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Research Article

Learning and learning-to-learn by doing: An experiential learning approach for integrating human factors into maritime design education

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Abstract

This paper presents the findings of a study conducted to integrate Human Factors (HF) and Human Centered Design (HCD) knowledge into maritime design students' educational platform and to motivate them to utilize this knowledge in their designs. Naval architecture students at the Australian Maritime College (AMC) were the participants in this study. Firstly, a classroom survey was conducted to determine the students' current level of awareness and understanding of maritime HF and HCD. Then, an onboard survey was conducted after 5 HF-related activities during a 7-day voyage onboard the research vessel of AMC, MV Bluefin. The onboard activities provided the students with an opportunity to experience experiential learning, including all its key elements, based on Kolb's experiential learning model. The findings prove experiential learning is a "paradigm of noteworthy learning" that supports multiple learning objectives of learners and shapes their knowledge through experience.

1. Introduction

The life of a seafarer depends on a ship's design characteristics, such as equipment accessibility, habitability, workability, maintainability, operability (Dobie, 2003; Hemmen, 2008; Matsangas & Shattuck, 2020), usability, reliability, supportability, and acceptability (Rumawas, 2016). Some design features affect the mental workload, some affect the crew's ability to sleep, and others affect the level of physical stress on the crew (Ellis, 2009). To ensure that a design is fit for the intended purpose and is appropriate to the context in which it will be used, the designers and the design process should consider Maritime Human Factors (HF) and apply a Human Centered Design (HCD) approach to consider the users' capabilities and limitations (Mallam, 2016; Petersen, 2010, 2012; Vries et al., 2017).

Maritime design practice today does not show explicit consideration of the end-user, and therefore does not apply HF, ergonomics, and usability knowledge during design to their full extent (Costa & Lützhöft, 2014; Petersen et al., 2011). Most of the maritime designers involved in the maritime design process seem to be unaware of HF, HCD, and the operational issues which ships' crews face during their sea time (Mallam, 2016; The Nautical Institute, 2015). This lack of

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knowledge can be traced back to the maritime design educational system (Abeysiriwardhane et al., 2017; Lützhöft et al., 2017), which shows a clear inclination towards the technological field, and very few or no maritime designers have been exposed to such non-technical topics (Abeysiriwardhane et al., 2016). Many research studies suggest transferring and integrating HF and HCD knowledge into maritime designers' education systems in a more targeted, engineering-oriented fashion to teach them about non-technical topics (Abeysiriwardhane et al., 2017; CyClaDes, 2014; Mallam, 2016).

The literature study revealed that the field of engineering education has gone through several re-engineering efforts under various names. Some of the popular names in the past have been sustainable engineering and concurrent engineering (Christie & de Graaff, 2017; Tejedor et al., 2018). While each of these names has a different purpose, the underlying principle of effective engineering education has been its ability to provide practical and functional learning opportunities to students. Experiential learning, which encompasses all types of practice-based learning opportunities (Gautam et al., 2020; Kolb, 2015), is the founding principle of a successful engineering education model (Ghrayeb & Vohra, 2011).

The essence of experiential learning is "learning by doing" (Kolb, 2015) and is the sense-making process of active engagement between the inner world of the person and the outer world of the environment. The pedagogy of experiential learning is well established as a pedagogy that makes the students technically functional and enables them to be better engineers as a result of their understanding of the real-life content of their engineering education (Kolb, 2015). Experiential learning has been successfully applied to several engineering disciplines, such as mechanical, electronic, and electrical, to introduce new knowledge, create curricula, and conduct new courses and programs (Bakr, 2015; Gautam et al., 2020; Greene, 1992; Konak et al., 2014; Lam et al., 2019; Zhan et al., 2013). However, there is a lack of literature on the application of experiential learning in the maritime engineering discipline.

This research project is conducted aiming to introduce non-technical HF and HCD topics using the experiential learning approach into technical-oriented maritime engineering education. The study also aims to identify success factors of the experiential learning approach to motivate students to utilize the new knowledge in their future profession. Section 2 of this paper discusses how experiential learning is used as the theoretical platform of this study. The methodology of this study is presented in Section 3, including details of the participating student cohort. The remainder of the paper is organized as follows: Section 4 provides the results, and Section 5 discusses the results, of mainly how students' onboard experiences influence their learning process by doing, discovering, reflecting, and applying. Additionally, Section 5 discusses the validation of research methods employed in the study, and Section 6 concludes the paper.

2. Theoretical framework

The theoretical framework of this study was built on the classic argument of "learning by doing" (Dewey, 2012). He argued that while traditional education has little need for theory, since the practice was determined by tradition, the new experiential approach to education needs a sound theory of experience to guide its conduct. The same is reflected in constructivism (Perkins, 1991; Piaget, 1969; Vygotsky, 1978) and, according to this, learning involves personal construction resulting from an experiential process (Bruner, 1986; Piaget, 2013). Experiential learning can also be clearly defined by these well-known maxims:

I hear and I forget, I see and I remember, I do and I understand. Confucius, 450 BC
Tell me and I forget, Teach me and I remember, Involve me and I will learn. Benjamin Franklin, 1750

The principles and practices of experiential learning have been used to create curricula and conduct educational courses and programs since their emergence in the early 1970s. Many of the nontraditional educational innovations that have flowered during this period, such as college programs for adult learners and prior learning assessment, used experiential learning as their educational platform (Girvan et al., 2016; Moon, 2013). Experiential learning, or learning through experience, is often defined as opposite to traditional learning, where the students play a comparatively passive role by hearing or reading about others' experiences. In engineering education, a similar concept is often expressed as 'active learning' (Gautam et al., 2020; Wankat & Oreovicz, 2015), terms which imply an active role of the learner. Students take responsibility for their own learning and the instructor takes the role of facilitator, guide, or mentor in the learning process (Guerra, 2015). This is a significant departure from lecture-based learning, which signifies a paradigm shift. Therefore, experiential learning or active learning is a major student-centered learning tool in which learning is not only real-world based but a function of activity, context, and culture in which it occurs (Babu et al., 2020; Girvan et al., 2016).

To be effective, the experiential learning process involves a cyclical process that offers the students a hands-on, collaborative, and reflective learning experience which helps them to "fully learn new skills and knowledge" (Haynes, 2007). A very well-known model of experiential learning is described in Kolb's work on cognitive learning theory (Kolb, 2015). He described the experiential learning model as a cyclical process consisting of 4 main elements, namely:

- Concrete experience: the learner must be willing and be actively involved in the experience;
- Reflective observation: the learner must be able to reflect on the experience;
- Abstract conceptualization: the learner must possess and use analytical skills to conceptualise the experience; and
- Active experimentation: the learner must possess decision-making and problem-solving skills to apply the new ideas gained from the experience.

It is understood from these steps that experiential learning is a process of building knowledge on the experience and context of real life, involving students in doing a task, solving a problem, or handling an activity through feedback, reinforcing a concept, and applying knowledge in a new situation. Also, this kind of learning does not have one end goal; rather, it supports the learner to become a self-directing learner (Fink & Fink, 2009) and, thus, learn how to learn (Fink, 2003).

The authors of this study used the experiential learning model, as it is not only inviting to reimagine the classroom, but also to reconsider what constitutes learning and the formation of knowledge. This learning model calls students to be the agents of their education to learn by doing, discovering, reflecting, and applying. Also, the authors believe that the onboard activities can support the student learning process, whereby knowledge is created through the transformation of experience, and that they offer all the elements that are key to successful experiential learning.

3. Materials and methods

Action Research (AR) was used as the methodological framework, which is considered appropriate for studying the effectiveness of a teaching intervention. AR is a research methodology which combines 'action' (what researchers do to solve an issue or to improve the current practice), and 'research' (how researchers learn from the action and understand the effectiveness of the action) (Elliot, 1991; Kemmis & McTaggart, 1987). Furthermore, it is a collaborative process (Efron & Ravid, 2020) of investigating how the action has contributed to the problem solving or improved current practice, hence becoming a process of knowledge creation. All AR models involve the continuous process of identifying an issue, planning an action, taking the action, reflecting on the action, and then re-planning it in new ways in light of the results, which ultimately then becomes a cycle of action and reflection (Lawson et al., 2015; Mertler, 2016). The action research method has been widely used by researchers in social science and educational fields as a practical problem-solving method (Efron & Ravid, 2020; Lawson et al., 2015; Stevenson et al., 2020).

This study firstly conducted a classroom survey to determine the students' current levels of awareness and understanding of maritime HF and HCD. Third-year undergraduate naval architecture students who enrolled in the unit "Maritime Engineering: Bluefin" at the Australian Maritime College (AMC) were the participants of this study. An onboard survey was conducted after 5 HF-related activities during a 7-day voyage onboard Bluefin, which is the research vessel of AMC.

This research study followed a general cycle of AR: planning, acting, data collecting, reflecting, and re-planning. To investigate how the experiential learning program contributed to the improvement of student understanding of maritime HF and HCD, the following data collection techniques were used during this study:

- Researcher's journal;
- A classroom survey before onboard activities;
- Onboard survey - student record sheets after onboard activities; and
- Video evidence - videos recorded during the onboard activities.

The primary researcher maintained a research journal throughout the study, which enabled an enquiry-reflection process at the heart of learning (Moon, 2013). A research journal, kept systematically and regularly, is a record of events, dates, and people, and is a record of the researcher's interpretative, self-reflective personal experiences, thoughts, and feelings, and is used as a means of helping them understand their actions.

For the classroom survey activity, the students were invited to participate through the unit lecturer. Open-ended questions, closed-ended questions, and scaled questions were included in this questionnaire (**Appendix A**). Before distributing the questionnaire, a brief introduction about the aim of the project was given to the students to provide everyone with a basic understanding of it. They were given 20 min to complete the questionnaire.

Due to the easy access to the target group and the significant population available at AMC, a questionnaire survey was employed as the best approach to initiate the study. Since the researcher was available during the survey, this instrument can be further identified as an investigator-administered survey, which has advantages and some disadvantages which may influence the data collected. Mitchell and Jolley (2012) explained that the presence of the investigator (researcher) can lead to a higher response rate as one of the major advantages. On the contrary, the participants may feel discomfort regarding anonymity, and might not be open and honest in their answers. To overcome these issues, the researchers obtained ethics committee approval and made an effort to obtain open and honest results by providing maximum freedom for the participants to complete the classroom questionnaire.

Five HF-related experiential learning activities are listed in **Table 1**. Students were requested to familiarize themselves with the general tasks carried out in the area which was related to the activity before it commenced. Then, the activity sheets and the record sheets were distributed to the students (**Appendix A**). The researcher requested them to record their feedback on the record sheets once the activities were completed. All the activities were digitally recorded with the participants' permission.

Table 1 Experiential learning activities carried out onboard the AMC research vessel Bluefin.

Activity	Description
1) Evacuate an injured person from the main engine room machinery space	Students were requested to carry an injured person on a stretcher from the machinery space to the main deck.
2) Check accessibility/operability of valves	Students were requested to observe the accessibility and operability of valves available in the engine room and the main deck of the vessel.
3) Check space utilization	Students were requested to observe the space utilization in accommodation and the washroom space and recreation space and check if the design appropriately addressed the comfort of seafarers' lives.
4) Carry provisions through the ship	Students were requested to carry a medium-size provision box from the main deck to stores, then to the galley and garbage station.
5) Evacuate an injured person from the laundry space to the main deck of the vessel	Students were requested to carry an injured person on a stretcher from the laundry space to the main deck.

These activities were developed to provide an opportunity for successful experiential learning based on Kolb's experiential learning model. Through these activities, the students were able to learn HF issues within the design of a ship by experiencing them while working and gained a better understanding of the practical aspect and the importance of HF and HCD for seafarers' life. For successful implementation of these activities, the researchers developed learning objectives, including establishing a clear understanding of workplace (onboard) processes, tasks, potential HF risks, and operational HF issues associated with the given practical task by doing, and establishing a clear understanding of the benefits of applying HCD approach to the design to produce usable ships by doing the given scenario.

Before, during, and after each activity, the researcher spent time with the students, having friendly discussions with them to change their 'common sense' viewpoint of HF by showing them the practical difficulties that seafarers face due to designers' 'uncommon' common sense. The researcher explained to them how 'common sense' changes among designers when making innovative designs, and that one idea of common sense is likely to contradict someone else's idea of common sense. Furthermore, the researcher requested that they spend more time with the crew members to study their daily tasks - by frequency and demand - and issues they face while performing the tasks.

In this research study, content analysis was used to examine the qualitative data that the researcher collected throughout. Content analysis refers to a family of procedures for the systematic, replicable analysis of written texts (speeches, letters, articles, video, films, or other visual communication messages). In essence, it involves the classification of parts of a text through the application of a structured, systematic coding scheme, from which conclusions can be drawn about message content. Therefore, through content analysis, it is possible to distil multiple words into fewer content-related categories (Berg & Lune, 2012; Krippendorff, 2018; Vaismoradi et al., 2013).

Verbatim transcription of each onboard activity video recordings was completed using NVivo software following the procedure as described by Wiggins (2017). This is a basic method of transcription without indication of nuances or body language, so that purely the spoken content and steps of the activity can be analyzed. Notes were made on each video to establish the subject conversations. Transcripts of all videos went through a quick peer review process, including a review by all the researchers involved in the study. The coding process was then started, and the NVivo software enabled these transcriptions to be coded and compiled in one place. Coding was first completed on a portion of the data transcribed. The lead researcher then presented it to the other researchers to get their feedback and refine it. Qualitative data collected through both surveys were also analyzed using the same approach. As an overall summary, a 6-step process of content analysis was used as a framework to code content and define common patterns within the data: (1) familiarization with the data; (2) generating initial codes; (3) searching for categories among codes; (4) reviewing categories; (5) defining and naming categories; (6) final reporting. Three members of the research team independently reviewed the findings. This was followed by a group meeting where the researchers presented their reviews to validate individual interpretations of the qualitative data and establish final results.

3.1 Ethical framework

Relevant ethical approval for this study was granted by the Tasmania Human Ethics Research Committee (HREC). Before data gathering began, all potential participants were informed about the project, including their right to withdraw at any time. Those who opted to participate signed an informed consent form. A detailed explanation of the study was provided to the ethics committee, including a justification for the choice of participants, how participants would be recruited, identifiability of the data, the extent to which confidentiality would be maintained, the procedure of the study, including the methodological approach, the methods of collecting and analysis of data, how the researcher would store the data securely, and the procedure used to obtain consent from participants. The ethics approval numbers for the survey activities are H0014268 and H0014412.

4. Results

4.1 Classroom questionnaire

A total of 24 students participated in the classroom survey. A total of 24 responses were received; none of these were rejected, since the participants gave all the necessary information. Upon analysis, the results were described under the key 3 categories listed below.

Awareness of HF and HCD

None of the students had experience onboard ships before. They were not aware that HF is a scientific discipline concerned with the application of what we know about people and their abilities and characteristics, limitations to the design of equipment they use, environments in which they function, and jobs they perform. The majority (70 %) believed HF and HCD are nothing more than the application of “common sense”. They did not appreciate that “common sense” is disreputably uncommon.

Awareness of existing ship design standards and HF and HCD guidelines

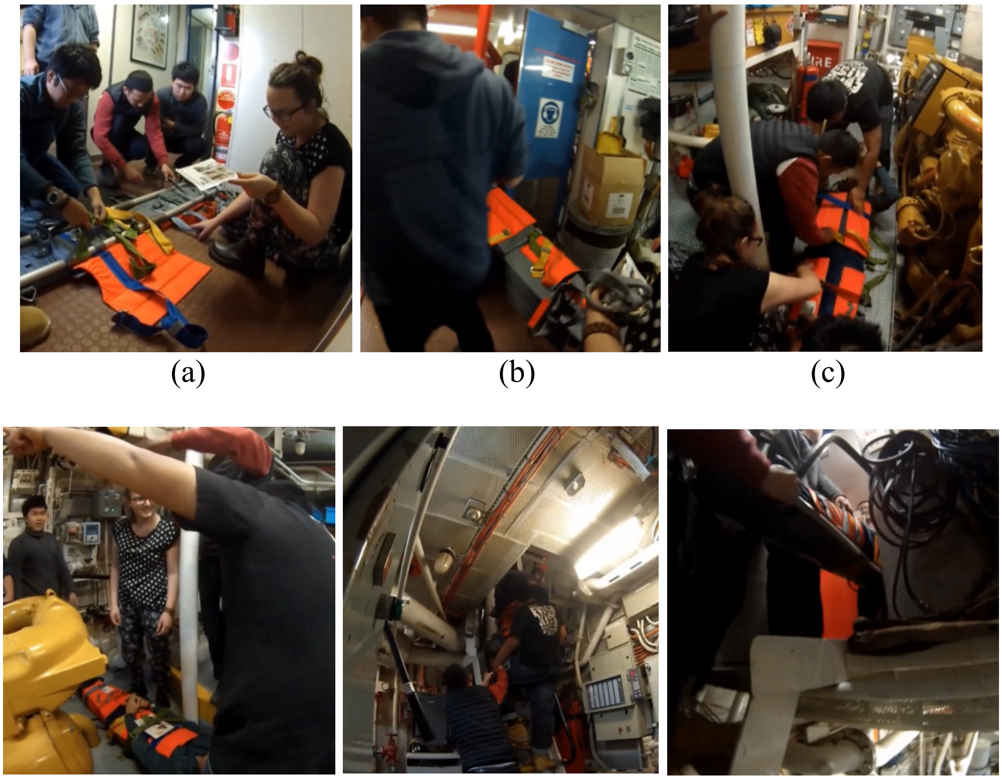
None of the students were aware of good practice HF guidelines available for ship designers to refer to during the design process. However, all students were aware of the codes, rules, and regulations which are compulsory to be approved by any classification society. The majority (85 %) of the students believed that the existing ship design standards, rules, and regulations are sufficient to minimize HF-related issues onboard a ship. They were not aware that conformance with these standards is insufficient to achieve good usability of ship systems. None of the students had been exposed to maritime HF or HCD-related topics during their undergraduate studies. The majority (70 %) agreed that the HF, HCD related education had not yet been included in their education system and, therefore, unawareness among the ship design community may have led to the situation where the current ship design process neglects an HCD approach.

Approaches suggested by the students to address HF issues onboard ships

The majority suggested that if the users (seafarers) were well-trained and notify about the potential issues, most onboard accidents could be eliminated. Among the respondents, 25 % of them emphasized that designers are responsible for problem elimination in the initial design stage, 8 % of them suggested shielding against the problem, and 17 % of them suggested warning the operator. The remaining 50 % suggested training the operator to avoid the problem.

4.2 Onboard activities and student record sheets

A total of 24 students participated and 50 responses were received (10 responses for each activity). The findings demonstrate how students' onboard experiences influence their learning process by doing, discovering, reflecting, and applying. The researcher noted the difficulties related to design issues that students faced while performing the activities, especially while carrying an injured person from the engine room to the main deck (**Figure 1**). They tried different ways to carry the stretcher with an injured person on it and sometimes they failed due to obstructions within the access path or due to poor design considerations given to stairs and landing spaces.



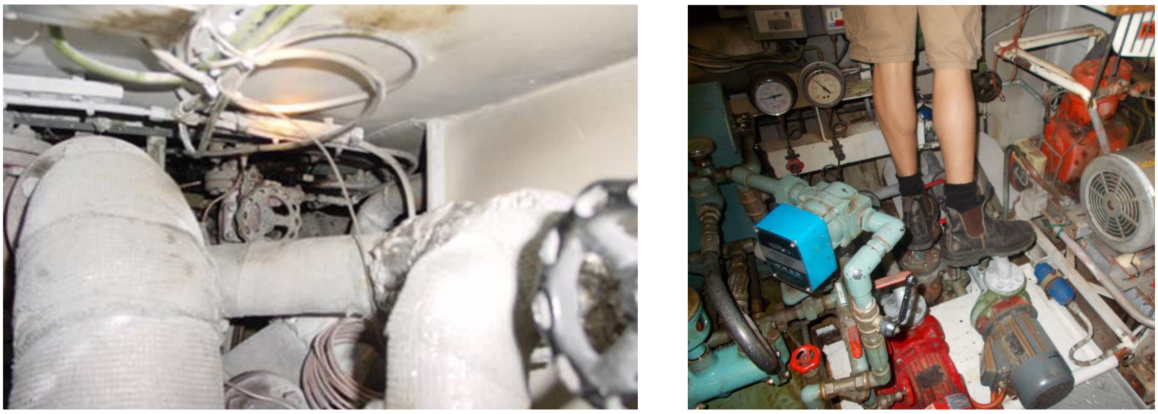
(a) (b) (c)

(d) (e) (f)

Figure 1 Photos taken during an onboard activity: (a) Assembling the stretcher; (b) Door obstructions while carrying the stretcher down to the engine room; (c) Strapping in the patient; (d) Discussing different ways of carrying the patient; (e) Stretcher with a patient - almost vertical due to poor design of the stairs - and the struggle to turn the stretcher due to inadequate landing space; (g) Door obstructions while carrying the patient to the main deck. (Pictures used with consent).

The following statements were given by students after the first activity:
"I learned how difficult [it was] even assembling the stretcher. It also needs a lot of patience. So, imagine in such an emergency situation if you are not able to carry the injured person safely, then you are so stressed. So, I know how important [it is] to think these things [through] when we design layouts."
- a student after the evacuation activity.

While performing the second activity, students discovered that there are frequently operated valves which have very poor accessibility, as seen in **Figure 2**.



(a) (b)

Figure 2 An activity of students checking accessibility/operability of valves inside the engine room. (a) Regularly used valve position leading to awkward work posture; (b) Operators' position to reach a valve.

While checking the space utilization in accommodation and recreational spaces, they were able to identify design failures such as insufficient headroom, poor accommodation layout, insufficient ventilation, insufficient natural lighting, and excessive vibration in the room next to the engine room. After the provision transporting activity, the students realized the importance of analyzing the logistical and personal access routes during concept design to identify the most user-friendly and efficient path to accomplish the task. The following statements were given by students after the 4th activity:

It was good that the boxes were empty. Otherwise, it could have been just a dream for me to carry heavy provision box from [the aft loading deck] of the vessel to all the way forward of the vessel (provision stores) passing such obstructions. Cannot imagine how this is possible for the staff.
-a student after the carry provision activity.

The following statements were given by students after completing all the activities:
It was [more] difficult to evacuate from [the] laundry space than [from the] machinery space. Even space was also limited to assemble the stretcher inside the laundry. Personal access routes were extremely poor. It took [a] long time to think of what to do and how we carry the stretcher upstairs. If the person was really a patient, then he would have died.
-a student after completing all the activities.

"I personally recognized HF as nothing more than common sense. But after all these activities, my experience 'common sense is not common for all' with some serious examples, that changed my mind. No doubt that all designers must take this approach into consideration if he or she wants to make both users and client happy. I will make sure I always consider HCD in my career."
-a student after completing all the activities.

"I [am] completely convinced and learned that, as a future designer, we must consider these emergency scenarios when we design ships. Otherwise, that design will dissatisfy the users of it. They will for sure blame us."
-a student after completing all the activities.

"I now clearly understand that we cannot blame operators or users for human error. The root causes for the mistakes often might be linked with many other factors, mainly design issues. The designers should be aware of real operational issues onboard ships."
-a student after completing all the activities.

Based on their individual experience after performing the activities, they realized the significance of including HF in the early stages of the ship design process. They identified issues and design improvements to advance the overall safety of the ship and comfort of the seafarers (**Table 2**).

Table 2 Design failures and improvements identified by students after HF-related onboard activities.

Design issues	**Improvements**
The current design has steep stairs, insufficient landing spaces	Redesign the stairs to reduce the steepness and increase the landing space and width.
Poor accessibility and operability of valves	Redesign according to the users' requirements especially based on the operating frequency.
Poor accommodation layout design	Needs more privacy, space, storage space, improved headroom, sufficient natural light in accommodation.
Insufficient headroom everywhere	Increase headroom clearance throughout the ship.
Poor working environment	Users' working scenarios have to be properly analyzed before designing the layouts of ships.
Accommodation close to machinery space and excessive vibration	Modifications need to be done to reduce vibration.
Cramped entry and exit points	Many entry and exit points must be modified.

It was encouraging to see that all the students were able to recognize the benefits that seafarers may receive by applying HF and HCD, and their feedback was given as follows:

- less chance of accidents & better safety;
- reduce fatigue;
- seafarers' job satisfaction;
- seafarers will have ships that are comfortable and safe for them to operate;
- improved workflow;
- longer working life;

- can increase efficiency;
- can increase productivity; and
- decrease the risk of personal issues.

As an overall summary, the students' HF and HCD perspectives were highly influenced by the onboard activities. There was no negative feedback on the facilitation, guidance, and knowledge dissemination approach. Once the activities were performed and the survey was completed, all of the students requested the introduction of HF and HCD themes in their degree course for them to gain in-depth knowledge.

4.3 Researcher's reflections

The researcher understood that reflecting on actions and their outcomes will be salient points to re-plan the research actions in new ways in light of results, which ultimately then becomes the next cycle of action and reflection. Therefore, the researcher used her research journal and the survey findings to make reflections throughout the process. Furthermore, to make the representation transparent, the researcher used quotes from students as widely as possible (see above Section 4.2). The researcher also did not forget to discuss the summary of the research journal with the primary supervisor and co-supervisors, who have experience in AR projects. They reviewed the reflections, opinions, and interpretations of the collaborative process with participants. The researcher's key reflections can be summarized as follows:

- Maritime design education is often articulated as biased towards the technological field, thus missing HF and HCD components;
- The positive influence that the onboard activities based on experiential learning pedagogy had on the students' HF and HCD perspective and understanding made the researcher pleased;
- The researcher understood the significance of providing future maritime designers with seagoing training within their undergraduate studies and integrating such HF activities into their curriculum; and
- The researcher realised that the HF-related onboard activities are a good practical method for students to understand many operational issues that seafarers face and to appreciate the significance of using HF and HCD concepts during the design process.

As an overall summary, the survey findings and the researcher's reflections were incorporated to plan the next action cycle, which is a follow-up lecture series to integrate HF and HCD knowledge into the maritime design undergraduate curriculum. The following key areas are identified to be addressed in a new follow-up lecture series:

- fundamental principles of HF, HCD, and HF methods;
- development of an understanding of the nature and application of these principles and methods in complex socio-technical systems;
- demonstrations of the importance of safety and comfort for the life of a seafarer and the designer's responsibility to integrate HF and HCD into ship design; and
- how to become a usability champion in a working environment where other employees are not aware or interested in HF.

5. Discussion

Findings from the classroom survey can also be supported by the findings of previous research studies done by Walker (2011) and Rasmussen (2005), which reported that the maritime education system is heavily biased towards the technological field and lacking subjects related to maritime HF and HCD. One of the recurring themes found during the survey was that the majority of students suggested using designers' 'common sense' to design user-friendly ships, which is an embarrassing defensive attitude shown by the future ship designers. Thus, it was understood that there is a great need to introduce maritime HF and HCD knowledge into the maritime undergraduate syllabus and teach them in a systematic and engineering-oriented fashion.

Experiential learning theory suggests a holistic integrative perspective on learning that combines experience, perception, and cognitive behavior. Experiences comprise knowledge, skills or observation of event gained through involvement in that event. Therefore, the design of onboard activities has focused on the implementation of experiential learning to improve student engagement and learning experience.

The findings of experiential learning activities performed onboard demonstrate how students' experiences influence their learning process by doing, discovering, reflecting, and applying. The experience they gained by doing the activities and being onboard with real users (i.e., a ship's crew) encouraged them to reflect upon what they have experienced. When the students were given the opportunity to understand real HF issues by partaking in them, they learned that design shortcomings can affect the mental workload of seafarers, some can affect the crew's ability to sleep, and others affect the level of physical stress, which can then lead to poorer operations and an increased risk of failing at the task, as well as increased human errors and fatalities. Students learned that, if they are not familiar with seafarers and ship operations, then impressive innovative designs may be less satisfactory for end-users. Also, this changed their view on human error, and they learned that HF and HCD need to be considered in ship design to help to reduce the potential for human error if seafarers are to operate ships and systems safely and effectively.

The students developed a strong bond with the ship's crew throughout their onboard time and grew through a series of confrontational experiences, such as doing day to day activities with users. They gained an appreciation of 'the ways of the sea' and of 'the ways of the seafarer' to produce ships that are 'usable'. The majority (92 %) of the students recognized that the experience supported the construction of a new perspective and new interpretations of the past. As a result, most importantly, students' 'common sense' perceptions of HF and HCD were transformed. They learned that 'common sense' changes between designers when making innovative designs and that one idea of common sense is likely to contradict someone else's idea of common sense. Furthermore, the responses establish their eagerness of having an in-depth HF and HCD knowledge during their degree course.

The results showed that the pedagogy of experiential learning not only made the students technically functional but also enabled them to be better engineers as a result of their understanding of the real-life content of their engineering education. The pedagogy of experiential learning, therefore, can be used as a theoretical framework to integrate new non-technical knowledge into the maritime design education system and to motivate students to utilize their knowledge in the design process. This will support them to become skillful designers, with technical as well as non-technical skills for more user-friendly designs.

As an overall summary, the experiential learning process was highly effective and offered students a hands-on, collaborative, and reflective learning experience which helps them to perceive HF and HCD as an added value in terms of physical, psychosocial, and organizational improvements onboard ships. Also, they identified HF and HCD knowledge as an essential addition to their undergraduate course. Most interestingly, the findings of both surveys are couched in the optimism of having designers with improved HF and HCD knowledge for the future maritime industry by influencing fresh minds.

Quality issues in relation to research methodology must be viewed within the context of the particular research paradigm (Efron & Ravid, 2020). Greenwood and Levin (1998) said that "rigour, credibility, validity, and reliability in AR are measured by the willingness of the participants to act on the results of the AR". In this research study, rigor and validity are enhanced through multiple approaches to data collection (triangulation) and the creation of opportunities for confirmation and disconfirmation (dialectical processes). Data triangulation was achieved by a combination of data collection methods, such as classroom questionnaire, onboard activities, and an onboard survey using activity record sheets. Also, investigator triangulation was achieved by involving more than one investigator in the research process. The lead researcher shared the findings with the other 2 researchers in the team and also with a few faculty members at AMC to receive their feedback.

Furthermore, the active involvement of participants provided a climate of supportive critique in which only quality interpretations could survive. The summary of the results, the researcher's reflections, and interpretations were explained to all the participants during and after the data analysis was performed. This allowed participants to correct errors and challenge the researcher's interpretations. Furthermore, the researcher emailed the summary of results to all participants of this study, hoping to further establish outcome validity for it. They did not show any disagreement with the results and reflections, rather stating satisfaction about the levels that they reached in HF and HCD understanding.

6. Conclusions

This study was performed to introduce HF and HCD non-technical topics into a more technical educational platform and to motivate students to utilize the new knowledge in their future profession. Third-year naval architecture students at AMC were the participants of this study. Firstly, a classroom survey was conducted to determine the students' current level of awareness and understanding of maritime HF and HCD. The findings of this survey showed that the maritime design education system does not provide students with enough HF knowledge and experience to understand and appreciate user requirements and user perspectives.

This research study then focused to supporting the improvement of this situation and, therefore, it explored the success of the classic argument of "learning by doing", or experiential learning or active learning, which is a major student-centered learning tool that has relevance where learning is not only real-world based but a function of activity. Five HF-related activities were introduced during a 7-day voyage onboard the AMC research vessel. These activities provided an opportunity for the students to experience experiential learning, and offered all the elements that are key to successful experiential learning based on Kolb's experiential learning model.

The following conclusions can be drawn from this study:

- None of the maritime design undergraduates who participated in this study had been exposed to maritime HF or HCD before the commencement of this study. The majority (70 %) believed HF and HCD is nothing more than the application of "common sense". They did not acknowledge the influence of HCD on the life of seafarers. With a philosophy of learning by doing, experiential learning activities effectively transformed the students' 'common sense' perception about HF and HCD. It is found that meaningful experiences can lead to a change in an individual's knowledge and mindset.
- The experiential learning process was highly effective and offered students a hands-on, collaborative, and reflective learning experience which helped them to perceive HF and HCD as an added value in terms of physical, psychosocial, and organizational improvements onboard ships.
- Through applying the pedagogy of experiential learning to the selected maritime course unit, it is identified that the students had been engaged in a deep learning process through their experience. As a result, they identified HF and HCD knowledge as an essential addition to their undergraduate course. They learned-to-learn by doing. This highlights experiential learning as being a "paradigm of noteworthy learning" that supports multiple learning objectives for learners, including shaping their knowledge through experience.
- Restructuring of a more technical-oriented engineering unit by applying experiential learning theory has provided the opportunity for students to get in touch with the real-practical world and, therefore, gain an appreciation of 'the ways of the seafarer'. As a result, the experiential learning opportunity was found to be enjoyable, enhanced the course offering, and possessed course features that can be implemented in the future.

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Appendix A

Classroom questionnaire

Instructions

This questionnaire can be completed in less than 20 min and all information provided will remain anonymous and be treated as strictly confidential. Your participation is valuable to our research and is highly appreciated.

1. Please respond to all questions.
2. Give your honest views without consulting others.

Submission of this completed survey implies your consent to participate.

1. How long have you been onboard a ship?

For a Visit		Up to a week		Up to a month	

More or less? Please specify

2. Did you ever learn maritime Ergonomics, Human Factors or Human Centred Design approach during your engineering education (undergraduate or school)? (if 'Yes', please go to question number 7; if 'No', please go to question number 9)

Yes		No	

(If 'Yes', please go to question number 4, if 'No', please go to question number 6)

3. How do you define maritime Human Factors?

4. How do you explain Human Centred Design approach?

5. Please circle the numbers to indicate whether you:

	Strongly Agree	Agree	Somewhat Agree	Somewhat Disagree	Disagree	Strongly Disagree
Human errors contribute to most marine casualties and accidents	1	2	3	4	5	6
Many of the underlying causes of maritime accidents are linked with Human Factor issues	1	2	3	4	5	6

6. Please list basic Human Factor issues onboard a ship that you know need to be addressed adequately.

7. Please rank the following in the order of importance for minimising or eliminating most of the onboard accidents linked with Human Factor issues.

Shield against the problem	
Warn the problem	
Design the problem out	
Train the operator/seafarer to avoid the problem	

8. Please explain your viewpoint/understanding about naval architects' responsibility to design user-friendly ships?

9. Please explain your opinion on the paramount importance of proper understanding of Human Factors and Human Centred Design by a Naval Architect to design usable ships.

10. Please list any maritime design guidelines support designers to incorporate Human Factor requirements into the design.

Record sheets - HF-related onboard experiential learning activities

Instructions

All information provided in this record sheet will remain anonymous and be treated as confidential. Your participation is valuable to our research and is highly appreciated.

1. Please respond to all questions.
2. Give your honest views without consulting others.
3. Fill in answers on separate paper.

Please note that the activities will be recorded and converted to still images to use in publications within the project period.

Submission of this completed Record Sheet implies your consent to participate.

1. Please name the activity you were involved in (number or name of activity).

2. Please explain the experience you gained by doing the activity and being onboard with the ship's crew.

3. What are the design failures which may cause discomfort or disturb work-flow for seafarers that you experienced during your activity?

4. What are your suggestions to improve the design failures you identified during your activity?

5. Based on today's experience, what is your opinion about applying HCD discipline in ship design? Please explain your answer.

6. What are the benefits you recognize that seafarers may receive by applying HCD to ship design?

7. Would you like to experience more of HCD?

8. What should we do better, and what should we do next?