IT FOR SOCIETY, Vol. 09, No. 02
ISSN 2503-2224

Effects of AI Image Generator Application on Student Cognitive Load in Design Studies

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Abstract*— AI image generator applications have been widely developed for various purposes in the process of creating fine arts and designs. One of them, OpenArt, provides a facility to develop sketch images into realistic images. This study aims to examine the effect of using this facility on students' mental burden in presenting ideas into realistic chair designs. Fourteen interior design students were involved in this study. The experimental method was used, where they were asked to work on the design of a lounge chair through the stages of sketching manually and with OpenArt. From the two steps of work before and after using this AI application, students were asked to fill out a questionnaire regarding the mental burden they felt. With descriptive data analysis, the experiment showed that OpenArt had a positive effect in helping to reduce students' mental burden in translating ideas into realistic images of chair designs. From these results, it can be concluded that this AI application is considered useful for the design learning process, especially in helping students substantially realize their original ideas without having to be burdened by the mind to work on technical visualization matters alone.

Keywords*— Furniture design, cognitive load, Artificial intelligence, OpenArt

I. INTRODUCTION

Interior design is one of the design disciplines and professions that offers a promising professional career to support the service and construction industries. Interior design offers a low-level role in supporting the needs of the development of human civilization and is closely related to sociological, cultural, psychological, and physiological problems that are constantly changing over time, making it more complex and dynamic to study and apply in society. On the other hand, furniture, as an important element of interior design, is an object in a building that is often in direct contact with its users such as chairs, where sitting ergonomics becomes a vital science to study in order to produce the right design solution, before fulfilling other values from users such as aesthetics, social and sitting culture. Furniture design requires a fairly complex analysis and synthesis process to understand the problem and solve it. In fact, for students in general, developing design ideas with realistic perspective images for a rattan chair is not easy to do or at least takes time.

With the presence of artificial intelligence technology AI in the form of computer applications, such as OpenArt AI, the need to simulate realistic images or images can be easily obtained through the transformation process from other images, including hand sketches. In general, the facilities provided by AI for design are limited to manipulating existing image images into various modes, therefore until now there has been no research that specifically discusses how AI-based computer applications can help students and lecturers in the process of teaching and learning furniture design. For students who are not yet proficient in drawing conventionally or using digital devices will still be constrained in creating realistic images. Therefore, researchers see the opportunity for the role of AI in supporting their learning process by looking at the role of AI related to the burden of thinking they experience when having to create realistic images, but so far there has been no research that tests the correlation of student cognition with the role of AI.

II. LITERATURE REVIEW

A. Cognitive Functions in Daily Life and Learning

Basically, the learning process involves various processes, including the attention process, where the brain through its senses will capture messages if there is a stimulus that attracts its attention (Motivelli, 2021). The second process is orientation, where humans use their brains to determine the direction in which they should choose and decide, both regarding travel or

career life. Next, the ability of the human brain is used to store messages, information, knowledge and experiences obtained by humans through sharing sources of information, other people and when taking lessons at school in memory. Apart from this, humans use their brains to carry out various daily activities (executive functions) in order to support their lives.

As social beings, humans need to socialize, which requires a brain to communicate. According to the Constructivist theory developed by Lev Vygotsky, the social environment, community and culture play a major role in the learning process, increasing knowledge and meaning. The presence of people around encourages increased interaction, exchange of knowledge and collaboration, thus stimulating the learning process to understand something. Therefore, the concept of the "zone of proximal development" (ZPD) helps teachers how they can provide support for students without violating student independence in building knowledge. Vygotsky also stated that knowledge is produced through dynamic interactions between individuals in a group in a community, to be discussed and solved together. Learning activities are the process of creating meaning, that is how humans interpret what is perceived from their experiences (Merriam and Caffarella, 1999, p. 260).

B. Creation of Meaning and Cognitive Load in Design

Meaning in design is vital. A product design by a research and development team usually refers to the vision of the developer or manufacturer and the target user market. The meaning contained in a product becomes the center of attention of every design development effort. In order for a product to have meaning for its users, an object must have utility value and must be able to demonstrate its usefulness, so that the product can be used effectively (Sunde, nd.). This is then studied specifically through the science of UX (User Experience) and UI (User Interface).

To create a product design that has a certain value requires various approaches between creativity, problem solving and decision making (Lavrsen & Daalhuizen, 2024). These two researchers quoted Sun et al. (2014) that to produce a good design an experienced designer needs to make more effort to think and perceive a wide intake of information (high cognitive load). The amount of information that can be perceived, filtered, and used for momentary activities (working memory) and stored for the long term (long term memory) for someone who is learning will be more limited (Alvarado, et.al., 2007). Therefore, appropriate learning methods and strategies are needed to study design which is a complex multidisciplinary science.

Good design is created by utilizing the right design principles and design elements. To be able to reveal all design variables in the image certainly requires a very representative visual quality or close to realism. Of course, it requires a very large cognitive effort (cognitive load) which is relatively difficult to achieve by inexperienced designers such as students who are just starting to learn. Therefore, a learning strategy is needed for students to manage cognitive tasks by utilizing existing sophisticated simulation technology and considering the mastery of design science that needs to be prioritized.

C. Artificial Intelligence to Help Humans

"Artificial intelligence", hereinafter written as AI, is a branch of computer science created to help humans solve problems in various cognitive-based fields (Cheng, 2022). Various AI-based computer applications have been developed to help humans develop pictorial or video messages to meet various needs, including education, business or marketing, entertainment, industry, medicine and so on (Dwivedi et.al., 2023).

AI works by combining algorithmic systems and machine learning, deep learning and natural language to build a program that is able to solve decision-making problems, language, and do various jobs that were previously done by humans (Dwivedi et.al., 2023). AI works based on data input, be it text, images or spoken words to then process and take decisions and actions based on algorithms by identifying patterns.

If the decision taken is not as desired, then AI will learn from the error, correct it and repeat the process above from the beginning in a different way to achieve more expected results. The algorithm may need to be re-adjusted to produce a more appropriate decision, and at the end of the process an assessment will be made of the final decision to conclude whether the final algorithm is considered sufficient to solve the main problem (Cikis and Ek, 2010; Kahraman, et. al. 2024).

D. Artificial Intelligence for Design

AI has been developed to support the performance of Adobe Photoshop and Illustrator to perform various image manipulation tasks much more efficiently. AI is also capable of performing tasks such as improving the use of color, object recognition, and controlling image dimensions. AI is even able to help designers predict how users are likely to react to the resulting design, so that this information can be used by designers to improve their designs in the hope that the user experience in using their design products will be more positive (Renaningtyas, 2022).

In general, there are several advantages that can be expected from efforts to integrate AI and Design, namely: increased efficiency, accuracy, more effective

use of funds, and a better user experience (Irbite and Strode, 2021). However, the use of AI for design can also have an impact on creativity, dependence on technology, bias in the resulting design, and weaknesses in AI in maintaining the privacy of personal data from being processed (Ivcevic and Grandineti, 2024).

In the world of education, AI should be able to help see the needs of individual students, identify strengths, weaknesses and preferences of students, so that lecturers can adjust their teaching according to the uniqueness of their students' profiles. With the help of AI, teacher feedback on student performance can be improved in objectivity and speed, something that is very useful for student progress. Learning with the help of AI may help improve the effectiveness of delivering information and knowledge, whether text-based, verbal or visual.

E. Visual and Motoric Skill Factors in Design Process

The brain plays an important role in the development of "visual motor skills" to guide humans when they have to face various problems in determining the sequence (alphabetic), reproducing or repeating previously decided actions (Motivalli, et. al. 2021). A student will use his brain's ability to improve his skills and knowledge according to the field he is studying in order to pursue his education. Especially for design students, they will use a lot of visual motor skills to study, analyze and understand design problems, and propose design solutions. The ability that has been trained since childhood to translate visual images into accurate actions needs to be further developed to support the creative process when undergoing design education.

Design students are not only trained to translate passive images, but also need to be actively trained to create design images based on a creative idea as a response to a design problem. Visualizing ideas through technical drawing by hand, stationery and drawing media will always involve thinking and "visual motor skills" so that the expected image representation is created.

Essentially, the more realistic a design image can simulate a proposed design idea, the better the perception of the design. The assessment process by lecturers on the design idea proposals submitted by students regarding related design problems will be based on the quality of the design drawings and the description of the thinking behind the idea (Cikis and Ek, 2010). Therefore, the quality factor of design drawings on the one hand and the ability to describe ideas on the other hand are things that need to get special attention in design education in general or furniture design in particular.

F. Problems in Studying Furniture Design

In interior design education, the learning process to master design skills is carried out through design practice courses in the studio as a simulation of activities carried out by professional designers in design consultant offices. In carrying out furniture design practices, students will be given assignments through case studies of design problems that must be solved by students according to their level of ability (Ayvaz & Yasar, 2024).

A furniture design concept is usually assessed through impressions (subjective impressions) or perceptions through multi-sensorial experiences, especially sight, hearing and touch, to capture the stimulus of a furniture design (Barbara, nd.; Spence, C. 2020). Each element of furniture design can of course always be manipulated by the variability of its formation, resulting in various design characters that will be perceived differently by each prospective user. This difference in the perceptions of prospective users is a problem in the delivery of ideas by students.

Given that the need for these design resources is very vital for students, lecturers and practitioners of the design profession, a strategy, method or even special computer equipment supported by AI is needed, given its increasingly sophisticated capabilities in taking over many human cognitive roles. (Cheng, 2021).

The choice of AI applications, such as “OpenArt” to support the creation of this solution is based on AI's ability to process large amounts of data, with the support of algorithmic work. So far, AI, especially the Image Generator application, has not been studied for its ability to solve the problem of transforming ideas based on sketch images into realistic chair design concepts (Dwivedi, et. Al. 2023).

G. Research Objectives and Hypothesis

The objectives of this study are:

- To explore how Artificial Intelligence, such as OpenArt, can help support students' skills with confidence, especially in visualizing chair design styles realistically.
- To investigate the effectiveness of AI-based tools, such as OpenArt, to assist students as special learning partners who can support the process of creating meaning to produce quality furniture designs
- To evaluate the role of OpenArt in helping to ease students' cognitive load in developing designs and depicting them realistically based on two-dimensional design idea sketches

H. Research Question

- Can OpenArt AI platform express realistic furniture character design based on two-dimensional sketch?
- Can OpenArt AI help reduce the cognitive load of students in creating images in a more realistic way?
- How can AI be a learning partner for students in creating and drawing a design?

III. Analysis System

A. Research Framework

- Investigation of problems faced by lecturers and students in terms of communication to confirm if students are having difficulties in delivering ideas.
- Tools analysis, in this case, the OpenArt with the focus on Natural Language Processing (NLP) and Computer Vision (CV) that are able to interpret design-related terminologies

B. Research Steps

- Learn the commands in OpenArt AI that could help in answering the students' problem in visualizing ideas realistically.
- Conduct testing using a command to answer problems related to this research

C. Respondents

The respondents involved in the research are 15 students from President University Interior Design Study Program. The mentioned students are coming from batch 2023 who are taking the Furniture Design 2 subject with a focus on "Public Furniture Design". In the subjects, the students are learning based on a case study to design a lounge chair for a resort hotel in Tanjung Lesung, Banten, Indonesia.

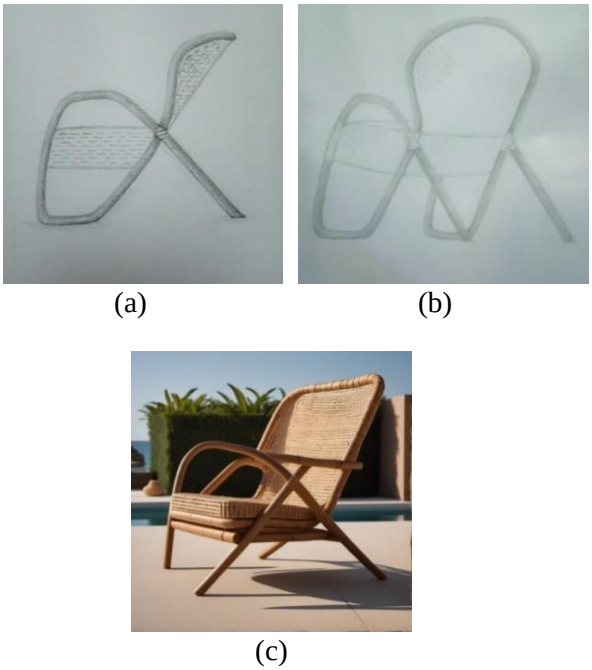
D. Research Procedure

- As the part of the research, after the brainstorming activity, respondents were asked to choose and develop a thumbnail or the side view sketch by rendering to make it look as real as possible
- Then, from each rendered thumbnail image, they were asked to develop it into a three-dimensional or perspective design using hand rendering techniques to produce a realistic chair design image from a slightly sideways rear perspective
- Each rendered thumbnail image above was also developed with the help of OpenArt using the "Sketch to Image" facility to produce a realistic chair design.
- Then students were asked to fill out a "Cognitive Load" questionnaire with Likert-type periodic answer choices. The goal was to test whether they felt that the support of the OpenArt application could reduce the burden of thought or not and to evaluate the attitudes or opinions of respondents towards the role of this technology to support learning furniture design.

IV. Result and Discussion

A. Result

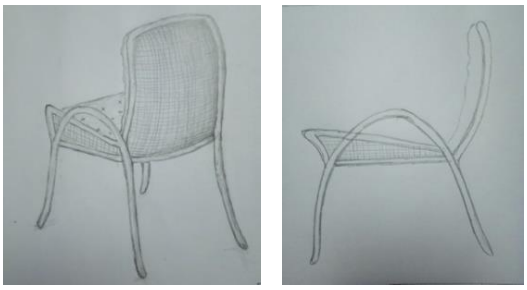
1. The two samples below show the results of thumbnail development, manual rendering of the lounge chair design by students and OpenArt.
2. The rendering result of one of the "thumbnails" of the student lounge chair design that was developed by hand into a final design with realistic hand drawings and developed into a final design with the help of OpenArt. (See Figure 1).
3. Rendering of one of the "thumbnail" designs for another student chair that was developed by hand into a final design by hand, and developed into a final design with the help of OpenArt (See Figure 2).



(a) (b)

(c)

Figure 1. a. Result of rendering thumbnail of lounge chair design, b. Manual design development, c. Design development with the help of OpenArt



(a) (b)

(c)

Figure 2. a. Result of rendering thumbnail of lounge chair design, b. Manually developed design, c. Design development with the help of OpenArt

- From the questionnaire distributed via Google Form, the following descriptive analysis results were obtained:
- As many as 92% of students stated that they rarely use OpenArt AI
- As many as 92% of students stated that they were beginners in using OpenArt AI.
- As many as 40% of students stated that they agreed and 13.3% stated that they strongly agreed, 33.3% stated that they were neutral, and only 6.7% strongly disagreed and 6.7% disagreed that depicting furniture designs realistically was considered complicated without assistance.
- As many as 46.7% of students stated that they agreed; 6.7% stated that they strongly agreed, 6.7% stated that they disagreed, and 40% stated that they were neutral, that the use of OpenArt made students focus more on the design aspect rather than the technical aspects to produce realistic images.
- As many as 40% of students agreed, 46.7% were neutral, 6.7% strongly disagreed, and 6.7% disagreed that OpenArt reduces the burden of thinking required to create realistic images.
- As many as 60% of students stated that they agreed, and 40% stated that they were neutral that the results of the OpenArt development made it easy for designs to be developed.
- As many as 66.7% of students stated that they agreed, 13.3% strongly agreed, and 20% were neutral that OpenArt saves time in creating realistic images compared to the manual method.
- As many as 46.7% of students stated that they agreed, 6.7% strongly agreed, 6.7% disagreed and 40% were neutral that OpenArt helps students focus more on the creativity and conceptual aspects of design.
- As many as 60% of students stated that they agreed, 6.7% strongly agreed, and 33.3% were neutral that OpenArt as a partner in drawing has improved my understanding of furniture design.
- As many as 60% of students stated that they agreed and 40% were neutral that they felt confident in their realistic drawing skills after using OpenArt.
- As many as 40% of students stated that they agreed, 13.3% strongly agreed, 6.7% disagreed, and 40% were neutral that in carrying out the process of drawing furniture designs realistically
- As many as 60% of students stated that they were quite bored, 26.7% were very bored, and 13.3% were a little bored in carrying out the work of creating realistic furniture images.
- As many as 80% of students stated that they were somewhat less saturated, 13.3% were very less saturated, and 6.7% were slightly less saturated after using OpenArt.

B. Discussion

To answer the first research question, the results of the experiment show that OpenArt is able to create chair design images with a quality that is close to the original image or realism. This means that the quality of the image can be considered qualified to assess whether the chair design answers the demands of the task giver or not, without being disturbed by bias that may occur due to the poor quality of the simulation image. The images produced by OpenArt can also be considered more representative than the achievements of the images produced by students. The time required by OpenArt to transform one hand sketch image into one three-dimensional model image with a quality that is close to realism is no more than 3 minutes.

However, it can be acknowledged that the results of the transformation of the modeling image from the hand sketch may not be in accordance with the student's design expectations. This is acceptable because the design sketch in the form of a side view is not detailed enough to describe the design expected by the student. In fact, the student may not have imagined what kind of

design could be produced from the appearance of the chair depicted from the side. So the results of the transformation by OpenArt can be considered as a way to provoke further design inspiration. Because in reality, OpenArt can be ordered to produce several alternative design models from just one design sketch depicted from the side.

To answer the second research question, related to OpenArt's ability to reduce students' cognitive burden in creating realistic images, it can be confirmed from several answers to questionnaire no. 1, where 53.3% of students stated (agree and strongly agree) that creating realistic images is felt to be very complicated without assistance. Implicitly, it can be confirmed that the role of OpenArt is very helpful in fulfilling the task of the image..

From the results of this questionnaire, 40% of respondents who stated neutral and 6.7% disagreed, seemed to be biased or ambiguous answers, this was confirmed by the quality of the students' three-dimensional sketch images (See Figures 1 and 2 as samples of the quality of students' achievements in general) which were very far from the quality produced by OpenArt. This answer would be acceptable if the quality of the three-dimensional model sketch images approached the imaging results by OpenArt..

The second research question was also confirmed from the answers to questionnaire no. 3, where 46.7% agree and strongly agreed that OpenArt's assistance could reduce cognitive load in creating realistic images. As in the answer to question no. 1, that 46.7% of respondents who stated neutral did not seem to show the actual facts, it was proven that the three-dimensional sketch images produced manually by students were very far from the details as produced by OpenArt (See Figures 1 and 2). The second research question can also be answered from the answer to research question 4, where 60% of respondents stated that OpenArt reduces students' thinking efforts to create realistic design images. The remaining 40% of respondents who answered neutral were not reflected in the quality of the results of their hand drawings which were far from the image of realism..

A more convincing answer to the 2nd research question is by reading the results of the 11th questionnaire, where 93.3% of respondents answered somewhat to strongly agree that OpenArt helps reduce students' boredom in creating realistic design images. This fact is also supported by the answers to the 10th questionnaire, where 60% of students answered somewhat bored and 26.7% very bored when asked how bored they felt in creating realistic design images, and 13.3% stated slightly bored.

To answer the third research question, as an addition to the study of the role of AI partnerships in helping students' learning process. The results of the study from the first questionnaire answers showed that OpenArt was felt by more than half of the respondents to feel the complexity of the drawing task without OpenArt's help. If the remaining respondents' answers are assumed to be biased, the number of those who felt helped would be much greater. From the answers to the 8th questionnaire, it was confirmed that OpenArt was felt by 60% of respondents as a helpful partner in improving their understanding of how realistic design images are created. The answers to the 9th questionnaire also supported the role of OpenArt partners by showing that 53.3% of respondents stated that OpenArt increased their confidence in creating realistic design images..

From the explanation of the answers to the research questions above, it can be concluded that the role of AI has helped significantly in helping the student learning process, especially in creating three-dimensional design modeling through realistic images (Cheng, 2021; Dwivedi, et. al., 2023; Renaningtyas, 2022). Although this has only been tested on students in the second year of school where their drawing skills seem not yet ideal or far from the impression of realism.

Confirmation of OpenArt's role in substantially reducing cognitive load in creating realistic images is relevant to Alvarado, et.al. 's (2007) statement that their new learners' abilities are limited, especially in absorbing information, selecting it for immediate use and storing it for later use. OpenArt's technical role in helping students create realistic design images is also in line with Irbite and Strode's (2021) statement, where AI will greatly assist humans in carrying out work efficiently, accurately and with a better user experience..

The answer to research question 3, related to the role of OpenArt partnership in helping the learning process, is in line with Lev Vygotsky's social constructivist theory, where students feel their self-confidence has increased in creating realistic images after the presence of OpenArt as their learning "partner".

V. Conclusion

As a conclusion of this study, the results of the study can answer all research questions quite well accompanied by evidence of experimental data that was carried out and the results of the respondents' questionnaire answers. Where the respondents' answers showed a positive attitude towards the role of AI or OpenArt in helping students to create realistic design images. Likewise, students responded positively to the presence of OpenArt in answering the main question of this study, namely the role of OpenArt in reducing the cognitive burden of students, especially in working on design imaging tasks. The role of OpenArt as a learning

partner was also responded positively by students.

Although the results of the study show positive signs about the role of OpenArt as a sample of the many AI applications offered, it does not mean that this application can be considered ready to be applied in the design learning system in general. Given some possible weaknesses of this study, namely the number of respondents is still limited, the sample of students is not ideal because it does not represent the level of student ability in designing and drawing.

The descriptive method of this study is not enough to be able to show the significance of the effect of one special treatment to be tested, for example in this study, the determination of the use of OpenArt can be reviewed; control of the course of the experiment, especially when respondents carry out drawing tasks, is still constrained; the questionnaire to measure students' "cognitive load" needs to be reviewed to allow for a pure experiment, where the measurement of this value is carried out repeatedly in conditions after students have done the drawing task manually and after using OpenArt. In this way, the significance of the results to answer the effect of OpenArt on students' Cognitive Load can be answered more ideally. However, as an initial stage of research on the role of AI or openArt and/or other applications, these results can be used to perfect all aspects of the research needed, especially if the aim is to provide a contribution to design and AI science and the possibility of its application in Design Education.

VI. Acknowledgement

The author would like to express a gratitude towards the President University Interior Design Study Program that provided all the necessary facilities to conduct this research. The author would also thank all the students and the study program that became the part of respondents in this important research.

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