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Application of Participatory Design in Solving Ergonomic Problems

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Abstract

AIM: The main focus in this research is pointed to the application of participatory design (PD) as an approach in which designers work together with users to create appropriate solutions to given problems.

MATERIAL AND METHODS: As an example, for design and development in which PD is applied, a task is established – finding a solution for improving the management and manoeuvring of a specific sailing ship. The redesign implies a comprehensive application of ergonomics, anthropometry and numerous tools for creative and design thinking, with the aim of ensuring the highest level of comfort, safety, ease of communication with the operator, good organization of space, and accessibility for all.

RESULTS: At the end of the research, several concepts are developed as solutions for the assigned task. The modelling and visualization of the final concept solution are made using modern software tools, as well as the creation of a simple prototype.

CONCLUSIONS: Through the process of redesigning the operating station of the particular sailing ship, the methods for PD and need for including all target groups and users to contribute with their different knowledge in the design process was emphasized.

Introduction

Participatory design (PD) is an approach applied in industrial design in which designers work together with potential users to create appropriate solutions for consumer products, information systems, organizations of workspaces, and various other humanitarian solutions. Understanding the complexity of collaboration is vital for planning and evaluating participatory design projects. Participatory design strives to implement more efficient, ethical projects, which is why it must focus on the interaction with the research participants, namely end users on one hand and designers on the other, and to understand the factors that influence this collaboration. When solving complex design tasks, a high-level conceptual model is also needed to clearly understand the factors that have the greatest impact on the user needs and how they are interconnected. In doing so, there is a need for testing and interaction with the concept model done by all participant groups present in the research to enable them to contribute with their different knowledge and experience.

Vehicles and transportation systems belong to the group of products which are complex to develop, in which the most advanced technologies, and strict standards and regulations are applied. In addition, their design implies a comprehensive application of ergonomics in order to ensure the highest degree of comfort, safety, ease of communication, good organization of space, and accessibility for all. In this sense, the design of safe sailing ships, especially ones intended for long distances, requires a wide range of skills, experiences and extracted knowledge from the captain and crew regarding: navigation, meteorology, the use of mechanical and electrical systems, radio communications, first aid, survival at sea etc., all of which are necessary for designing safe operation of the sailing ship. The most crucial aspects are in fact the comfort of navigation and steering of the ship, as well as the visibility of the horizon and from the ship's navigation control stations, located inside and outside the deck. Therefore, this research is focused on applying participatory design principles to generate improved solutions for the navigation station of a particular sailing ship, with the main goal to improve the comfort and safety.

Research Objectives

This research focuses on the application of participatory design as an approach to redesign the stations with navigation controls through which the

crew operates the sailing ship – “Paliador”. The goal is to ensure a successful redesign, which will ergonomically respond to the needs for comfortable and convenient access to all commands and control devices during navigation, with an emphasis on safety when performing this navigation process, as well as improving the visual field. With these design corrections, a provided improvement and facilitation of one of the most difficult operations during navigation – the process of parking the yacht in a port is expected. The initially established hypothesis for this research is that the application of participatory design and creative and design thinking tools can provide high quality solutions to user problems related with transport means, including sailing ships.

Research Methodology

In this research, participatory design was applied primarily as a design approach that offers solutions to design tasks that require specific expert knowledge in particular areas of human life. At the same time, it was necessary to apply methods and principles from the field of ergonomics and anthropometry to solve the specific assigned task – improve the navigation of the sailing ship “Paliador”.

The overall research was performed in the following phases:

1. Analysis of specific literature in the field of participatory design, user-cantered design, co-creation and similar research methods applied in industrial design. Ergonomic research in the field of vehicle control was also studied.
2. Analysis and presentation of existing design examples of sailing ships and yachts, sailing ships of similar size as “Paliador” and larger, analysis of their positive and negative characteristics, in order to extract useful information regarding the solution of the given problem.
3. Application of qualitative and quantitative methods – observation, detailed interviews, in order to precisely define the user requirements. Participatory design was applied through collaboration with the ship crew and conclusions were drawn about the main factors that make the navigation and management process difficult.
4. Generating and testing a prototype with several configurations and a focus group for an additional ergonomic research regarding the use of controls and visual fields of persons with different characteristics.
5. Defining main goals of the redesign, which would contribute to improving the navigation and management process of the yacht, and applying them in the creation of a concept presented as a virtual 3D model.

Design Thinking and Participatory Design

Participatory design is interconnected with design thinking processes which includes steps for solid understanding of the problem and user needs. There are several stages of the design thinking process which are often viewed as linear, but in practice this is not always the case. Some of the steps can be repeated several times in the design process, or even skipped [1]. By applying all the five stages of design thinking, the designer can come up with a new innovative solution: (1) understanding of the problem; (2) observing people in the performance of their daily activities in order to accurately define their needs; (3) using sublimated results of the previous two stages to clearly structure the problem; (4) generating as many concepts and conceptual solutions as possible; and (5) prototyping and testing.

To properly conduct stage 2 and stage 3 of the design thinking process, it is best to rely on participatory design methods. As mentioned in the introduction, participatory design is a process in which expert designers work together with stakeholders seeking to implement more effective solutions based on collaboration with research participants. To do so, it is also important to understand the factors that influence this participant-designer collaboration and its’ complexity so that the planning and evaluation of participatory design projects can be done correctly [2]. However, due to the different interests, experiences and expertise, difficulties in collaboration can arise. Reciprocal empathy can improve the connection with different stakeholders on a deeper level and as such, play an important role in encouraging closer internal and external collaboration [3]. This requires different roles, competencies and expertise from designers. In order to understand the context and the diverse and sometimes contradictory views of all the people involved, designers need to be interested in and empathetic towards all stakeholders. Empathy aims to understand what is important to people and how to use that understanding when: making design decisions, developing products, services and systems or imagining new meaningful and alternative futures. In collaborative design projects with multiple stakeholders, designers occupy a specific role, which requires a particular participatory mindset, behaviour, skills, and knowledge. Designers are often “facilitators” rather than design experts, as the boundaries between designers, users, and stakeholders blur. This requires designers to have an open, engaging, and curious mindset, good observational skills, and collaboration skills.

Ergonomics in the Design of Sailing Ships

Ergonomics is a multidisciplinary science which includes information from several fields, such

as psychology, anthropometry, biomechanics, anatomy, physiology, psychophysics. It involves studying human characteristics, abilities, and limitations and applying this information to the design and evaluation of equipment and systems used by humans [4]. The primary goal of ergonomics in the design of transport means is to design equipment that achieves the best possible fit between users/operators and equipment. In doing so, user safety (freedom from harm or injury), comfort, performance, and efficiency are improved. Designing transportation means involves the integration of inputs from many disciplines, and thus the knowledge of relevant professionals (e.g., designers, body engineers, chassis engineers, manufacturing engineers, product planners, market researchers, ergonomic engineers, electronics engineers). Design activities are driven by complex coordination and simultaneous consideration of many requirements, such as customer requirements, engineering functional requirements, business requirements, government regulatory requirements, manufacturing requirements, etc., and interconnection between the requirements of various systems in the vehicle. All ergonomic needs are considered early in the design process and are addressed to accommodate user needs.

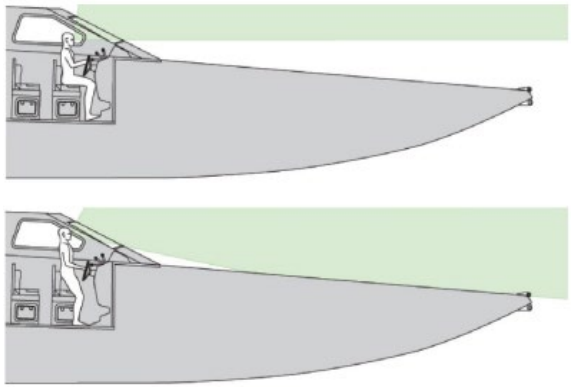


Figure 1: The line of sight in sitting and standing position in a closed super-fast boat (source Naci Kalkan [10])

When a human is involved as the operator or user of a product (e.g., a car or ship), all relevant human characteristics must be studied and used in the ergonomic design of the product. In addition, when designing a thorough understanding of the user population (anthropometric measurements) and the operating environment (e.g., roadway, traffic, weather conditions, and operating conditions such as dawn, day, dusk, and night) must be considered. When operating transportation means, the operator receives information available from various displays, for example: speedometer, fuel gauge, radio display, warning lights, warning sounds, symbols, view of the environment through the windshield and window openings, interior and exterior mirrors, etc. According to that information, the operator generates outputs (e.g., presses pedals and buttons, steers the steering wheel, etc.) with which s/he controls or changes the movement. Depending on the levels of different abilities and available resources, the operator/driver may or may not be able to perform an appropriate control action. The time required to perform an action will also depend on the amount of information he will have to process, as well as his or her information processing abilities. If the controls and displays are not designed to easily perform these tasks, the driver may not be able to complete the tasks in the time available or may even make errors. That is why the design of the control station in transportation means is of crucial importance when safety is considered.

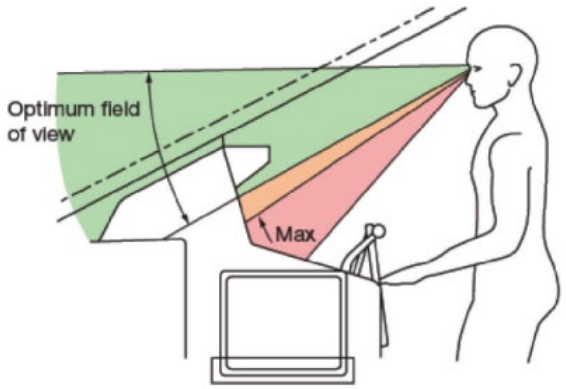


Figure 2: The optimal field of view of the workstation in a super-fast boat (source Naci Kalkan [10])

In this research, aside from the gathered information from observation and interviews with the cabin crew, data was also extracted from relevant literature sources and latter applied in the design concepts. This data mostly included ergonomic rules for designing according to different anthropometric measurements, appropriate design of chairs for users, zones of comfortable reach, optimal field of view, placement of controls, etc. [5], [6], [7], [8], [9].

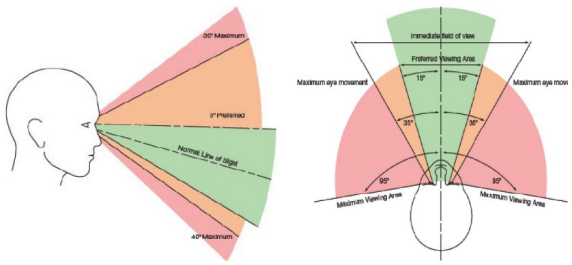


Figure 3: The optimal vertical and horizontal field of view (source Naci Kalkan [10])

When operating a ship from a navigation control station, many factors can directly affect the performance of crew members, and therefore they should be considered when designing the station [10]. Some of them are:

- correct eye position in relation to the visual field and the screens;
- correct postural support that can be provided by adjustable seat height, backrest depth and backrest angles;
- control of arm and leg reach according to hu-

man requirements.

The seating position and visual field when operating a ship from a navigation control station can be determined by considering the following situations:

- the crew should be able to observe the sea surface (horizon);
- the crew should be able to see the front of the ship;
- the crew should be able to see the marks placed in the water (usually buoys for signalling).

Visibility of the horizon is an important consideration for the captain and crew. While designing a navigation and manoeuvring control station, the requirements of different crew members need to be considered, such as the height of the eye position, in order to ensure optimal operational performance. The differences in the visual field from a seated and standing position should be considered (Figure 1). The most important information on the navigation control panel should be located within a range of 30 degrees horizontally and vertically measured from the centre of vision line (Figure 2 and Figure 3). Less important information can be positioned within 60 to 70 degrees, measured from the centre, and the remaining percentage belongs to the least important information.

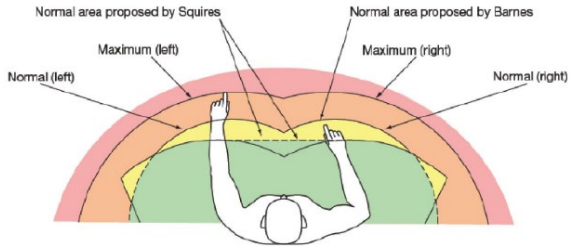


Figure 4: Effective reach parameters (source Naci Kalkan [10])

In addition, the working spaces, in this case the navigation and control stations, must be designed to be compatible with different human statures and characteristics (anthropometric dimensions). Furthermore, the parameters for an optimal vision field, as well as the parameters for reach, should also be observed (Figure 4). The controls should be easy to operate. The control panels, which are the most important and frequently used, should be easy to access and a normal working position for the crew members needs to be ensured.

All of this information was considered when creating concepts and 3D models for the redesign.

Participatory Design Task: Redesign of the Sailing Boat “Paliador”

As stated, this research aims to present the significance of the application of participatory design as an approach that enables the solution of complex design tasks such as the control and maneuvering of a sailing ship, where the operator and user are at the center of attention. To do so, a particular task was established – finding a solution for improving the management and maneuvering of the sailing ship "Paliador". The persons who manage and control “Paliador” were involved in the design process of finding the suitable solutions. The research was conducted through observation of the work and interviews with the two ship captains and the engineer/assistant captain. The initial interview conducted with the members of the sailing crew revealed that they have difficulties in navigating/managing the ship from both command stations. After analyzing this issue, a large number of methods and design tools were implemented in different phases of the design process, in order to provide potential solutions to meet the needs and achieve the requirements set by the sailing crew.

Observation

The observation process was done naturally while working on the “Paliador” during which time it was easy to see when and where crew members had a problem performing their work tasks. Information was collected and documented with photographs and notes and conclusions are described in this section.



Figure 5: Navigation control station on the “Paliador” ship

The placement of the navigation control panel inside the ship is not at the appropriate height, it is located below the clear open view of the horizon, meaning that the person steering the ship, in a sitting position, has difficulty seeing the real situation in front of, and even from the sides of the ship (Figure 5 and 6). The view is also obstructed by the lifeboat that is placed at the front of the ship, in front of the windows, where the navigation panel is located. There are instruments which are “trusted”, so the crew monitors the position of the ship via GPS. Radar is also used to additionally monitor water traffic. However, it is not often, but it can happen that some of these instruments do not provide accurate information, i.e. the system fails, etc. Add to this the fact that smaller

boats, and sometimes fishing boats, do not have a GPS signal at all, and they are not always clearly displayed on radar. In many cases, drifting wooden logs or containers that have fallen from large ships float on the open sea. This is a great potential danger and it would be good to see them in advance and avoid them, so as not to collide with them.



Figure 6: The crew of the ship "Paliador" during navigation and steering of the ship

Interview

In order to obtain as much useful information as possible that will assist in the process of redesigning and improving the control and navigation process of the ship "Paliador", an interview was conducted with the captain, assistant captain for navigation and with the engineer of the ship "Paliador". From the conducted interview a description of the navigation process was gained, together with clear and precise information about some discomforts when steering and manoeuvring the ship. Questions helped to gain knowledge regarding: the type of navigation instruments used on the ship; ideas for making the operating process more convenient; experiences when navigating another sailboat, other types of navigation instruments, issues and strong sides; ideas for design improvements that would make it easier to park and leave the boat from the dock; information that is shared between captains when they change "watch" while sailing; importance of the feeling of safety while operating the ship (being in a safe position, being attached to the safety straps/ropes on the deck, etc.); the role of parking sensors and possibilities for use in other situations besides parking; materials for a platform for the station/control panel inside the ship; etc.

From the interview conducted many conclusions were drawn and some of them, together with ideas regarding the improvement of the control station of the ship, are stated below:

- "if two boards with navigation controls and rudders were installed on the deck of the ship (on the left and right side), from a practical point of view, during sailing the visibility would be improved, since the one who is steering at the moment would be at a higher level of the ship when it is turning, there would be a greater visibility of the horizon and of approaching ships, and this type of design could also help a little when parking the ship in a port";
- "there is a need to replace the existing chair and add a new rotating chair with a different design, which will be fixed or with some kind of attachment mechanism";
- "there is a need to improve the view of the horizon when steering the boat from a seated position from the inboard control station";
- "there is no need to add a rudder to the inboard navigation control station, since the "Paliador" has hydraulic steering, we can add a joystick for steering";
- "the navigation instruments on the "Paliador" are relatively new and are specifically designed for sailing boats";
- "the idea of installing parking sensors/cameras needs to be further investigated and considered";
- "safety is of vital importance and is the number one rule".

Prototyping

For the purposes of this research, a simple prototype was developed for the navigation control station located inside the ship "Paliador". The purpose of the prototype was to provide answers to specific questions regarding visibility of the horizon and the environment, comfortable body position when handling the instruments of different users, as well as to discover possible issues early on in the research, and to redefine the concept.

The participants in this study included to test the prototype are people of different statures, as well as different ages (Figure 7). Their height varies from 157-178 cm. The testing was done to investigate positions of the controls placed at different distances and heights that all users would be able to reach while sitting on a chair with a fixed point of support. In the "Paliador", the chair only rotates around its axis and adjusts in height, but does not move, so the same chair characteristics were kept with the prototype. The focus of this prototype was the panel with buttons and navigation instruments, which is longer and placed parallel to the side of the ship. In this study, it was placed at 3 different angles – an angle of 120° (its actual inclination), and additionally inclined at angles of 135° and 140°. In addition, the location of the controls was changed – to the left side, and to the right side. Each of the users "A", "B", "C" and "D" interacted with the simulated control buttons 1, 2, 3 and 4, placed on the navigation panel, 12 times – 120° right,

120° left, 135° right, 135° left, 140° right and 140° left (with lowered chair) and 120° right, 120° left, 135° right, 135° left, 140° right and 140° left (with chair in the highest position). Sample photographs of the interaction of the participants (users) with the prototype are given in Figure 8, and the conclusions are elaborated below.



Figure 7: Physical differences between users – participants in the prototype testing

- *Navigation instrument panel with 120° tilt angle*

Users “A”, “B” and “C” could reach all the controls on the screen when placed in the right part of the panel (controls 1, 2, 3 and 4) both when the chair was raised and when it was lowered. When operating with the chair raised, user “D” could comfortably reach controls 2, 3 and 4, but control 1 was out of reach. When the chair was lowered, user “D” struggled to reach controls 2 and 4, control 1 was out of reach, and control 3 could be pressed.



Figure 8: Different users photographed interacting with the controls on the control panel of the prototype

Regarding the view of the horizon, all users preferred to be in a raised position with the chair, from which user “D” still saw the horizon with difficulty. User “C” had a slight obstruction of the view of the dashboard while operating with a lowered chair, user “D” had difficulties, while for “A” and “B” users it was still fine.

The buttons of the navigation instruments on the panel, when are placed on the left side, were easily accessible by the users. The problem occurred only for user “D” when steering the boat from a lowered chair, when the highest control, control 1, was unreachable.

- *Navigation instrument panel with 135° tilt angle*

Users “A” and “B” could reach all the controls on the screen when placed in the right part of the panel (controls 1, 2, 3 and 4) when the chair was raised, but when the chair was lowered, they struggled to reach the button 1 which is on the top, in the right corner. User “C”, when steering the boat with the chair raised, could reach all the buttons, but struggling with button 1. When steering with the chair lowered, however, button 1 was not reachable at all, button 2 was reachable with a little effort, and the remaining buttons could be comfortably reached. User “D” could reach only button 3 while steering the boat with the chair lowered. When the chair was raised, the user managed to reach buttons 2 and 4, but with difficulties. Button 1 was not reachable at all, and button 3 could be comfortably pressed.

Regarding the view of the horizon, “C” and “D” users preferred to be in a raised position with the chair, while “A” and “B” users could see the horizon even when steering the boat with the chair lowered. User “C” had little obstruction of the view while steering with the chair lowered, and user “D” had significant difficulty.

The navigation instrument buttons on the dashboard, when located on the left side, were easily accessible by “A” and “B” users at any height of the chair. User “C”, when steering the boat with the chair raised, could reach all the controls, while when steering with the chair lowered, could not reach control 1. User “D” could not reach controls 1 and 2 from any height of the chair. While steering from a raised position, the user could reach buttons 3 and 4, and when steering from a lowered position, only control button 4.

- *Navigation instrument panel with 140° tilt angle*

Users “A” and “B”, when steering the boat with the chair raised, could reach all the buttons on the screen when located on the right side of the navigation instrument panel. When steering from a lowered chair, user “A” stretched more to reach button 1, and user “B” stretched for buttons 1 and 4. User “C”, with the chair raised, could reach all the controls except control 1, and user “D” stretched a lot to reach controls 2 and 4, but did not reach control 1 at all. When steering with the chair lowered, user “C” could reach buttons 3 and 4, stretched for button 2, but did not reach button 1. User “D”, when steering with the chair lowered, reached only button 3.

Regarding the view of the horizon, all users preferred to be in a raised position with the chair, although they could also see from a position with the chair lowered, but “C” and “D” users still had a difficulty in viewing the horizon when operating with the chair lowered.

The navigation instrument buttons on the

dashboard, when located on the left side, were within reach for “A” and “B” users at any height of the chair. User “C”, when steering the boat with the chair raised, could reach all the controls, while when steering with the chair lowered, could not reach control 1, and for control 2 there was a need to stretch to reach it, while controls 3 and 4 could be reached. User “D” could not reach controls 1 and 2 from any height of the chair. While steering from a raised position, this user could reach buttons 3 and 4, and when steering from a lowered chair, only control button 4.

Concept development

Based on all gathered knowledge from observing, interviews, literature, examples, as well as the testing with a physical prototype the idea for the redesign formed and was developed and presented through a 3D model. The 3D visualization of the final concept solution (with a focus on the navigation control station located inside the ship) and obtaining realistic renderings was achieved using the Maya software program, where all basic and additional elements were modelled in detail, and then the appropriate materials, colours and textures were added to present the redesign as a whole.

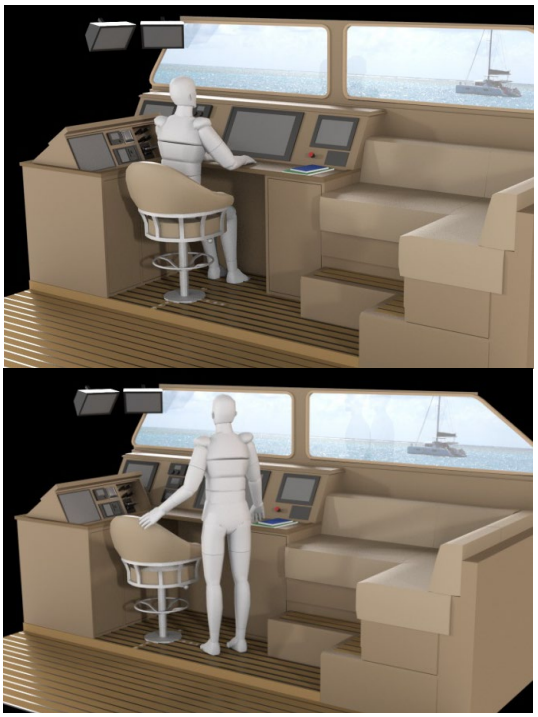


Figure 9: 3D visualization of the virtual model of the concept for the station redesign, with ship navigation controls and platform installation (at level 1)

When redesigning the station with navigation controls, many of the suggestions and ideas of the ship's crew were considered. In Figure 9, it can be seen that screens were added that would project images from cameras installed outside the ship, in order to facilitate the process of parking the ship in a port. Also, at the ship's speed adjustment lever, joysticks were added with which the ship could be moved left and right using the front and rear propellers.

From the examination of the physical prototype, the need for the installation of a platform to raise the level of the station was seen, that is a platform with two levels (level 1 for a taller person and level 2 for a shorter person). The need for two levels was realized during the creation of the 3D model, because a person with a height of 1.8 meters can be lifted onto a platform with a maximum height of 8 cm, because at any height above this the tall user would not be able to stand upright without hitting the roof. With this design, the sitting position of the tall user is comfortable as well, with the chair is placed at a normal height, according to standards.

To allow a clear view of the horizon for a smaller person steering the boat, the platform needs to be raised to a level 2, with a maximum height of 16 cm (Figure 10). In this redesign, the focus was to achieve the goal of obtaining a clear view of the horizon even for shorter crew members, while not disturbing the aesthetic aspect of the overall design.

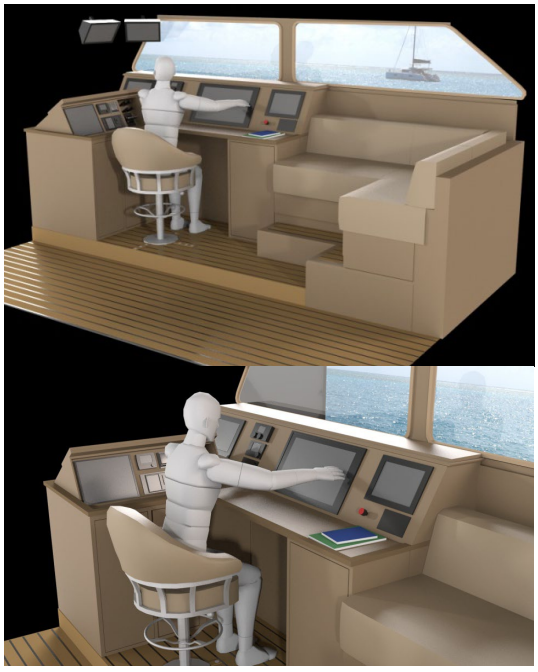


Figure 10: 3D visualization of the virtual model of the concept for the station redesign, with ship navigation controls and platform installation (at level 2)

When examining the physical prototype, it was realized that not only the height, but also other physical characteristics of a person play an important role in the comfortable reach of the buttons on the navigation panel, so if the instrument panel was tilted at an angle of 135° or more, it would cause difficulties for a certain group of people when steering the boat. Therefore, in the final concept model, the panel was placed at an angle of 130°, but as an addition, the possibility of moving the chair along fixed tracks on

the floor was included (Figure 11). This was done to allow accessibility to all buttons for any person of different size/height.

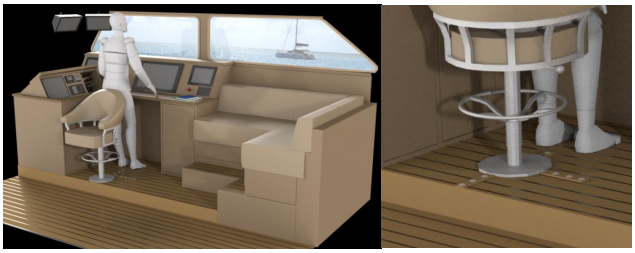


Figure 11: 3D visualization of the virtual model of the concept for the station redesign, with a person in a standing and seated position, showing the option for chair movement

Conclusion

The goal of this research has been achieved by successfully presenting the significance of the application of participatory design, as an approach that enables the solution of complex design tasks such as the management of means of transport, where the user is at the center of attention. As an example of a development process in which participatory design has been applied, the given task was to find a solution to improve the control and steering of the sailing ship “Paliador”. The ship crew members were involved in solving the given problem, with their specific knowledge and experience.

The entire process included the use of various methods as well as the creation of a physical prototype, with the help of which a detailed ergonomic analysis was carried out, and the specific requirements that the redesign should satisfy were defined, as well as additional analysis of all important factors. If implemented, the proposed redesign will certainly provide additional comfort, safety, improved visibility of the horizon and the environment, easy and comfortable handling. Weather conditions and influences, as well as sea level and turbulence, will not interfere with the navigation and use of control panels. The main goal has been achieved with small changes in the design, but still contributing to better visibility and comfort when navigating and steering the ship, appropriate to the age and differences in the physical characteristics of the crew.

In the development of concepts and models, several ideas obtained through interviews with the ship's crew were used, such as changing the height of the navigation control panel located inside the ship, changing the angle of the monitors and buttons, as well as finding a solution for the sitting position when steering. By installing cameras and screens at the helm station and navigation controls on the deck, the process of parking the ship in ports can be facilitated, and the process of managing the ship in general will be improved. The redesign was also inspired by existing examples, but above all by the crew's experience in navigating and managing ships and yachts.

Looking forward, the application of participatory design holds significant potential for further exploration, especially in complex systems where user interaction is central to safety, performance, and comfort. Future research will aim to expand the methodology to other domains such as public transportation, or assistive technologies, where ergonomics, inclusivity and usability are critical. For industrial designers, this approach is particularly important since it shifts the focus from designing for users to designing with users. It strengthens the social relevance and ensures that the provided solutions are not only innovative, but also deeply rooted in real human experiences. The participatory design framework offers a robust pathway toward more meaningful, ethical, and sustainable design practices in the evolving product and system development.

References

1. Lewrick M, Link P, Leifer L. The design thinking toolbox: A guide to mastering the most popular and valuable innovation methods. John Wiley & Sons; 2020 Apr 14.
2. Drain A, Sanders EB. A collaboration system model for planning and evaluating participatory design projects. International Journal of Design. 2019 Dec 1;13(3):39-52.
3. Smeenk W, Sturm J, Eggen B. A comparison of existing frameworks leading to an empathic formation compass for co-design. International Journal of Design. 2019 Dec;13(3):53-68.
4. Bhise VD. Ergonomics in the Automotive Design Process: Advanced Topics, Measurements, Modeling and Research. CRC Press; 2024 Jul 10.
5. ANSI/HFES 100-2007. Human factors engineering of computer workstations. Human Factors and Ergonomics Society. 2007.
6. Macey S, Wardle G. H-Point: the fundamentals of car design & packaging. (No Title). 2009 Apr.
7. Openshaw S, Taylor E. Ergonomics and Design A Reference Guide: Allsteel Inc. Muscatine, Iowa. 2006:52761-57.
8. Panero J, Zelnik M. Human dimension and interior space: A source book of design reference standards. Watson-Guptill; 1979 Nov 1.
9. Tilley AR. The measure of man and woman: human factors in design. John Wiley & Sons; 2001 Dec 31.
10. Kalkan N. Human Factors and ergonomic considerations for super-fast boat design. Environmental Science an Indian Journal. 2015;10(9):309-25.