OBE-based Design Thinking Model for Computer-aided Design Courses

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Abstract. This paper explores the integration of Outcome-Based Education (OBE) and design thinking in CAD courses for product design education. OBE provides a framework to cultivate students' design thinking and innovation skills, ensuring their preparedness for future careers. The proposed OBE-based Design Thinking Model (ODTM) incorporates the four components of OBE into the design thinking process. The case study on a household air purifier design demonstrates the application of ODTM in a 3D modeling and rendering CAD course. By integrating OBE and design thinking, CAD courses promote critical thinking, creativity, and problem-solving skills, while ensuring reliable assessment aligned with learning outcomes. Overall, this approach equips students with the necessary skills to excel in their future careers.

Keywords: Computer Aided Design · OBE · product design education · Design thinking model

1 Introduction

Computer technology has had a profound impact on the field of education, including the teaching and learning of CAD courses within the context of product design education [1]. Ensuring the effectiveness and relevance of CAD courses in product design education necessitates the adoption of teaching methods aligned with the expected learning outcomes. One such method is Outcome-Based Education (OBE), which emphasizes clear learning objectives and utilizes instructional strategies and assessment to achieve those objectives [2].

OBE is a student-centered educational philosophy that prioritizes the desired learning outcomes. In the context of CAD courses in product design education, the application of OBE provides a structured framework to cultivate students' design thinking, problem-solving, and innovation skills. By defining explicit learning outcomes, OBE ensures that the design of educational programs equips students with the necessary skills and knowledge for their future professional development. Within the background of product design education, OBE offers a structured framework to address the limitations of traditional instructional models. It enables educators to clearly articulate specific learning outcomes related to design thinking, problem-solving, and innovation

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skills, which are crucial in product design practices. By integrating design thinking principles into instructional design, OBE-based CAD courses and product design courses facilitate a comprehensive mode of learning that goes beyond mere proficiency in CAD software tools [3]. Students are encouraged to engage in critical thinking, unleash their creativity, and simulate real-world design challenges through iterative problem-solving processes. Furthermore, OBE advocates for active learning, where students actively participate in their educational journey. They are encouraged to take ownership of their learning, engage in self-assessment, reflection, and continuous improvement. By aligning assessments with explicit learning outcomes, OBE provides a reliable assessment of students' mastery of product design knowledge and their ability to effectively apply design thinking principles [4].

However, there is currently a lack of specific implementation frameworks when it comes to integrating OBE principles into CAD courses within the realm of product design education. While existing research has explored attempts to apply OBE in CAD education, more detailed and systematic guidance and implementation approaches are still needed within the domain of CAD courses in product design education.

In conclusion, OBE offers a valuable framework for designing and implementing CAD courses in product design education, with a focus on the development of design thinking and innovation skills. By defining clear learning outcomes, aligning instructional strategies, and implementing effective assessment, OBE ensures that students possess the desired abilities and are well-prepared to meet the evolving demands of the product design field. Integrating OBE principles into CAD courses within product design education paves the way for a comprehensive and impactful learning journey for students, equipping them with the skills needed to excel in their future careers.

2 Propose the OBE-based design thinking model ODTM

Based on the principles of OBE and the design thinking model, this study proposes a teaching model (fig.1) called ODTM (Outcome-Based Design Thinking Model) that integrates the four key components of OBE, namely definition, implementation, assessment, and utilization, into the design thinking process. The ODTM model divides the design thinking process into three main stages: preparation stage, ideation stage, and visualization stage, aiming to guide students in developing comprehensive design thinking abilities and achieving the expected learning outcomes. The specific steps of ODTM are as follows:

Preparation Stage:

1.1 Define Design Objectives: Clearly articulate the design objectives to be achieved in the course, such as solving specific problems or meeting user needs.

1.2 Competitive Information Collection: Students work in groups to collect relevant information and data on competitive products related to the design objectives.

1.3 Needs and Competitive Analysis: Analyze the needs and functionalities of the competitive products, and establish a competitive analysis information table.

Ideation Stage:

2.1 Generate Innovative Strategies: Utilize tools such as TRIZ (Theory of Inventive

Problem Solving) [5] to propose innovative design strategies.

2.2 Product Function Layout Analysis: Employ CAD software and finite structure methods to analyze the functional layout of the product.

2.3 Product Form Exploration: Combine morphological charts [6] with CAD software to explore and converge on the final design solution through a divergent and convergent process.

Visualization Stage:

3.1 3D Modeling with CAD Software: Utilize CAD modeling software such as Rhino to create three-dimensional models of the design concepts.

3.2 Rendering with CAD Software: Use CAD rendering software like Keyshot to add materials, environmental settings, and lighting effects to the product form.

3.3 Graphic Presentation: Employ layout software to create graphic presentations that explain the inspiration, value proposition, and usage steps of the design concept.

By following the steps of the ODTM model in instructional design and implementation, students can develop comprehensive design thinking abilities and achieve the desired learning outcomes in the CAD course. This model provides a guiding framework for educators to integrate OBE principles and design thinking methods, enabling students to have a more impactful and practical learning experience in CAD education. Figure 1 illustrates the overall structure of the ODTM model.

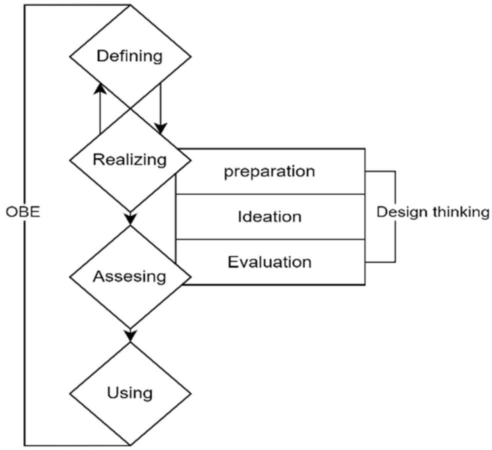

Fig. 1. OBE-based Design Thinking Model for Computer-aided Design Courses

3 Case study

In this study, the ODTM (Outcome-Based Design Thinking Model) was applied in the CAD course of 3D Modeling and Rendering (1). This section explains how ODTM was implemented in the instructional process using a case study of a household air purifier design.

3.1 Preparation Stage:

In the preparation stage, the teacher first sets the design objectives. According to the curriculum plan, the design of an indoor air purifier is used as the design objective for the CAD course. This serves as the final assignment for the CAD course. By doing so, students have a clear goal, which helps promote motivation for learning. Secondly, students are divided into groups and tasked with collecting relevant information about air purifiers. The information gathering process should include specific keywords, databases used, and search strategies employed. Thirdly, students analyze the collected information in terms of functionality and extract design strategies, similar to a design heuristic approach. At the end of the preparation stage, all the gathered information is compiled into a competitive analysis information table.

3.2 Ideation Stage:

During the Ideation phase, students were tasked with using TRIZ to propose innovative strategies for product development. They employed the finite structure method to combine the functional units of the product in various forms, resulting in several initial layouts. Furthermore, within their respective groups, students drew specific configurations for each functional unit based on the initial layouts and organized them in a chart. This approach, known as the morphological chart method, effectively facilitated the divergent and convergent exploration of design details within the conceptualization phase. In the final stage of this phase, students combined different functional units and their respective styles within the morphological chart, ultimately generating several preliminary product concepts.

3.3 Visualization Stage:

In the visualization stage, students utilize the 3D modeling software Rhino 7.0 to transform the design concepts derived from the previous step into tangible forms (Fig.2). Rhino 7.0 offers a wide range of tools and functionalities that allow students to accurately depict the various details and shapes of the product. By using Rhino 7.0, students can establish highly precise three-dimensional models of the product, thus laying a solid foundation for subsequent rendering and visualization work.

Once the basic form modeling of the product is complete, students employ the 3D rendering software Keyshot to add textures and lighting effects, enhancing the realism and specificity of the product design concept (Fig.3). Keyshot is a professional rendering software that provides an extensive library of materials and lighting options, enabling students to effortlessly simulate various materials and lighting setups. By importing the design concept into Keyshot, students can achieve lifelike rendering and visualization of the product, effectively showcasing their design concepts and creativity.

Finally, to further refine the presentation of the design concept, students utilize Photoshop for layout and post-processing. Photoshop, being a powerful image editing software, offers a plethora of tools and effects that allow students to make precise adjustments and modifications to the rendered images. By employing Photoshop for layout and processing, students can add text, annotations, and other graphical elements to the design concept, enhancing its professionalism and visual appeal.

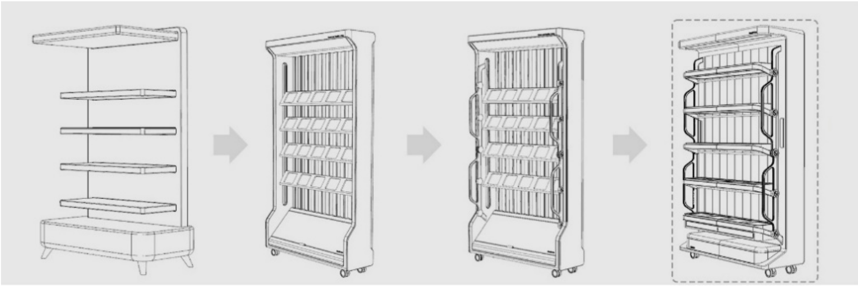

Fig. 2. Product shaping derivation by 3D modeling software Rhino

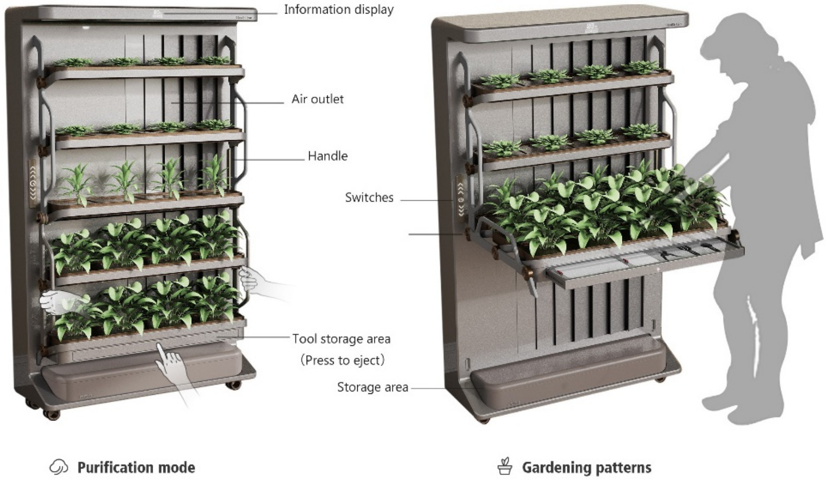

Fig. 3. The product design solution is finally rendered by keyshot and typeset by Photoshop.

4 Conclusion

This paper explored the integration of Outcome-Based Education (OBE) principles and design thinking methods in CAD courses within the context of product design education. By adopting OBE, CAD courses can be structured to enhance students' design thinking and innovation skills, ensuring their preparedness for future professional development in the product design field. The OBE-based Design Thinking Model (ODTM) was proposed as a guiding framework that incorporates the four key components of OBE (definition, implementation, assessment, and utilization) into the design thinking process. A case study was conducted to illustrate the implementation of ODTM in a CAD course on 3D Modeling and Rendering. The case study demonstrated how ODTM was applied to the design of a household air purifier. The integration of OBE principles and design thinking methods in CAD courses enables students to go beyond mere proficiency in software tools and engage in critical thinking, creativity, and real-world problem-solving. By aligning assessments with explicit learning outcomes, OBE ensures reliable assessment of students' mastery of product design knowledge and their ability to effectively apply design thinking principles. In conclusion, the adoption of OBE in CAD courses within product design education provides a valuable framework for cultivating design thinking and innovation skills. The ODTM model offers a structured approach to instructional design and implementation, empowering students to excel in their future careers by equipping them with the necessary skills and abilities to meet the evolving demands of the product design field.

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