COMPARATIVE STUDY OF HAND SKETCHING AND DIGITAL MODELING IN DESIGNING SUSTAINABLE OFFSHORE PLATFORMS

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Abstract:
Sustainable offshore platforms need inventive, technically precise, and ecologically responsible technology. Especially at the conceptual design stage, hand sketching and digital modeling stand out for their special benefits, including perfect correctness, precision, and attention to detail. Most contemporary approaches either employ sophisticated digital technologies or traditional drawing techniques, resulting in a lack of design inventiveness, insufficient early-stage environmental evaluation, and more rigidity. These restrictions endanger newly developed ideas and the integration of sustainability in the fundamental layers of design. This study provides a hybrid design method based on hand sketching and digital modeling (HS-DM). It lets first ideas proceed through standalone drawing, developing, and piloting in digital environments, stressing simulations and environmental checks on frameworks. This approach guarantees environmental and technical compliance while giving the best space for innovation. Case studies and expert interviews emphasizing sustainability limitations for offshore platform design helped to evaluate the method. The results verify that the hybrid method maximizes general design performance, increases creativity and flexibility, and considers sustainable design concepts at the early phases. The balanced use of the HS-DM technologies helps to create sustainable and effective offshore platform designs.

Keywords: Sustainable Design, Offshore Platforms, Hand Sketching, Digital Modeling, Conceptual Design, Design Workflow Integration.

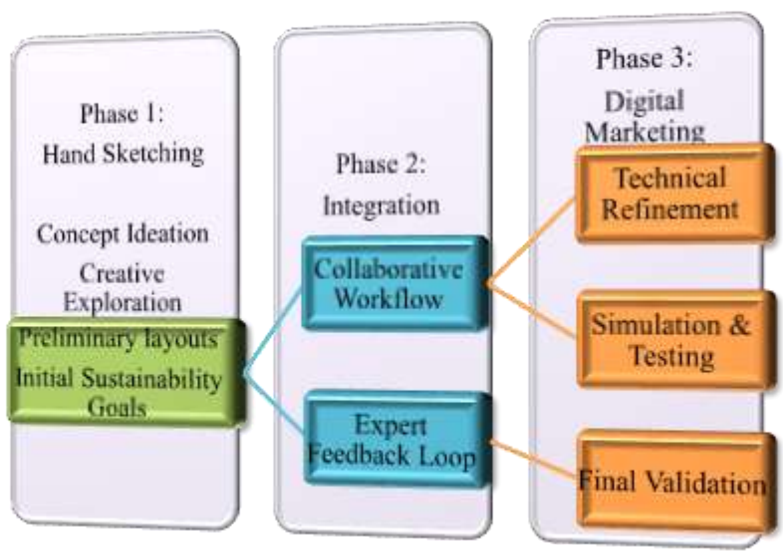

Figure 1: Graphical abstract

1. INTRODUCTION
2.

Preamble: Rising complexity in floating crane design calls for innovation, precision, and environmental sensitivity [1]. Since protecting the marine environment and lowering climate change are top priorities on the worldwide agenda [15], offshore engineering sustainability has grown in relevance. Sustainable offshore design is difficult at the idea-generating stage, as the first concepts influence the environmental and functional performance of the project [3]. For quick and easy generation of alternative ideas, architects and engineers have traditionally mostly relied on hand sketches [22]. Given its laid-back character, drawing encourages fast iteration, creative ideation, and larger vision [5]. Emphasizing precision, analytical capacity, and interoperability with simulation software, the design profession has been changed by the development of digital modeling tools in recent years [17]. Combining these approaches with the design process helps to investigate early structural efficiency, material use, and environmental effects [7]. Sometimes, computer technologies could stifle innovation and support rigid processes [23]. This work investigates how computer modeling and manual sketching can help to produce more environmentally friendly offshore platform designs [9][2]. The study contrasts their advantages and disadvantages to better grasp their roles in creating environmentally friendly solutions [19].Offshore platforms are famously difficult, given the harsh conditions and far-flung sites where they operate [11]. Therefore, key elements of sustainable design approaches are structural adaptability, energy economy, and marine biodiversity [24]. The design tools chosen directly influence the incorporation of these elements from the start. Case study analysis and interviews with designers define the approach of the research [13].

2. RELATED WORKS

2.1 Sketch-Based Modeling in Mechanical Engineering Design (S-M-MED)

This paper reviews mechanical engineering's current application of sketch-based modeling. It shows how early design stages, ideation, and creativity are improved by drawing[16]. The paper examines current tools and their inadequacies, particularly in integrating the digital environment[4]. One can improve the flow from sketches to CAD files in several ways. According to the study, using one's sketches will enable one to go from abstract idea to digital precision[10].

2.2 Deep Learning for Freehand Sketch (DL-FHS): A Survey

The investigation thoroughly evaluates deep learning methods for analyzing and producing freehand drawings. It lays out the pros and cons of the production framework, as well as the three main duties of acceptance and retrieval[18]. The research delves into the difficult endeavor of AI deciphering abstract artwork[8]. Topics covered include generalization, dataset limitations, and stylistic variation. The findings provide insight into potential future applications of AI and drawing together[6].

2.3 Hand Painter: 3D Sketching in VR with Hand-Based Physical Proxy (H-PP)

It shows Hand Painter, a virtual reality (VR) tool that uses hand gestures and physical proxies to enable natural 3D drawing[20]. Virtual drawing environments should thus be more immersive and controllable. Using the technique, users may more quickly and naturally create complex 3D forms than with more traditional approaches[21]. Both spatial knowledge and user contentment were determined to have grown throughout the assessment. The study claims that VR is a terrific tool for generating fresh ideas in design.

3. DISCUSSION
4.

The research proposes a hybrid framework for design termed HS-DM to help overcome the limitations of using digital modeling or hand sketching alone[12]. The method combines the intuitive and creative advantages of sketching with digital tools' precision and simulation features. Due to this comprehensive approach, early sustainability assessments help offshore platform design by encouraging innovation and validating technical components[14].

Conceptual Framework of the HS-DM Approach

Combining the best elements of old-fashioned hand sketching and modern digital modeling, the HS-DM framework helps to provide a more unified design process.

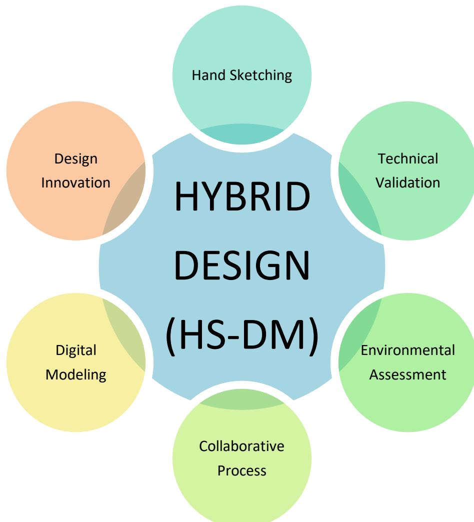

Figure 2. Proposed system overview

This approach uses free-form hand drawing for ideation, concept development, and intuitive spatial thinking. After the development of conceptual ideas, using digital modeling tools enables the running of simulations, design refinement, structural feasibility assessment, and environmental impact evaluation, as shown inFigure 2.Early integration of sustainability goals into the design process helps to close the distance between technical accuracy and creative expression. The HS-DM approach's basis is that no instrument can sufficiently satisfy the complex needs of building an offshore platform with sustainability.

$$\Delta OC(im + 1) = \sum_{i=1}^{n} A_s \frac{\Delta H^S(n)}{ec} \quad (1)$$

Equation 1 shows how design output changes ΔOC by iteratively modeling im for technical validation $(im + 1)$ and sustainability analysis A_s, then hand sketching for first inspiration $\Delta H^S(n)$. The iterative technique lets one meet ecological concern ec, accuracy, and innovation $\frac{\Delta H^S(n)}{ec}$ using a comprehensive design workflow.

Combining analog and digital methods, the framework supports a more environmentally friendly, creative, and well-rounded approach to design. This gives designers more freedom to be creative while fulfilling offshore engineering projects' strict technical standards.

Workflow Integration and Implementation Strategy

When combined with an iterative method that combines the numerical precision of computer modeling with the visual advantages of drawing, the HS-DM framework performs most effectively. The initial stage in the process is freehand drawing since it lets designers rapidly explore several concepts without restrictions.

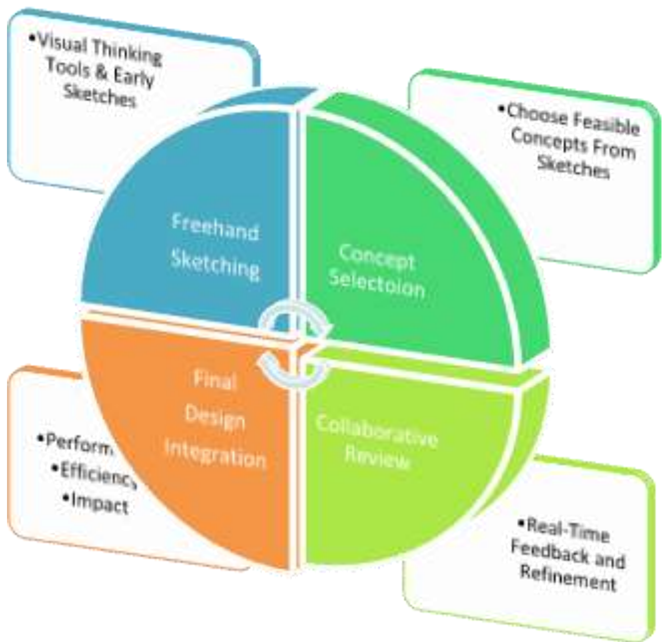

Figure 3:Workflow Integration illustration

These sketches might seem to early designs and visual thinking tools. Bringing the selected ideas into digital systems for environmental analysis, simulation, and accurate modeling comes next in figure 3. The digital tools help one evaluate structural performance, material efficiency, and environmental impact. Engineers, architects, and sustainability experts can collaborate in real time throughout this step to enhance the design. Feedback loops are considered in the design; hence, it's easy to go from sketching to modeling.

$$Cm = \arg\max\left(\sum_t\left(\Delta vn(hd)\right)^2 + pc * \sum_e |\frac{el}{cc}|\right) \quad (2)$$

As this Equation 2 shows, the ultimate design is achieved by combining computer modelingCm for accuracy and validation $\Delta vn$with early hand drawing(hd), therefore promoting creativepc experimentation$e$. Combining technical and creative elementsel, cooperative commentscc from multidisciplinary teams $|\frac{el}{cc}|$help to improve the design. In the framework of offshore platforms, this increases the general sustainability and quality of the design.

Further implementation support comes from tools for mixed-reality interfaces and digital sketch recognition. Apart from enhancing workflow efficiency, the approach ensures that sustainability and creativity are first important during the design process.

4. MATERIALS AND METHODS

5.

The effects of using the proposed HS-DM technique in offshore platform design projects with environmental consideration are presented in this part. These came from a combination of real-world case studies and professional interviews. Examined in connection with the hybrid technique are efficiency, creativity, and the inclusion of sustainability into the design process. Key performance criteria include the effectiveness of teamwork, the ability to assess the surroundings, the timeliness of designs, and the caliber of those designs.

Design Tools and Technology Integration

For hand drawing, used digital tablets to supplement initial ideas with more conventional tools like pencils and paper. Utilizing CAD programs, 3D modeling platforms, and environmental simulation tools, digital modeling was executed. For offshore platform building, early-stage sustainability evaluations were made possible by integrating both digital and analog technologies, which allowed for a smooth shift from creative to technical validation, guaranteed design continuity, and facilitated both integration.Digitalizing the sketches, they were included in CAD and BIM systems, including Refit, AutoCAD, and Rhino for exact modeling. Simulation technologies like ANSYS and Autodesk Ecotect were used to examine structural integrity and environmental performance.

Methodological Framework and Case Study Procedure

The case studies' offshore infrastructure relevance, complexity, and sustainability goals were considered when making the selections. This paper spoke with architects, maritime engineers, and sustainability consultants to determine how well the hybrid technique worked. Some key indicators were design time, creativity, teamwork, and environmental assessment integration. The HS-DM process was also evaluated against more traditional methods. The information collection tools were organized into conversation transcripts, evaluation of design sheets, and observation diaries.

Analysis of design efficiency

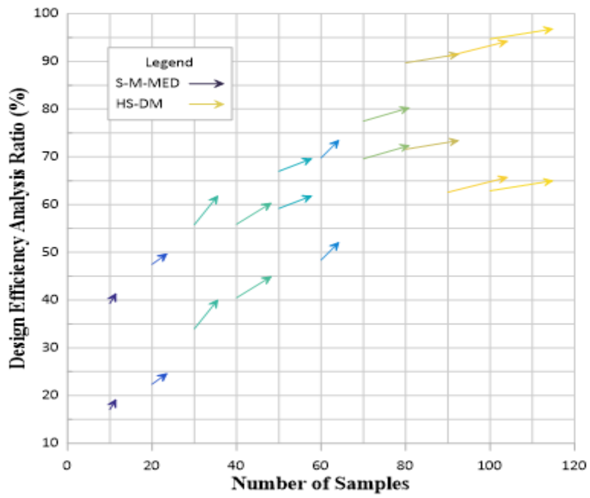

Figure 4: Design efficiency analysis

This paper investigate how the HS-DM framework affects design speed and agility, as illustrated in Figure 4. Concentrating on iteration count, concept development time, and sketch-to-digital model conversion ease helps hybrid integration increase workflow efficiency and expedite decision-making.

Analysis of sustainability integration

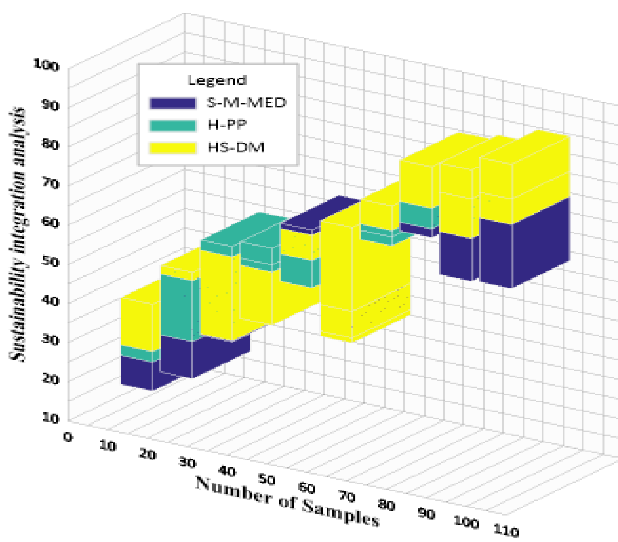

Figure 5: Sustainability integration analysis

This paper examines how effectively the HS-DM process's early design phases integrate sustainability concepts. The study shows how sustainable practices are more considered and combined throughout the process in Figure 5, from brainstorming to finalization, evaluating the effect of early visual ideas and digital simulations on achieving environmental criteria.

The HS-DM framework was validated using a structured methodological approach that included qualitative and applied research methodologies. Compared to traditional methods, the designers would first create rough drawings by hand for certain offshore platform projects.

5. CONCLUSION

The present work, combining current digital modeling tools with conventional hand-sketching techniques, presented an HS-DM for more environmentally friendly offshore platform construction. This approach lets designers integrate environmental responsibility with innovation by bridging the gap between artistic inspiration and technological validation. Case studies and expert evaluations indicate that the HS-DM approach improves early-stage designs, supports multidisciplinary cooperation, and facilitates sustainability analysis. The framework promotes better offshore platform design methods by using the best aspects of digital and manual tools.

Future research will include new technologies like artificial intelligence and augmented reality into the HS-DM process. These technologies could transform real-time visualization, data-driven sustainability evaluations, and design automation. Other maritime engineering initiatives will also undergo more extensive testing to ascertain the hybrid method's scalability, industry applicability, and training needs.

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