five (5)-point Likert-scale, with 1 = Strongly Disagree, 2 = Disagree, 3 = Unsure, 4 = Agree, 5 = Strongly Agree. (N = 74; asterisk indicates $p \leq 0.05$ for two-tailed, paired Student's t-Test).

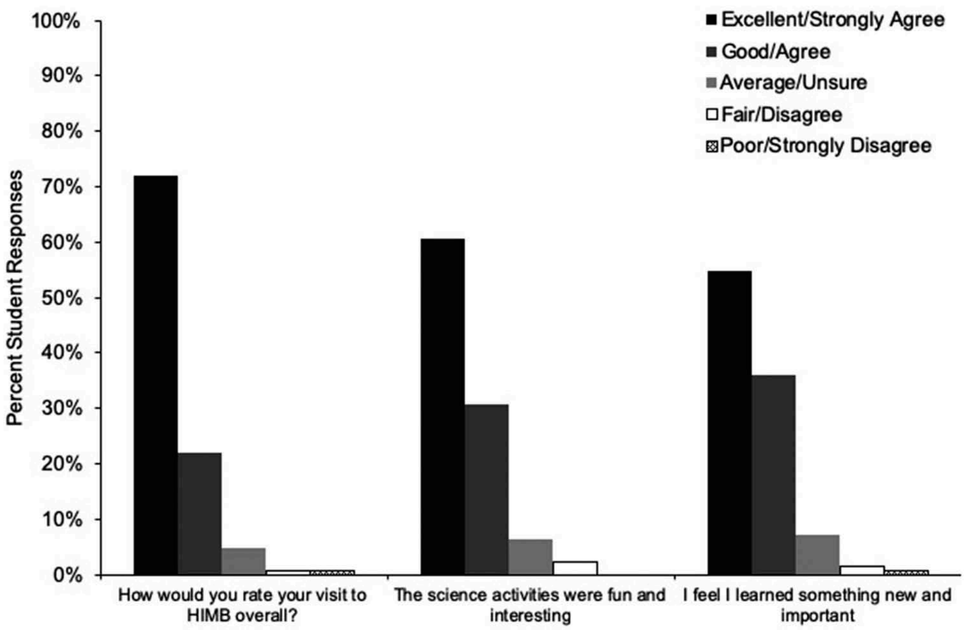

Figure 4. Graph showing student evaluations of the programme in anonymous online survey after participating in the laboratory module. (N = 74).

observations unless directed otherwise. We try to balance this need for guidance without being a 'cookbook' laboratory. We adjust our module to the needs of the individual classes in terms of the complexity of the research questions and experimental design that students devise during their visit, and we encourage teachers to adapt the module to fit their own classrooms as well.

The study of animal behaviour provides an ideal opportunity for students to develop the observational skills so important in scientific inquiry and highlighted in the NGSS. Although laboratory experiments allow the students to control the environmental conditions of their test animals for easy study, more complex observations can be made of animals in their natural environment. Animals found on school grounds, or in the students' backyards, are all fair game for ethological study. Using animals from their local environment should encourage students to think more critically about the behaviours and biological processes they experience every day.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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Appendix: relevant next generation science standards

Science and engineering practices

(1) Scientific Knowledge is Open to Revision in Light of New Evidence
  (a) Most scientific knowledge is quite durable, but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence.
(2) Engaging in Argument from Evidence
  (a) Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments.
(3) Analysing and Interpreting Data
  (a) Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.
(4) Obtaining, Evaluating, and Communicating Information
  (a) Communicate scientific information (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).
(5) Planning and Carrying Out Investigations
  (a) Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.

Connections to nature of science

(1) Scientific Investigations Use a Variety of Methods
    (a) Scientific inquiry is characterised by a common set of values that include: logical thinking, precision, open-mindedness, objectivity, scepticism, replicability of results, and honest and ethical reporting of findings.

Disciplinary core ideas

(2) LS2.D: Social Interactions and Group Behaviour
    (a) Group behaviour has evolved because membership can increase the chances of survival for individuals and their genetic relatives.
(3) LS4.C: Adaptation
    (a) Natural selection leads to adaptation, that is, to a population dominated by organisms that are anatomically, behaviourally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not.
(4) LS1.A: Structure and Function
    (a) Systems of specialised cells within organisms help them perform the essential functions of life.
(6) HS-LS2-8 Ecosystems: Interactions, Energy, and Dynamics
    (a) Evaluate the evidence for the role of group behaviour on individual and species' chances to survive and reproduce.
(7) HS-LS4-4 Biological Evolution: Unity and Diversity
    (a) Construct an explanation based on evidence for how natural selection leads to adaptation of populations.

Crosscutting concepts

(1) Stability and Change
    (a) Much of science deals with constructing explanations of how things change and how they remain stable.
(2) Cause and Effect
    (a) Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.
(3) Patterns
    (a) Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

Common core state standards connections

ELA/Literacy -

(1) SL.11–12.5
    (a) Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-LS1-4)
(2) RST.11–12.1
    (a) Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-LS2-2)
(3) WHST.9–12.2
    (a) Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-LS2-2)
(4) RST.11–12.7
    (a) Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-LS2-6)
(5) WHST.9–12.7
    (a) Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesise multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-LS2-7)
(6) WHST.9–12.9
    (a) Draw evidence from informational texts to support analysis, reflection, and research. (HS-LS4-4)

Mathematics -

(1) MP.2
    (a) Reason abstractly and quantitatively. (HS-LS2-2
(2) HSN.Q.A.3
    (a) Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-LS2-2)