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CASE REPORT

Teaching sustainability at the high sea: the "One Ocean Expedition"

Jarle Eid[1] · **Marianne Aanerud**[2] · **Katja Enberg**[3]

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Abstract
This case study explores educational practices and processes in an interdisciplinary summer course addressing SDG14 (Life below water), SDG13 (Climate action), SDG4 (Education), SDG3 (Good health and wellbeing), and SDG17 (Partnerships). From May to August in 2022, students from 12 countries participated in an undergraduate summer course (SDG 200 Ocean–Climate–Society) on the sailship Statsraad Lehmkuhl as part of the One Ocean Expedition. Sustainability, marine biology, behavioral science, and sail training were core aspects of the daily assignments for the 86 students during the Pacific crossing from Chile to Tahiti. The students took part in watch duties 24–7 and were assigned to 18 working groups in their academic studies. Active learning approaches such as team-based learning and storytelling proved essential to engage students in interdisciplinary exchange on sustainability issues. A major challenge was to strike a balance between the academic work and the requirements from sea duties and life on board a sailship. Student feedback and assessment contribute to contextualize the learning experiences and personal development during the first five weeks on board. This case study provides an example of how life on a sailship can present a formative learning experience and an interdisciplinary laboratory to study and live in alignment with SDGs and with the overall mandate of the Global Agenda for Sustainable Development.

Keywords Higher education for sustainable development · Sustainable development goals (SDGs) · Storytelling · Team-based learning · Interdisciplinary · Pacific Ocean

Introduction

Sustainability is an increasingly important topic worldwide and higher education institutions (HEIs) will play an essential role in delivering on the U.N. Sustainable Development Goals (SDGs) by promoting education, research, innovation, and leadership (Alm et al. 2022). The SDGs are embedded and interlinked with the U.N. "Agenda 2030" in providing a common platform and comprehensive understanding of planetary sustainability (Resolution 2015). In response to the SDG challenges, it is considered crucial to move HEIs beyond disciplinary and sectoral silos and to engage in cross-boundary research, collaboration, and deep forms of learning (Franco et al. 2019; McCrory et al. 2021; Binagwaho et al. 2022). An interdisciplinary approach is essential to analyze the factors threatening the sustainability of natural and human systems and to transform these systems in a sustainable manner (Komiyama and Takeuchi 2006). Active learning approaches to sustainability have been proposed as a viable approach to promote critical thinking skills necessary for addressing the complex problems associated with SDGs across different sociocultural contexts (Dengler 2008). The combined application of active, participatory, and experiential learning, grounded in a specific environmental context, allows students to not only memorize factual knowledge, but also examine true to life processes and form a meaningful relationship with the environment they live in (Burns 2015).

A promising approach to this end has been to introduce work-integrated learning projects and to expose students to real-life experiences as part of their studies to enhance the students' understanding of sustainability (Alm et al. 2022).

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✉ Jarle Eid
Jarle.Eid@UiB.no

[1] Faculty of Psychology, Department for Psychosocial Science, University of Bergen, Bergen, Norway

[2] Faculty of Medicine, Department of Clinical Science, University of Bergen, Bergen, Norway

[3] Faculty of Mathematics and Natural Sciences, Department of Biological Sciences, University of Bergen, Bergen, Norway

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Designing educational programs that strengthen key competencies and self-efficacy in ways that allow students to develop their professional skills and interpersonal competencies will contribute to this end (Bielefeldt 2013). Challenges with active learning on campus can include absences, poorly prepared students, large class sizes, competing interests, and limited continuity in educational and interpersonal learning processes (Dengler 2008). A way to overcome some of these limitations could be to develop and detail more integrative, transdisciplinary learning environments to support off-campus, real-life experiences in a work-integrated educational approach to sustainability (Vilsmaier and Lang 2015).

The overall aim of this case study is to show how this undergraduate off-campus course on the sailship Statsraad Lehmkuhl contributes to teaching and learning of sustainability. First, we give an overview of the learning space and the educational context on board (c.f., SDG4 Education). Second, we describe how a collaborative learning strategy (Prince 2004) and a storytelling approach were applied to the academic studies in marine biology (c.f., SDG14 Life below water) and behavioral science (c.f., SDG13 Climate change). Third, we detail how fatigue, individual resilience, and adaptation to life as a seafarer presented medical and individual challenges (c.f., SDG3 Good health and wellbeing). Still, the challenges and mastery of sailing and cross-national collaboration grew self-confidence in support of interdisciplinary action to tackle sustainability issues (c.f., SDG17 Partnerships). In closing, we share student evaluations and offer recommendations derived from this experience that could be beneficial to other living lab educational approaches to SDGs.

Teaching sustainability on a sailship: the Pacific crossing

Statsraad Lehmkuhl is one of the world's largest and oldest square riggers still sailing. She was built as a training ship for the German merchant fleet over a hundred years ago, but is well maintained and in excellent condition. The ship is 98 m long, has 22 sails, and can do about 18.5 knots under optimal conditions. She has a permanent crew of 20 persons and 10 apprentices/volunteers, and can have up to 150 sail trainees on board. From August 2021 to April 2023, Statsraad Lehmkuhl served as a living lab (c.f. SDG4) for the One Ocean Expedition https://oneoceanexpedition.com, a circumnavigation with the aim of sharing knowledge about the crucial role of the ocean for a sustainable future development. The One Ocean Expedition presented a unique opportunity for the University of Bergen to contribute to SDG4 and education for sustainable development (ESD) by hosting the interdisciplinary summer course SDG 200 Ocean–Climate–Society on board the sailship from May to August 2022. The SDG 200 is a 30 ECT elective summer course with a particular emphasis on SDG14 (Life below water) and SDG13 (Climate action). The sailing ship also provided a unique context for interdisciplinary and cross-national collaboration that showcased the significance of SDG17 (Partnerships for the goals) when the students were working as sail trainees and applied collaborative learning (Prince 2004) to their academic assignments. In accordance with SDG4.7, the course on the sailing ship was designed to promote *Global citizenship education for sustainability.* A core ambition of the SDG 200 course was to build skills for interdisciplinary cooperation, professional discourse, and learning in a multinational setting. Students were recruited from partnering universities with an emphasis on cultural, educational, and gender diversity. There were no tuition fees, but students had to cover their travel expenses to and from port. Board and lodging on board (250 NOK/27 EUR per day) included breakfast, lunch, afternoon fruit/cake, dinner, and unlimited water, coffee, or tea. Most non-Norwegian students' board and lodging was covered by scholarships, while the tuition for the Norwegian students was covered by the university.

In the beginning of May 2022, an interdisciplinary group of 86 international students (24 male and 68 female), accompanied by an academic staff of two professors and a teaching assistant, embarked on the sailing ship Statsraad Lehmkuhl in the port of Valparaiso, Chile. The students came from different higher education institutions in Canada, Peru, South Africa, Germany, Austria, Italy, Greece, Fiji, and Norway, and the nationalities represented included in addition Sweden, Finland, and Papua New Guinea. The SDG200 was designed as an elective course to complement the students' graduate studies in a broad variety of study programs. The students were enrolled in total in 31 different study programs, and the largest group was biology students (20 persons), followed by political science, law, and geography with five students each. In broader disciplinary terms, most students were from natural sciences (37 persons) and social sciences (18 persons). See Table A and B in supplementary material for further details. The first five weeks of their four-month journey were dedicated to the Pacific crossing from Valparaiso in Chile to Tahiti in French Polynesia.

After leaving the port of Valparaiso, the sailship became a self-sustained community that provided a unique environment for inclusive and equitable quality education aligned with SDG4 and the global citizenship perspective. Sustainable travel by wind and sail and conservation of the limited food and resources became essential aspects of the journey that resonated well with the overall SDG framework. In addition to their work as sail trainees, the students had daily time periods dedicated to their academic assignments. In their dual roles as students and sail trainees, students were divided into three watch teams who were on duty for 4 h two times

Fig. 1 The living quarters of the students under the deck. Each student had their own, numbered hammock and lockers. Photo: Fredrick Clausen

per day and also during the nights. When on watch, the student trainees were supervised by the ship's permanent crew and took part in sail duties. They served on a rotational basis 1 h at a time in one of four physical tasks, such as man the helm, look out, man overboard, or fire watch. These very real responsibilities and the collaborative efforts needed from the students in their role as sail trainees became an integral part of SDG4.7 *Education for sustainable development and global citizenship,*[1] where watch duties and education provided a framework that instilled collaboration and became an embodiment of SDG17 (Partnerships for the goals).

The life and learning environment on board

The students slept below deck in hammocks that were attached to numbered hooks on the ceiling. The hammocks of each watch were aligned next to each other. Students had a small private locker and a chest to stow away their personal belongings. Below deck was a small classroom, sufficiently equipped to serve about 30 students. The crowded spaces, limited resources, and multinational student group provided an educational context in stark contrast to life on campus and spurred a deeper understanding of the need for collaboration, human adaptation, and change (c.f. SDG17) (Fig. 1).

Since the students had no Internet access on board the ship, an internal server provided a closed intranet service to support the academic studies, facilitate student interaction, file sharing, and teacher feedback on the academic assignments. A selection of literature from the university library addressing core aspects of SDG13 (Climate action) and SDG14 (Life below water) had been uploaded to the server and was available to the students. In addition, the students and staff had access to a small paperback library with recent literature on sustainability issues.

The weekly teaching plans were provided to the students on the intranet server and on the notice board. The three sailing watches were on duty as follows; Red watch: 0–04 and 12–16; White watch: 04–08 and 16–20; Blue watch: 08–12 and 20–24. The teaching was organized from Monday to Saturday outside the duty time and the eating and sleeping times. As a result, the teachers held three sessions each day, once for each watch. Table 1 shows a sample of the weekly schedule and how the academic studies were organized to align with the sea training and life on board.

The highly diverse and interdisciplinary student group provided a learning environment that incorporated individual differences of opinions and preferences, professional skills, cultural differences, and social backgrounds in accordance with the objectives of SDG4.7 *Global citizenship education for sustainability* and SDG17 *Partnerships for the goals*. In support of SDG4 and SDG17, a collaborative learning strategy (Prince 2004) was adopted to serve both the seafaring training and the academic studies. Within each of the watches, the group of about 28–29 students was divided into six interdisciplinary teams of 4–5 persons. These 18 teams from all the three watches were

[1] SDG4.7: By 2030, ensure all learners acquire knowledge and skills needed to promote sustainable development, including among others through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship, and appreciation of cultural diversity and of culture's contribution to sustainable development.

Table 1 Example schedule for week 4 of the Valparaiso–Tahiti leg

Time	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
9–11 White watch	SDG 14 session 7: Present research plan	SDG 13: Alvin's request for innovation	SDG 14: session 8 – RAT 3	SDG 13: Working on Alvin's request	SDG 14: Expanding on Excel assignment	SDG 14: (Fisheries) management objectives	Free
13–15 Blue watch	SDG 14: session 7: Present research plan	SDG 13: Alvin's request for innovation	SDG 14: session 8 – RAT 3	SDG 13: Working on Alvin's request	SDG 14: Expanding on Excel assignment	SDG 14: (Fisheries) management objectives	Free
16–18 Red watch	SDG 14: session 7: Present research plan	SDG 13: Alvin's request for innovation	SDG 14: session 8—RAT 3	SDG 13: Working on Alvin's request	SDG 14: Expanding on Excel assignment	SDG 14: (Fisheries) management objectives	Free

White, Blue, and Red refer to the three watches

tasked with weekly readings, assignments, and presentations with relevance to SDG13 (Climate action) or SDG14 (Life below water). Working in teams highlighted the importance of collective action whether sailing the ship on a day-to day basis or contributing toward long-term goals and a sustainable future, cf., SDG17 (Partnerships for the goals).

A team-based learning approach to marine biology and SDG 14 (Life below water)

The marine biology teaching was centered around the different SDG14 targets (Hall-Spencer and Firth 2021; Kilduff et al 2009; SAPEA 2017). The three modules during the first leg were: (1) Agenda 2030 introducing all the SDGs and how they are interlinked; (2) SDG14.2 Protect and restore ecosystems and SDG14.5 Conserve coastal and marine areas; and (3) SDG14.4 Sustainable fishing and SDG14.6. End subsidies contributing to overfishing. In addition, each team read a relevant popular science book and presented this to their fellow students. The modules are described in more detail in Table 2.

During the first leg from Chile to Tahiti, the modules were taught according to a team-based learning (TBL) methodology (Michaelsen et al. 2002). The TBL teaching and learning framework consists of a five-step Readiness Assurance Process (RAP). This pedagogical process was guided by the recommendations by Sibley and Ostafichuk (2014). The consecutive steps of the RAP that was adopted on board were as follows. (1) Pre-readings, where the students were required to read certain material as part of their individual preparations for class. (2) In class, the students then completed the Individual Readiness Assurance Test (IRAT) which is a multiple-choice test of 12 questions tailored to the lecture topic. (3) Then, the students completed the Team Readiness Assurance Test (TRAT) where they addressed the exact same multiple-choice quiz as in their IRAT, but this time they solved the questions through a group discussion (Fig. 2). In group discussion, the students answered by using scratch cards. For each question, the team could choose to scratch one out of four squares. If the answer was correct, a small star appeared in the square, but if the square was empty, the team had to renegotiate and try to figure out which alternative answer could be correct. If the students got a correct answer on their first attempt, they were awarded four points, and then subsequently less points for each new attempt, until they reached zero points if they had to scratch all four squares to find the correct answer to the question. (4) After completing the TRAT, there was an appeals process where students could make a written appeal if they thought some of the questions or answers were confusing or wrong. (5) Finally, the students were given the opportunity to ask about clarifications from the teacher or if they wanted to discuss or raise questions to the prereading or any of the IRAT topics. Further details on required and recommended readings can be found in the supplementary material.

After the Readiness Assurance Process, the students were then ready to apply their new knowledge. The application activities were performed in the study groups and should follow the **4-S** principles: it should be a ***Significant*** problem, the problem should be the ***Same*** for all teams, the teams should need to make a ***Specific*** choice, and they should report their choice ***Simultaneously***. For example, in an application activity, the students could receive four different SDG interaction maps, where the interactions between a selection of SDGs were depicted with positive or negative arrows. Each team was to choose which one of them they thought best described their view on the interactions, and why. The teams simultaneously voted which one they chose by putting up one of the letter cards provided to

Table 2 Description of the modules of the marine biology teaching during the first leg

#	Reading material	Application activities	Assessment elements	Learning outcomes
1	Transforming our world: The 2030 Agenda for Sustainable Development. UN 2015	(1) Students received different SDG interaction maps, of which they had to choose the one best describing the interactions between SDGs and describe in class why	IRAT, TRAT	Engage with the sustainability challenges in Agenda 2030, while acknowledging the role of individual and collective actions
2	(1) Marine Fisheries Ecology (Jennings et al. 2009), Chapter 2 Marine ecology and production processes (pp. 21–38) (2) Chapter 12 Fishing effects on populations and communities, Sect. 12.4 Community effects (pp. 245–257) (3) The Second World Ocean Assessment (U.N. 2021) Chapter 1: Overall Summary, Sects. 1–2 (pp. 5–7), Sects. 4–5 (pp. 10–15) (4) The film "Breaking the boundaries" that we will watch on Sunday, or the article: Steffen et al. 2015: Planetary boundaries: Guiding human development on a changing planet	(1) Learning to use EndNote in connection with the literature on the server on board (2) How to do research? Population dynamics as an example and designing a study on board Statsraad Lehmkuhl	IRAT, TRAT (A) Excel exercise in population dynamics made in teams (B) Oral presentation on the team's research plan (5–10 min)	Explain how planetary boundaries define the safe operating space for humanity Design a study using qualitative and/or quantitative research methods and explain how these are needed for finding solutions for sustainable development Apply simple models of climate and population dynamics Contribute to interdisciplinary teams and value the different roles within such teams
3	(1) Guide to Fisheries Science and Stock Assessments (Kilduff et al. 2009) Chapters 1 (pp. 1–6) and 4 (pp. 27–29) Atlantic States Marine Fisheries Commission 2009 (2) The Second World Ocean Assessment (U.N. 2021) Chapter 1: Overall Summary, Sect. 7 Sustainable food from the ocean (pp. 16–19) (3) SAPEA Evidence report (SAPEA 2017) Executive summary (pp. 7–9) and Chapter 5. Conclusions and options for how more food and biomass can be obtained from the ocean (pp. 89–99)	(1) Excel exercise on Fisheries Harvest Control Rules (HCR) and Maximum Sustainable Yield (MSY) (2) Analyzing the film Seaspiracy in teams	IRAT, TRAT (A) Excel exercise in HCRs and MSY made in teams	Compare different fisheries management systems and approaches Explore connections and contrasts between scientific literature and the literature of reports, conventions, and popular science literature Apply simple models of climate and population dynamics Contribute to interdisciplinary teams and value the different roles within such teams
Overarching activities during the leg				

Table 2 (continued)

#	Reading material	Application activities	Assessment elements	Learning outcomes
A	Each team read one of the following popular science books: (1) Hans Rosling (2023): Factfulness (2) Kate Raworth (2017): Doughtnut Economics (3) Charles C. Mann (2018): The Wizard and the Prophet	The students read the books and discussed each chapter within their teams and prepared a presentation of the book	Oral book presentation (max. 20 min)	Recognize and explain connections between social, cultural, economic, and environmental challenges in achieving socially just and sustainable societies Explore connections and contrasts between scientific literature and the literature of reports, conventions, and popular science literature Accommodate individual differences of opinions and actions, cultural and social backgrounds and negotiate across these differences Contribute to interdisciplinary teams and value the different roles within such teams Provide constructive feedback and conduct peer-reviews verbally and in written form

(1) Agenda 2030, introducing all the SDGs and how they are interlinked; (2) SDG14.2 *Protect and restore ecosystems* and SDG14.5 *Conserve coastal and marine areas*; and (3) SDG14.4 *Sustainable fishing* and SDG14.6. *End subsidies contributing to overfishing*. In addition to the modules, the students were also reading popular science books as part of the academic training during their voyage

them and were asked to justify their choice, followed by a class discussion (c.f. SDG4.7). In this activity, there was no definitely right answer—which also often is the case in real-life sustainability questions.

Behavioral science and SDG 17 (Partnerships for the goals)

The daily activities on the ship presented ample situations and opportunities to illustrate how individual, interpersonal, and social factors were important to understand how behavioral science could inform processes of change and the need to form partnerships in adaptation to a radically new context. The ship provided a rich learning environment where it soon became evident that collective action and collaboration were essential to accomplish common goals. The behavioral science component of SDG 200 was designed to provide a shared conceptual perspective on how interpersonal aspects of collaboration, competition, and conflict could motivate individual and collective behavior both on board and in relation to sustainability issues (c.f. SDG17). Core issues in the behavioral science classes, therefore, centered around questions like: What will motivate people to engage in proenvironmental behavior and collective action to address the SDGs? How can we understand individual and collective skepticism to science? In the following, we provide some examples of how such weekly assignments connected psychology to the SDGs.

Since all students were new to each other and met for the first time in Valparaiso, diversity and individual differences were an evident point of departure. The first module of the behavioral science class focused on individual differences and the discovery of human resources, capabilities, and the diversity of the students' cultural backgrounds, skills, and knowledge. In keeping with SDG4.7 *Global citizenship education for sustainability,* the students took part in structured feedback exercises that raised awareness about social identity, individual differences in values, preferences, attitudes, motivation, and competencies with relevance to sustainability issues. Getting to know others and learning how you are seen by others are core elements in establishing productive work teams and how social identity connected to proenvironmental attitudes and behavior (Fielding and Hornsey 2016; Hornsey and Fielding 2020). Cultural awareness, interpersonal collaboration, and teamwork would soon prove to be crucial competencies in both the maritime and the academic activities on board. To this end, one of the first assignments for the six working groups on each watch was as follows:

> *"The ship, crew, and fellow students will be significant elements in your micro-world for the coming weeks. To*

Fig. 2 Students working on their Readiness Assurance Test. In the picture on the left, on the Individual RATs; in the right, in the Team RAT, where the scratch card with gray scratch squares is visible in the lap of the student at front. Both pictures show a typical learning situation, where students are sitting or lying individually or with their teams on the deck. Photos K. Enberg

facilitate trust, support, and teamwork please share some of your professional and personal background, expectations, and what you hope to accomplish during the voyage. What do you see as your personal challenges and how can you contribute to the team efforts? Do you have any personal goals for the expedition? Be prepared to share your findings with the fellow students in your team".

Life on board the ship soon provided multiple examples of behavioral adaptation to a radically changed context, such as living in close quarters, attending to watch routines, safety, learning about sailship maneuvering, and adapting to life on board. In many ways, this radical shift in daily routines from their ordinary life as students also resonated well with the individual requirements and transformation needed to accommodate the goals of SDG and a more sustainable way of life.

Although the COVID situation was of less concern at the time of departure from Valparaiso, it was still a very recent and shared experience for the students. In the same way as the pandemic presented a threat to humanity and required a global response, the same is true if the SDG challenges are to be addressed according to the U.N. "Agenda 2030". Inspired by the students' personal experiences from the pandemic and the research by Bouman et al. (2021), a hot topic for one of the early student assignments was therefore to discuss if lessons learned from the pandemic could be applied to promote SDG outcomes. The following student assignment addressed this issue:

"The COVID-19 pandemic presented a sudden and unprecedented threat to humanity. Over a few weeks most European countries had introduced emergency laws and strict social regulations to curb the spread of the virus. Although some were skeptical and dismissed the pandemic as a hoax, most people complied with strict social regulations, quarantine, social distancing, testing, school closures, and restrictions on travel and social events. Likewise, the SDG 13 emphasizes the need to "Take urgent action to combat climate change and its impacts". Discuss if lessons learned from the collective responses to the pandemic could provide a template for tackling SDG 13?"

Another timely issue relating both to life on board and to the greater SDG challenges was to explore how competing interests and interpersonal tensions can erode trust, instill suspicion, and fuel conflict that prevents partnerships (c.f., SDG17). The ship offered very limited privacy and there was no escape from the daily watch routines and life at sea. The boundaries and limitations of the ship could in many ways resemble conflicts over space and scarce resources. Competing over marine resources, energy, or the use of land are a frequent source of conflicts relating to SDG outcomes. To illustrate the dynamic nature of intergroup conflicts, the student trainees were invited to take part in an intergroup decision exercise in the form of a zero-sum game. The exercise served to illustrate interpersonal and team dynamics associated with "win–win", "win–lose", or "lose–lose" conflicts. The study by Colvin et al. (2016) over community engagement in a wind energy conflict in King Island, Australia, served as a reading assignment and illustration of how local conflicts can spill over and derail partnership processes (c.f., SDG17).

Introducing "Alvin": a storytelling approach to SDG 13 (Climate action)

Storytelling is a powerful pedagogical approach that reduces depersonalization and encourages reflection and critical thinking by providing everyday examples that can serve as a shared experience (Abrahamson 1998; Alterio and McDrury 2003). Early in the behavioral science class, the students were introduced to the fictional character of "Alvin" who appears to be a climate skeptic. After reading the paper by Hornsey (2020) titled "Why facts are not enough: Understanding and managing the motivated rejection of science", the students were introduced to the following team-based assignment:

> *"On a summer holiday in Denmark, you meet Alvin, a classmate from high school. He is on holiday with his wife and two children. You used to hang out a lot, but now you haven't seen or heard from him in 6 years. He has moved to Denmark and is now working in a multinational company. You are surprised to learn that he apparently believes that climate change is a hoax, and he seems to be in a state of denial regarding the science behind many of the SDG issues you consider well documented. After meeting with Alvin, you are confused and feel the need to understand how Alvin could have changed so fundamentally from the person you used to know. How can you use behavioral science (social psychology) to explain why Alvin's attitudes and opinions seem to be so different from your own?"*

In the following week, the students were encouraged to consider ways to possibly influence or sway Alvin's seeming resistance to the facts and science behind the SDGs. In support of their next assignment, the students were provided with selected text material from social psychology on attitudes, the science of persuasion, influence, and how social identity and group processes could influence individual opinions and behavior (Fritsche and Masson 2021). To stay focused on the SDG outcomes, the students were encouraged to read the study by Barth et al. (2021) on *"Collective responses to global challenges: The social psychology of pro-environmental action"*. Since "Alvin" appeared to be a climate skeptic, the students were also recommended to read the study by Haltinner et al. (2021) on support for environmental policy among climate change skeptics before they took on their next team-based assignment:

> *"You have decided to approach Alvin and convince him that there is a valid scientific basis for the SDG goals. From your behavioral science class, you remember that you discussed different social influence tactics. Could influence tactics be used to convince Alvin about the science behind the SDG goals or would other strategies be even better?*

Prompting interdisciplinary action and sustainability innovations

Storytelling has emerged as a promising approach to support interdisciplinary action (Marín et al. 2018). In their final assignment before arrival in Tahiti, the students were encouraged to take advantage of their own professional background and apply behavioral science and biology to develop innovative and futuristic solutions to one or more of the SDG challenges inspired by Fritsche and coworkers (2018). Again, "Alvin" was introduced to the students and this time he encouraged them to engage in a creative team effort to produce innovative solutions to address SDG challenges:

> *"Quite surprisingly, you receive a call from Alvin after the summer vacation. He tells you that his CEO has tasked him to head up a new project for one of their major clients. The project is called "Green Solutions" – and this client wants to identify sustainable and profitable new products, procedures, or services that could be part of future initiatives to reach the SDG goals. Alvin wants you to gather your team of experts from different fields, that could use their interdisciplinary competence to craft new ideas on sustainable solutions that he could present to this potential investor. The product, procedure or service must be of relevance to one or more of the SDG targets."*

This final assignment spurred vigorous involvement in the student teams. The public showcasing of their innovation ideas created a sense of competition and motivation for an extra effort. In the final week of the Pacific crossing the 18 student teams presented their innovative ideas and results of their team-based processes (c.f. SDG4). This final assignment provided a form of closure and an opportunity to apply their interdisciplinary competencies and skills. A wide range of new ideas, products, processes, or procedures were showcased in public on board, some more futuristic than others. All presentations were accompanied by convincing arguments from the students on how their innovation could have a positive impact on sustainability and the SDG outcomes. Table 3 provides an overview of five sample ideas from this final assignment.

Table 3 Sustainability innovations—examples of five interdisciplinary student projects

Innovation idea	Brief description of the idea
GARBAGE GO	GARBAGE GO is an application like "Pokémon Go", a game for children of all ages. The purpose of the app is to find and collect litter from the street, parks, and coastal areas and recycle them. For every garbage you collect you gain points, which will be doubled when you are contributing to coastal or protected areas
GREENIE	GREENIE is an app for scanning products, starting with food in Norwegian stores. The app would show you the carbon footprint of the product, in addition to water usage, ethic, and shipping. We also want to include a social media part where you can share your score with your friends
SHARE RIDE	SHARE RIDE is an application where people who travel the same way connect and agree to ride together. Our goal is to fill the cars that we already use by having more people in fewer cars, a concept driven by an ambition to use resources in a more efficient and sustainable way than we do today. By connecting people going from A to B, this app will change the way we travel and our daily habits
BIO-PUNK	The BIO-PUNK project will use bioluminescence to light up the cities of the future, by circulating bioluminescent phytoplankton (algae) in water-filled glass tubes through the cities. The "waste" (old/dead algae) will then end up in "miniature oceans" in the middle of the cities: blue spaces
PAWN STARS	The aim of the PAWN STAR project is to reduce ghost fishing in the Indian Ocean by introducing a pawn system for used fishing gear so that fishers can bring their broken equipment back to shore and get money back which will compensate for the lost profit of fish. Collected gear will be recycled and reproduced to new fishing gear, contributing to a circular consumption pattern

Hardships, good health, and wellbeing (c.f., SDG3)

Due to the COVID-19 pandemic, the travel restrictions and infection control regulations had to be observed. To ensure compliance with SDG3.3 (Fight communicable diseases), all travelers had to present corona vaccination certificates and negative PCR tests less than 48 h prior to embarking on the ship in Valparaiso, Chile. The ships´s doctor performed rapid tests on all travelers before boarding the ship, and testing was done again on all travelers after 3 days at sea. One case of COVID-19 without symptoms was detected and confirmed by the ship's PCR testing machine on the 3rd day of the journey. The patient was isolated and the whole ship was retested after 3 days without positive results. The patient was let out of quarantine after a week, and we had no further cases of COVID-19 on this leg of the journey.

When planning the expedition, a high priority was to ensure nutrition and sustainable consumption of sufficient and varied food. The ship had substantial cooling and storage facilities that allowed it to preserve fruit and vegetables for the whole voyage from Valparaiso to Tahiti. Since it was not possible to resupply, the Pacific crossing provided an opportunity to highlight the need for sustainable consumption (c.f., SDG12.2) and reduction of food waste (c.f., SDG12.3). Another high priority was to cope with potential health issues, ensure good health, sanitation, safety, and a healthy psychosocial environment. In accordance with SDG3.8 (Universal health coverage), the ship had a medical doctor on board for the whole voyage and a small infirmary with four beds and basic medical equipment and medication to perform first aid, stabilize acute illness, and treat common illnesses. The students were aged 21–29 and had Seamen´s certificates, hence they were quite healthy. Sore muscles after sail maneuvers, blisters after handling ropes, and some cases of athlete´s foot (fungal skin infection due to tight footwear, compulsory when working on deck and aloft) were the most common reasons for seeing the ship´s doctor. There were also some acute injuries to the head due to falls caused by the ship's movement. The doctor was available around the clock for acute incidences, but mostly in office for consultations before noon, and practiced low-threshold consultations. Between 1 and 5 students visited the doctor´s office each day with all kinds of concerns—homesickness, need for contraception, skin infections, or injuries like a wound needing stiches after a fall from a hammock. At one point during the Pacific crossing, the ship's crew and students were allowed swimming. On this occasion, six persons were stung by a jelly fish or a siphonophore (only tentacles were observed) and needed medical attention. They all recovered without sequela.

Regardless of prior health status, motion sickness or seasickness affects from 60 to 90% of inexperienced sailors with symptoms ranging from reduced alertness to severe nausea with almost constant vomiting and significant consequences on their capacity to work or study (Koch et al. 2018). Apathy, passivity, and lack of concentration can also be symptoms of motion sickness and affected some of the students during the first week at sea. Some of the students received medical treatment for their sea sickness with drugs (e.g., H1 antagonists or scopolamine) that have side effects like reduced vision and drowsiness, which in addition to the sea sickness itself interferes with studying and learning (c.f., SDG4). After a few days most of the students had habituated to the swaying of the ship, and for the more severely affected individuals this took about a week. However, due

Table 4 The four most frequently endorsed learning outcomes from the first five weeks of the SDG 200 course ($n = 80$)

Which learning outcomes did you find most applicable to the first five weeks of the SDG 200 course?	Quite well or very well (%)
Contribute to interdisciplinary teams and value different roles within such teams	88
Explain how planetary boundaries define the safe operating space for humanity	80
Reflect on the role of oceans in climate, ecological, oceanographic, and food systems	79
Accommodate individual differences of opinions and actions, cultural and social backgrounds, and negotiate across these differences	70

Table 5 Individual student evaluations from the first five weeks of the SDG 200 course ($n = 80$)

Individual student evaluations of the first five weeks of the course	Agree or strongly agree (%)
The course has developed my interdisciplinary teamwork skills	95
The course has developed my cooperative skills	86
In general, I am happy with the SDG 200 course	86
I have received constructive feedback from my peers	83
The teamwork in my group has been good	81
The team RATs have helped me get familiar with new materials	71
The course has developed my theoretical and conceptual skills	71
The academic workload has been ok	70
I have received constructive feedback from my teachers	49
The individual RATs have helped me to get familiar with new material	49
Communication with teachers has been good	44

to changes in the movement of the ship, for instance due to shifting wind conditions, seasickness was induced again in some of the more susceptible students. Engaging in practical activities can be a way of coping and adjusting to seasickness, as opposed to reading and studying. Hence, during the first days of sailing, the students were mostly involved in practical learning during the watches with less time spent on academic assignments (c.f., SDG4).

Sleeping and eating had to be adjusted to the ship´s routines. Since everyone was on duty for 4 out of 12 h during day and night, nobody had 8 h of continuous sleep. During the first two weeks of sailing, many of the students complained about sleep deprivation and found it difficult to sleep in quarters shared with people working opposite shifts. However, after a while the students adapted to the routines and life on board and were actively engaged in the educational activities (c.f., SDG4).

How could the sailship experience inform other living lab educational approaches to SDGs?

The seafaring experience on board Statsraad Lehmkuhl was built upon established academic and maritime principles and values of global partnerships and cooperation (SDG17). The ship provided ample opportunities to engage in collaborative interdisciplinary activities (SDG4) aimed at life below water (SDG14) and human behavior in climate action (SDG13), and the ship also provided a living lab for sustainable consumption (SDG12), health and wellbeing (SDG3). In this final section, we explore student evaluations and offer suggestions to other education for sustainable development (ESD) initiatives.

Upon arrival in Tahiti, the students evaluated the first five weeks of the One Ocean Expedition by submitting their confidential evaluation reports and providing feedback from their study groups. When asked about the learning outcomes from this first part of the SDG 200 course, more than 70% of the students expressed satisfaction with the opportunity to take part in an interdisciplinary team and accommodate individual differences in opinions and actions. Quite a few also endorsed this opportunity to learn more about planetary boundaries and reflect on the role of oceans in climate, oceanographic, and food systems. See Table 4 for further details about student assessments of the learning outcomes.

Individual student assessments of their academic studies in the first five weeks of the SDG 200 are shown in Table 5. More than 80% of the students appeared satisfied with the SDG 200 course, their personal feedback from peers, and

the opportunity to develop their cooperative and interdisciplinary teamwork skills. Furthermore, more than 70% of the students expressed satisfaction with the academic workload, the way teamwork had facilitated learning of new materials, and how the course had developed their theoretical and conceptual skills. Finally, between 44 and 49% of the students were satisfied with the feedback and communication with teachers and their individual academic work.

The study groups provided additional context to the individual evaluation. The group was asked to give their opinions on what they had appreciated the most, what they would have liked to be different, and to offer their suggestions for future transdisciplinary courses on sustainability issues. A representative selection of feedback from the study groups is presented in the following.

What have you appreciated with the teaching and learning over the first five weeks?

- We liked that the sessions have been short, well-structured and had a broad variety of topics. We also enjoyed working in a team and the group discussions. The innovation project (with Alvin) was fun and engaging.
- We really enjoyed the team discussions throughout RATs and lectures since we had the opportunity to share our interdisciplinary views and knowledge. Also, we think that combination of marine biology with psychology was very constructive and well connected.
- Without grades, the learning hasn't been about competing, but about collaboration. The SDG 200 course has been interesting and exciting for us. It has been a good introduction to biology and its connection to the SDGs, especially for those of us lacking a natural science background.

What would you have liked to be different in the teaching and learning so far?

- The two first weeks we got way too much to do, both in the sailing and the workload in class.
- Classroom situation has not been ideal—work environments are in areas that are sort of distracting (though we know there is not much to do about this on a ship). It's been a challenge with the teaching environment, since we've had some occasions where you, the teachers, and the crew have competed for attention.
- It could have been beneficial to have one introductory lecture for each topic. It would be nice if it was more interdisciplinary. The introduction has been very focused on biology and psychology, but an introduction in the start of the course of how all the fields are connected to the SDGs would be very relevant.

In their assessments, the students also shared their thoughts on how to organize future education for sustainable development (ESD) initiatives. In short, the students' views can be summarized as follows:

- Keep ESD as a summer course with team-based learning and workshops, preferably in a place where you can do field work and live sustainably together. A normal semester subject is also possible, but then it should have more individual work.
- The course should involve some form of field work, even if it cannot be onboard a ship, maybe travel to some place, and learn about the environmental impacts there and learn how the locals are working against it and what the globe can do. Combine learning and adventure to keep it fun and motivating.
- Divide the course into modules that are done (online) or on campus, include field trips, and have part of the course as an excursion outdoors in a forest or other natural area.

Conclusion

We allude to Grindsted and Nielsen (2022) that implementing education for sustainable development (ESD) in higher education institutions (HEIs) is critical to facilitating a transition toward sustainable development. This case study from the One Ocean Expedition adds to the growing literature on living life approaches to sustainability in higher education. Keeping in mind that the transition from life on campus to life at sea was experienced as exhaustive and "*quite overwhelming*", the One Ocean Expedition presented a unique opportunity to live and experience core aspects of the sustainability objectives firsthand.

Life on a sailship follows a very predictable schedule of different work assignments and duties. One lesson learned from this living laboratory is the need to attend to potential role conflicts and the mere workload required to keep the ship operational. In the first weeks of the voyage, a priority was therefore to clarify roles and responsibilities, and to establish good lines of communication to minimize conflicts of interests, role ambiguity, and set priorities for the sail training, daily routines, and academic assignments.

The interdisciplinary discourse and collaborative learning emerged as key to innovation and engagement in pursuit of an alternative future (Holfelder 2019). The students appreciated the team-based learning, storytelling, and interdisciplinary projects. For most of the students, this was a valued new experience in higher education. Thus, this Pacific crossing on a sailship offered a living lab and challenging context where students could contextualize and explore the multi-scalar nature of the SDGs.

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Data availability Data in the form of video stories from the Pasific crossing is available on YouTube.

Declarations

Conflict of interest The authors have no conflict of interest regarding the present study.

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