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# JGED

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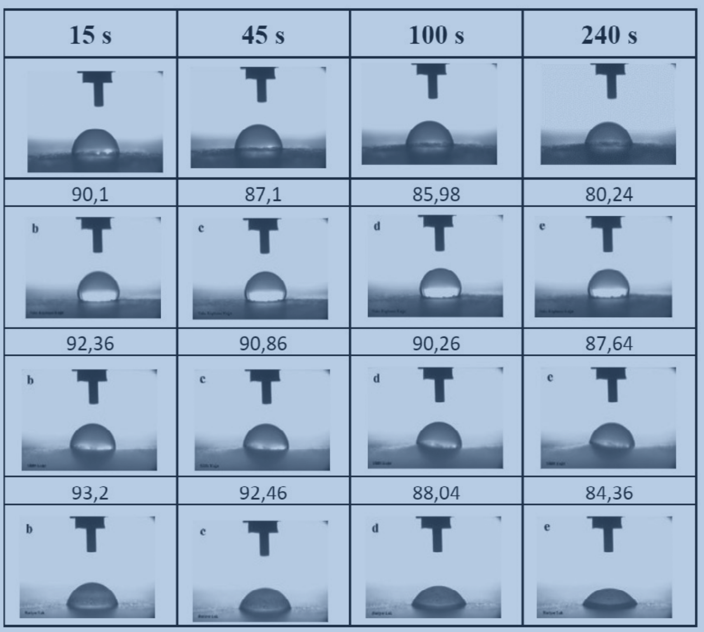


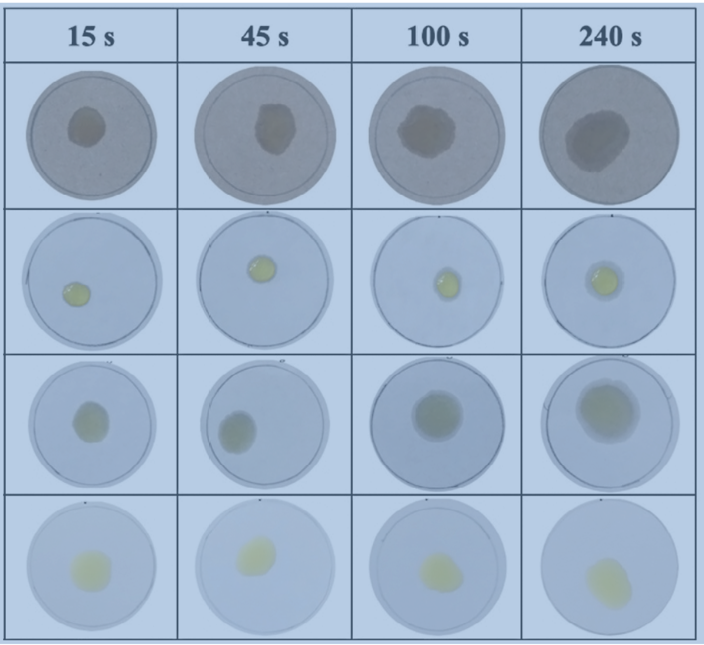


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# Oil and water resistant of packaging papers


**ABSTRACT**

*The permeability of paper and cardboard materials is extremely important for packaging safety. However, paper and cardboards have poor liquid resistance due to their naturally porous structure and the hydrophilic character of cellulose fibers. When packaging papers are exposed to liquid effects both from inside (by the product) and outside, they may become deformed and cannot fulfill their duty of protecting the product. For this reason, the resistance of packaging papers to liquids (water-oil, etc.) should be well known in order to make a selection appropriate to the content of the products. In this study, the effects of air permeability, liquid contact angle and surface energy values of various papers and cardboards used in the packaging industry on water and oil resistance were experimentally investigated. After determining the air permeability of the papers, liquid contact angle and liquid absorption measurements were carried out using the Sessile water drop method for surface wetting characterization. The surface energies of the papers were calculated depending on the liquid contact angle. Then the oil absorption of these papers was determined by measuring the time-dependent absorption of Castor oil. Differences in liquid resistance between papers were demonstrated and evaluated based on the air permeability of the papers, water contact angle, surface energy and liquid absorption. It was concluded that the wettability and surface energy of papers are the determining factors in water absorption, while air permeability is the determining factor in oil absorption.*



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## Introduction

Interest in eco-friendly, biodegradable, recyclable and renewable paper and cardboard packaging materials instead of synthetic packaging materials is increasing day by day.

Paper materials can be used as primary packaging that comes into direct contact with the foods or as a secondary packaging that provides mechanical resistance (Tutak, 2025)

The main function of packaging materials is to protect the contents from contaminants, leaks and damage during the production, storage, transportation and sales processes, and to provide safety, convenience and economic benefit (Shen et al., 2021).

Nowadays, the demand for ready-made and packaged food or beverages is increasing day by day, and these food items are mostly presented in non-biodegradable, single-use synthetic plastic packaging. Disposable plates, cups and straws account for approximately 70% of total global plastic production (Hossain et al., 2021). Since most of the plastic packaging waste cannot be biodegraded, it causes environmental pollution and endangers the ecosystem and life (Azmin & Nor, 2020; Bastance et al., 2021). Recently, with the greatly increased anti-plastic sentiment, there has been an increasing trend towards green packaging materials based on renewable resources that are recyclable, compostable and/or biodegradable (Aydemir, Yenidoğan & Tutak, 2023; Nechita & Roman 2020). Cellulose-based paper and cardboard materials, especially sustainable and eco-friendly, attract great attention in packaging.

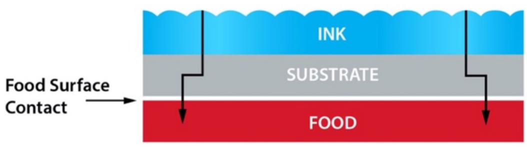
Compared to plastic materials, paper and cardboard materials have superior features in terms of being lightweight, biodegradable, recyclable, eco-friendly and low cost (Yenidoğan 2019; Herrera, Mathew & Oksman, 2017; Dai et al., 2021). When used as packaging materials, their good printability, mechanical strength, processability and ease of functionalization make them competitive.

Due to these properties, paper and cardboard materials are widely used in pharmaceutical packaging, food packaging, many other products such as paper bags, paper mats and paper placemat (Sheng, Li & Zhao, 2019).

However, depending on the content of the product, packaging paper and cardboard are expected to be resistant to liquids, especially water and oil. For example; Water and oil resistant paper and cardboard are needed for the packaging of refrigerated/frozen food labels, processed seafood, textile products, cosmetic products, paper filters and some other products. Therefore, knowing the water and oil resistance of paper and cardboard is critical for the safety of the product.

The liquid permeability of packaging paper is also important for printing processes. The resistance of papers to liquids determines the level of absorption of water, solvent and oil-based inks. The high liquid resistance of papers makes it difficult to absorb ink during the printing process and prolongs the drying time (Kandirmaz et al., 2020). In papers with low liquid resistance, ink is excessively absorbed by the paper layer (Yenidoğan, Aydemir & Ekinci Dogan, 2023).

In this case, the liquid phase of the ink (oil-water or solvent) penetrates the reverse side of the packaging paper (inside surface of the package) and may cause diffusion migration (Figure 1). Substances known as migrant ink components can penetrate from the printed side to the unprinted side of the packaging paper, and from there to the food due to their low molecular size (molecular weight <1000 daltons). This situation jeopardizes the safety of the product (contamination, etc.) in printed packages.




» **Figure 1:** *Diffusion migration (Yenidoğan, Aydemir & Ekinci Dogan, 2023)*

For all these reasons discussed above, the liquid resistance of packaging papers should be well known. In this study, the resistance of some papers to water and oil was tested in order to determine the right packaging material for different types of food and other products.

The effects of air permeability, liquid contact angle and surface energy parameters of papers on water and oil resistance were analyzed. Suggestions were made on choosing packaging paper suitable for the product content.

# Experimental

## Materials and Methods

The scope in study, the water and oil resistance of coated and uncoated papers (table 1), which are several commonly used in the packaging industry, were tested. As uncoated paper; Kraft Paper, Wrapping Paper, Sulphite Paper, as coated paper; Barrier Coated Paper (lacquered), Parchment Paper and Coated Paperboard were preferred.

Papers were obtained from companies operating in the packaging industry. After the samples were conditioned for 24 hours at 23±1°C and 50±2% relative humidity in accordance with the ISO 187:2022 standard, air permeability, water contact angles, water drop volume changes and oil absorption tests were performed and surface energies were calculated. All measurements were carried out in a conditioned laboratory environment.

## Air Permeability

The surface properties of the paper are extremely important in the process of settling and absorption fluids on the paper surface (Abd El-Rahman et al., 2021).

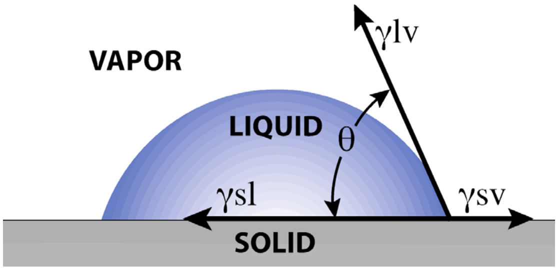
The permeability of paper and cardboard materials is related to their porous structure (Yenidoğan, Aydemir & Ekinci Dogan, 2023) and this porous structure is decisive for liquid permeability (Aydemir et al., 2021). Paper/boards have inherently poor barrier properties (low water and oil resistance) due to their porous structure and the hydrophilic character of cellulose fibers (Azmin & Nor, 2020). This limits the scope of application of papers.

Since the porosity of paper is not a directly measurable quantity, air permeability measurement is used to determine the porosity of paper. In this study, the air permeability of uncoated paper samples was measured with an L&W Air Permeance Tester (Lorentzen & Wettre, Kısta, Sweden) according to TAPPI T 460. Ten measurements were made from each sample and their averages were taken (Table 1).

## Water Drop Volume Change and Contact Angle (Wettability)

A liquid droplet touching a paper surface tends to both penetrate into the paper structure and spread over the surface (Aydemir, Karademir & İmamoğlu, 2010).

When any liquid is dropped onto a paper surface, the droplet takes a curved shape when it first contacts the paper surface. An angle is formed between this curve and the paper surface; this angle is called the contact angle (Figure 2).




» **Figure 2:** *Contact angle at the air-liquid-solid three-phase contact line*

Liquid droplet contact angle measurement is a widely accepted method for analyzing the surface wettability and absorbency of polymeric materials. The rate of change in wettability (contact angle) is considered as a result of liquid absorption in the paper.

In this study, the wettability and water resistance of coated and uncoated papers were measured using a computer-integrated TMI Pocket Ganiometer Model PG-X (FIBRO Systems AB Stockholm, Sweden).

First, distilled water droplets were placed on equal volumes of paper surfaces under constant experimental conditions. Then, the total volume and contact angle (TAPPI T 558 om-97) change values (Table 1) and images (Figure 3) of these sessile water drops on the papers were automatically measured and recorded for 4 minutes (50 data/minute) with a CCD video camera.

The changes of water drop volume and contact angle on the paper surfaces at 15 seconds, 45 seconds, 100 seconds and 240 seconds were analyzed.

## Surface Energy

The structure and surface energy of the paper greatly affect its interaction with liquids (Aydemir, Altay & Akyol, 2021). In this study, the surface energy of coated and uncoated papers was determined depending on the water contact angle according to the ASTM D5946 standard test method.

The relationship between static contact angle and surface energy forces is defined by Young–Dupré presented in Equation (1) from the interfacial tensions where Ysv = solid–vapor interaction, YSL = solid–liquid interaction, and YLV = liquid–vapor interaction (Aydemir, Altay & Akyol, 2021; Altay et al., 2022).

## Young's Equation

$$\gamma^{sv} = \gamma^{sl} + \gamma^{lv}\cos\theta \qquad \cos\theta = \frac{\gamma^{sv} - \gamma^{sl}}{\gamma^{lv}} \qquad (1)$$

θ is the contact angle
$y^{SV}$ is the solid/liquid interfacial free energy
$y^{sl}$ is the solid surface free energy
$y^{lv}$ is the liquid surface free energy

The surface energy of the test papers is listed in Table 1. Five samples were measured from each sample.

## Measurements of Oil Resistance

Castor oil (clv = 39.0 mN/m, g = 889.3 mPa/s, at 20°C) included in the TAPPI UM-557 test method procedure was used to determine the oil resistance of coated and uncoated papers. First, after the weights of the test papers were measured and recorded, Castor oil was dropped onto the surfaces of these papers in a fixed volume (from a height of approximately 13 mm) with a syringe. Castor oil on the surface of the papers was wiped with a tissue after 15 seconds, 45 seconds, 100 seconds and 240 seconds.

**Table 1**

Test Paper Types and Properties

| | Paper Type | Paper Symbol | Air Permeabilty (ml/min) | STDEV | Contact Angle (degree) | STDEV | Surface Energy (mJ/m²) | STDEV |
|---|---|---|---|---|---|---|---|---|
| Uncoated Papers | Kraft Paper | P1 | 260 | 17,13 | 90,5 | 2,25 | 32,2 | 1,13 |
| | Wrapping Paper | P2 | 220 | 3,28 | 92,8 | 1,86 | 31,3 | 2,55 |
| | Sulphite Paper | P3 | 277 | 0 | 93,3 | 2,51 | 30,9 | 1,84 |
| | | | | | | | | |
| Coated Papers | Barrier Coated Paper | P4 | - | 0 | 83,6 | 1,26 | 36,5 | 0,17 |
| | Parchment Paper | P5 | - | 0 | 71,9 | 3,7 | 43,2 | 2,54 |
| | Coated Paperboard | P6 | - | 7,68 | 79,4 | 1,73 | 37,9 | 0,77 |

Then, the weights of these papers in each time period (15s, 45s, 100s and 240s) were measured separately (Figure 6) and their wettability was displayed separately (Figure 5). Thus, the absorption amounts of oil into papers and the resistance levels of papers against oil were analyzed.

## Results and Discussions

The resistance to liquids of different types of paper and cardboard used in the packaging industry was tested using Distilled water and Castor oil. The measurement results and images are presented and discussed below.

### Paper Surface Wettability

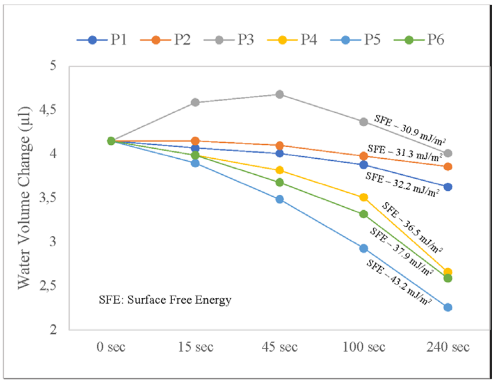
A liquid droplet dropped onto the paper surface, it shows spreading behavior on the paper surface and also tends to penetrate between the paper fibers. The extent of penetration or spreading depends on both the properties of paper and liquids (Aydemir, Karademir & İmamoğlu, 2010).

Contact angle measurement is a qualitative way to evaluate whether the surface has a hydrophobic or hydrophilic characteristic (Pasricha & Sachdev, 2017). Low contact-angle values demonstrate a tendency of the water to spread and adhere to the surface, whereas high contact-angle values show the surface's tendency to repel water (Huhtamäki et al., 2018; Aydemir et al., 2019).

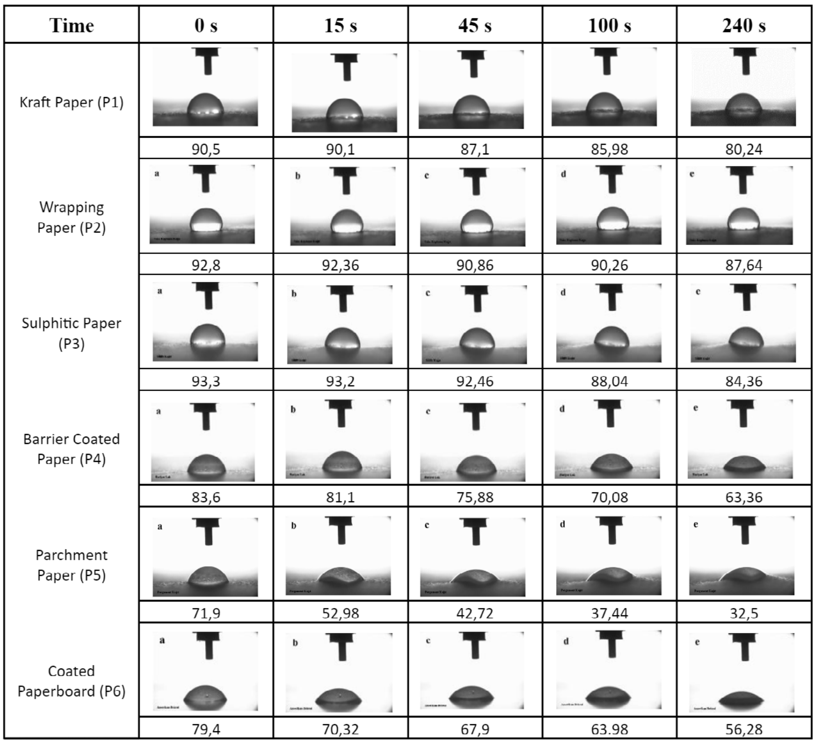
When the wettability and absorbency of test papers are evaluated depending on the contact angle; It was determined that Parchment paper (P5), Coated Paperboard (P6) and Barrier lack coated (P4) paper surfaces had the highest wettability and absorbency. Sulphite Paper (P3), Wrapping Paper (P2) and Kraft Paper (P1) were found to be the papers with the lowest wettability and absorbency (Figure 3). These papers with low wettability also have low surface energy.

### Water Absorbency of Paper Surfaces

According to the test results; The volume changes of the water droplet on different papers over time are shown graphically in Figure 4. These water absorption results are also compatible with the water-paper contact angles in Figure 3.




» **Figure 4:** *Water drop volume change on paper surfaces*



| Time | 0 s | 15 s | 45 s | 100 s | 240 s |
|---|---|---|---|---|---|
| Kraft Paper (P1) | 90,5 | 90,1 | 87,1 | 85,98 | 80,24 |
| Wrapping Paper (P2) | 92,8 | 92,36 | 90,86 | 90,26 | 87,64 |
| Sulphitic Paper (P3) | 93,3 | 93,2 | 92,46 | 88,04 | 84,36 |
| Barrier Coated Paper (P4) | 83,6 | 81,1 | 75,88 | 70,08 | 63,36 |
| Parchment Paper (P5) | 71,9 | 52,98 | 42,72 | 37,44 | 32,5 |
| Coated Paperboard (P6) | 79,4 | 70,32 | 67,9 | 63.98 | 56,28 |

» **Figure 3:** *Images and contact angles of sessile water drop on paper surfaces*

According to the test results, Sulphite Paper (P3), Wrapping Paper (P2) and Kraft Paper (P1) are the papers with the lowest water absorbency (Figure 4). The common feature of these papers is that they are not coated. Among these papers, Sulphite Paper (P3) has the lowest wettability (high contact angle) and absorption rate, but hygro-expansion (also called swelling) has occurred on its surface (Figure 4). Swelling means that when water enters the cellulose fibers, the internal pore structure of the paper changes and the cellulose fibers swell, deteriorating the sheet form and functional properties (Scott & Abbott, 1995). This may be due to the fact that carboxymethylation, which is commonly used to add acidic groups to cellulose, increases the water retention value of the fibers. These papers have a slower absorption rate, indicating that swelling of the surface fibers may lead to the closure of the surface pores (Akinli-Kocak, 2001).

According to the test results, Parchment paper (P5), Coated Paperboard (P6) and Barrier Coated Paper (P4) showed the fastest water absorption. This shows that the water resistance of coated papers is weaker than uncoated papers. These papers have lower static contact angles and higher surface energies than coated papers.

Considering that paper with higher polar components has more affinity for water, it is thought that the high water absorbency of papers is due to the water-loving minerals in the coating structure (kaolin clay, calcium carbonate, titanium dioxide, talc, etc.). In addition, the coating binder level and the coating pore size can also affect the absorbency of the paper.

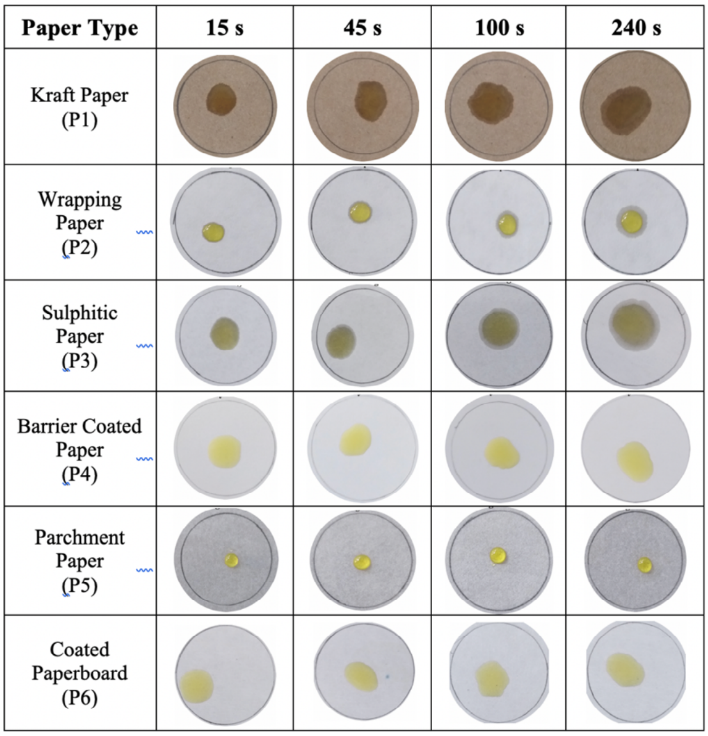
## Oil Resistance of Papers

The large variety of grease-containing foods has motivated the production of oil-resistant paper materials used in food packaging in recent years (Wang et al., 2022).

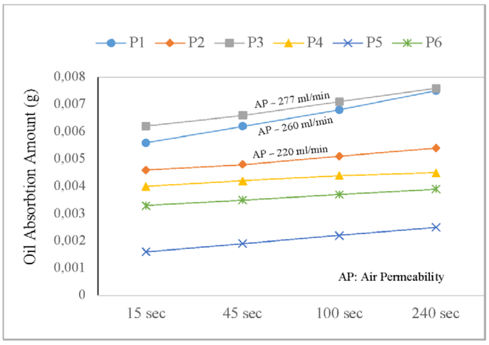
However, choosing the right packaging paper or board for fatty foods has become important due to reasons such as migration, contamination, and food spoilage. The oil absorption rate is a function of the surface absorption of the substrate. Castor Oil absorption test results of the papers used in packaging in this study are given below.

According to the test results; It has been determined that Sulphite Paper (P3) and Kraft Paper (P1) are the paper types with the highest oil absorption (Figure 5 – 6) and that the oil absorption in these papers increases over time (Figure 6). It is thought that the low oil resistance of these papers is due to their high degree of porosity. In this case, it becomes easier for the oil to pass through the paper fiber structure.

The high oil absorption of Kraft Paper (P1) is; It is known that it is caused by the removal of most of the lignin in the wood during the pulping process in order to provide strength. Low lignin is important to the resulting strength of the paper, as the hydrophobic nature of lignin interferes with the formation of the hydrogen bonds between cellulose (and hemicellulose) in the fibers. Because of this reason, the oil absorbency of kraft paper increased (Małachowska et al., 2020; Chandra, Lehtonen & Ragauskas, 2024).




» **Figure 5:** *Papers oil absorbsion images*




» **Figure 6:** *Oil Absorption values of papers and cardboards*

According to test results, it was determined that the oil resistance of Parchment paper (P5) - Coated Paperboard (P6) and Barrier Coated Paper (P4) was higher than uncoated papers (Figure 5 – 6). The common feature of these papers is that they are coated papers. High surface energy coatings also showed better oil resistance due to higher polar component content. Another reason for the high oil resistance of these papers is that the porous structure in the paper matrix is closed.

## Conclusion

The paper to be used in packaging must provide a barrier against water and oils. Knowing the liquid resistance of papers is important for the reliability of packaging and determines the scope of application.

The liquid resistance of paper and cardboard is also important for the correct management of packaging printing production processes. Printability parameters such as adhesion, drying, color and gloss are related to the penetration of ink into the paper. For this reason, in packaging printing applications with water, oil and solvent-based inks and varnishes, the right paper must be selected by taking into account the liquid permeability of the papers.

In this study, the differences between papers are demonstrated and evaluated on the basis of air permeability, liquid-solid contact angle, surface energy and liquid absorption. According to these evaluations;

- Wrapping Paper (P2) and Kraft Paper (P1) are paper types that are more resistant to water than coated papers.
- Although Sulphite Paper (P3) has low wettability, its usage area must be determined correctly due to the surface deformation that may occur when its surface interacts with water.
- Parchment paper (P5), Coated Paperboard (P6) and Barrier Coated Paper (P4) are the paper types with the highest resistance to oil. These papers can be used as food paper and baking paper or in the packaging of non-food products that require resistance to oil.
- Parchment paper (P5), Coated Paperboard (P6) and Barrier Coated Paper (P4) were the paper types with the lowest resistance to water, and Sulphite Paper (P3), Kraft Paper (P1) and Wrapping Paper (P2) were the paper types with the lowest resistance to oil.
- Parchment paper (P5) is the most oil-resistant type of paper. However, the water resistance of this paper is lower than all other paper types.
- As the wettability and surface energy of papers decreased, their resistance to water increased. Therefore, the water resistance of papers can be related to their wettability (contact angle) and surface energy.
- When the air permeability of uncoated papers increased, the oil absorbency also increased, and when the air permeability decreased, the oil absorbency also decreased. These results showed that the oil resistance of uncoated papers is correlated with air permeability. Therefore, the oil permeability of paper can be characterized by its air permeability.
- The liquid resistance of the paper and cardboard to be used in packaging should be well known. However, in packages where high oil resistance is desired, papers with low air permeability and high surface energy should be preferred, and in packages where high water resistance is desired, papers with low wettability and surface energy should be preferred.
- In general, the results have been shown that papers with high water resistance have low oil resistance, and papers with high oil resistance have low water resistance. This reveals that the resistance of papers to oil and water is different. It has been determined that uncoated papers are resistant to water, while coated papers are resistant to oil. This shows that the liquid resistance of papers depends on the surface structure, coating type, and the properties of the liquid in contact with its surface (density, etc.).
- In order to obtain water- and oil-resistant packaging, the surfaces of the papers can be coated with environmentally friendly and sustainable bio-containing materials (such as alginate and chitosan).

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# GANS for realistic animation: A qualitative study using ATLAS.ti

**ABSTRACT**

*This study aims to explore the effectiveness of GANs in generating animations that achieve high levels of realism, focusing on motion quality, texture detail, visual composition, and frame-to-frame coherence. A qualitative approach was employed using ATLAS.ti to analyze outputs from models such as MoCoGAN and StyleGAN3. The dataset included 110 animations, from which key visual elements were coded and analyzed thematically. The findings reveal that 68% of the animations demonstrated smooth motion transitions, while 20% exhibited jerky movements and 12% contained motion artifacts. Similarly, 70% of the animations featured highly detailed textures, but 20% had flat backgrounds, and 10% showed lighting inconsistencies. Visual compositions with strategic framing and depth perception were observed in 55% and 30% of the animations, respectively, whereas only 15% maintained symmetrical layouts. These results underscore the strengths and limitations of GANs in achieving realism, particularly in complex scenarios. This study contributes to the growing body of literature on GAN applications in animation by identifying critical visual factors that enhance aesthetic and narrative coherence. Practical implications include guiding designers and developers in leveraging GANs for high-quality animation production. Future research is recommended to address existing technical challenges and evaluate audience responses to GAN-generated animations, paving the way for more dynamic and engaging visual content.*

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## Introduction

In the digital era, advancements in artificial intelligence (AI) have transformed the creation and perception of visual content. Among these advancements, Generative Adversarial Networks (GANs) have emerged as a groundbreaking technology for generating realistic animations and visuals. GANs leverage deep learning to synthesize highly detailed and coherent images, videos, and animations by learning from extensive datasets (Goodfellow et al., 2014).

This innovation has opened new opportunities in animation production, particularly in generating realistic movement, textures, and environmental dynamics. Animation traditionally relies on human artistry and manual techniques to craft realism and aesthetic appeal. However, GANs challenge this paradigm by automating the generation of animations that often rival or even surpass traditional methods in terms of realism and efficiency (Sedkaoui & Benaichouba, 2024). Despite this progress, evaluating the aesthetic and realistic quality of GAN-generated animations remains a significant challenge, as existing standards for animation realism and aesthetics have been largely developed for human-created content (Chakraborty et al., 2024; Sangapu et al., 2024; Singh et al., 2024).

Moreover, while GANs have shown immense potential in creating static visuals, their application to realistic animation introduces unique complexities. These include ensuring smooth transitions between frames, maintaining consistency in texture and lighting, and accurately mimicking natural motion (Chakraborty et al., 2024;

Islam et al., 2024; Jain, 2024). Existing studies often focus on technical improvements in GAN architecture, such as video GANs or motion-aware GANs (Liang et al., 2025; Zhuo et al., 2024), but few have systematically examined whether these generated animations adhere to established principles of realism and visual coherence.

This study aims to address this gap by analyzing the visual and aesthetic trends in animations generated by GANs. Using qualitative methods with ATLAS.ti, the research explores dominant patterns in animation realism, focusing on elements such as motion quality, texture consistency, and visual composition. The analysis also evaluates how GAN-generated animations align with standards of visual realism, providing insights into their potential application in creative industries.

By situating GANs within the context of animation production, this research contributes to the growing body of knowledge on AI-generated visual content. The findings are expected to offer practical guidance for animators, designers, and technologists seeking to leverage GANs for realistic animation. Therefore, the research question this study seeks to answer is: How do GAN-generated animations adhere to established principles of realism and visual coherence? This question will be explored through a qualitative analysis conducted using ATLAS.ti, aiming to bridge the gap between technical innovation and artistic evaluation in animation.

# Literature Review

## Generative Adversarial Networks (GANs) and Animation

Generative Adversarial Networks (GANs), introduced by (Goodfellow et al., 2014), are a machine learning framework consisting of two competing neural networks: a generator and a discriminator. In the context of animation, GANs are utilized to produce realistic motion and dynamic visual elements (Mathew, 2024). This innovation has significantly advanced the creation of data-driven videos and animations that closely approximate human realism (Chakraborty et al., 2024).

The application of GANs in animation often involves algorithm modifications to accommodate motion and frame-to-frame transitions. For instance, MoCoGAN (Motion and Content GAN) (Tran, Bach & Doan, 2020; Ursegov, Zakharian & Miklina, 2022) separates motion elements from static content, enabling the creation of more consistent and realistic videos. Additionally, models like vid2vid and StyleGAN3 have demonstrated remarkable capabilities in adapting visual aesthetics to complex animations (Alaluf et al., 2023; Che Azemin et al., 2024; Kumar & Singh, 2023; Mallya et al., 2020; Zhuo et al., 2022).

However, applying GANs to animation is not without challenges. One major issue is ensuring frame-to-frame coherence, particularly when dealing with dynamic scenarios or complex movements. Furthermore, controlling visual elements such as lighting and texture remains a persistent problem that requires innovative solutions (El-Nasr et al., 2009; Kubiak, 2024; Vecchio et al., 2024). These challenges drive further research to optimize GAN structures for generating more realistic animations. With the advancement of GAN technology, the need to evaluate the quality of animations from an aesthetic and realism perspective has emerged. This research aims to fill a gap in the literature by analyzing the visual elements in GAN-generated animations, contributing to a better understanding of how this technology can be utilized in creative industries.

## Realism in Animation

Realism in animation refers to the concept of replicating the real world visually, whether through motion, textures, or lighting. In the context of GANs, realism is not only about creating visuals that resemble the real world but also about how these elements interact harmoniously within the animation (Rakshitha et al., 2024). Key elements in achieving animation realism include motion quality, frame-to-frame consistency, and texture integrity. For example, research by (El-Nasr et al., 2009; Kubiak, 2024; Vecchio et al., 2024) highlights that long-term motion prediction in GAN-based animation requires a hierarchical approach to maintain frame-to-frame coherence. Additionally, aspects such as adaptive lighting and dynamic shadows are critical focal points for enhancing realism (Hamza, 2024; Rakshitha et al., 2024; Zhang, 2023).

However, realism often clashes with the technical limitations of GANs. Visual artifacts, such as texture distortion or color inconsistencies across frames, frequently arise due to constraints in model training or inadequate datasets (Gao et al., 2024). Therefore, further research is needed to understand how these elements can be optimized through improved GAN architectures. This study seeks to explore the extent to which GAN-generated animations meet standards of visual realism. By using ATLAS.ti, a qualitative analysis of these elements will provide new insights into the strengths and weaknesses of GAN technology in creating realistic animations

## Evaluating GAN-Generated Content

Evaluating GAN-generated content has become an increasingly important topic, particularly in the context of animation. Traditional evaluation methods, such as Frechet Inception Distance (FID) and Structural Similarity Index (SSIM), are commonly used to quantitatively measure visual quality (Kancharla & Channappayya, 2018; Lee & Leeghim, 2022).

However, these approaches often fail to capture the nuanced aesthetics and human perception of animated content. Qualitative approaches offer a deeper alternative for evaluating GAN-generated animations. For example, thematic analysis of visual elements such as texture, lighting, and composition can provide insights not covered by quantitative metrics. Previous studies by (Li et al., 2021; Rakshitha et al., 2024; Re et al., 2022) have shown that aesthetic qualities, such as color harmony and visual dynamics, significantly contribute to the perception of realism.

Moreover, narrative-based analysis is also crucial for evaluating GAN-generated animation content. Animation is not only judged based on its visual elements but also on how these elements support the overall story or visual narrative (El-Nasr et al., 2009; Kubiak, 2024; Vecchio et al., 2024). Therefore, this study will utilize ATLAS.ti to identify patterns and themes in GAN-generated animations' visual and narrative elements. This research aims to provide a more comprehensive evaluation framework for GAN-generated animation content by combining qualitative and thematic approaches. These findings are expected to further expand the applications of GAN technology in creative design and animation production.

# Methodology

## Design Research

This research employs a qualitative approach with a case study design to analyze visual elements in realistic animations generated by Generative Adversarial Networks (GANs). A qualitative approach was chosen because the study focuses on exploring how visual elements such as motion, texture, and composition are utilized to create realistic animations.

The case study design allows for a detailed examination of complex visual phenomena within a specific context, namely GAN-based animation (Chen, Liu & Chen, 2020; Li et al., 2021; Purwanto et al., 2024; Re et al., 2022; Tian & Li, 2023). In this study, GANs are the primary focus for evaluating how this technology can produce animations that approximate visual realism. The analysis involves both technical and aesthetic elements to understand the extent to which GAN-generated animations meet standards of realism and aesthetics.

## Data Source

The data for this research was collected from GAN models that generate realistic animations, including MoCoGAN (Tran, Bach & Doan, 2020), StyleGAN3 (Alaluf et al., 2023), and other video-based models. The datasets used to generate animations include:

1. HumanML3D Dataset: This dataset contains descriptions of human motion to produce realistic GAN-based animations.
2. AMASS Dataset: This dataset was used to train GAN models to create accurate and realistic human body movements.
3. Pretrained Models: Pretrained models like StyleGAN3 were utilized to generate realistic textures and lighting for animation elements.

The selection of models and datasets was based on their ability to produce animations that incorporate complex movements, detailed textures, and dynamic lighting.

## Data Collection

The data collection process involved the following steps:

- Animation Generation: Animations were created using GAN models with preconfigured parameters to produce realistic motion and textures.
- Metadata Collection: Technical information was gathered, including model parameters, the number of frames, resolution, and input scenarios.
- Dataset Structuring: The dataset consisted of animation files (videos or frame sequences) accompanied by relevant metadata.

The data was collected in standard formats (e.g., MP4 or image sequences) and organized for qualitative analysis using ATLAS.ti.

## Data Analysis

### The Use of ATLAS.ti for Qualitative Analysis

The generated animation data was imported into ATLAS.ti for analysis using coding techniques and thematic analysis.

The analysis focused on the following aspects:

- Motion Quality: The smoothness and consistency of movement within the animations.
- Visual Composition: Framing, perspective, and balance of visual elements in the animation.
- Texture Realism: The level of detail in textures, lighting, and shadows.
- Frame-to-Frame Coherence: Visual consistency across animation frames.

### Coding Process

The animations were analyzed frame-by-frame to identify key visual elements. The codes applied include:

- Smooth Movement: Evaluates the fluidity of motion in objects or characters within the animation.
- Symmetrical Composition: Assesses the balance of visual elements.
- Lighting Effects: Examines the impact of light and shadow on visual realism.
- Visual Artifacts: Identifies distortions or technical shortcomings in the GAN-generated animations.

Table 1 shows the code and sub-code use for Analysis. The coding results were then organized into thematic networks to uncover patterns and relationships among the visual elements. This approach provided structured insights into the strengths and weaknesses of the animations analyzed.

## Thematic Analysis

Following the completion of the coding process, a thematic analysis was performed to uncover the primary themes emerging from the data. This approach is widely used in qualitative research to identify recurring patterns or themes within the dataset (Castleberry & Nolen, 2018; Vaismoradi & Snelgrove, 2019). Thematic analysis was conducted to uncover the main themes emerging from the data. This process involved grouping codes into the following categories:

- Trends in Visual Realism in Animation: Visual elements frequently utilized in GAN-generated animations, such as smooth motion, detailed textures, and balanced compositions
- Technical Weaknesses: Identification of artifacts or shortcomings in animations, including issues with texture fidelity, inconsistent lighting, or jerky movements.
- Visual Strengths: Elements that consistently enhance the perception of realism, such as cohesive frame-to-frame transitions, accurate shadowing, and well-executed lighting effects.

This thematic grouping allowed for a structured understanding of both the opportunities and limitations in the application of GANs for creating realistic animations. It also provided actionable insights for improving GAN architectures and their outputs in creative industries.

## Validity and Reliability

The validity and reliability of the data in this study are ensured through several strategies designed to guarantee the accuracy and consistency of results. First, triangulation was conducted by comparing the visual analysis results with relevant literature in the fields of animation and GAN technology. This approach aims to validate findings with evidence from credible sources.

**Table 1**

Codes and Sub-codes Used for Analysis in ATLAS.ti

| No | Code | Sub-Code | Description |
|---|---|---|---|
| 1 | Motion Quality | Smooth Movement | Evaluates the fluidity and continuity of motion between frames. |
| | | Jerky Movement | Identifies abrupt or unnatural transitions in movement. |
| | | Motion Artifacts | Detects visual inconsistencies, such as motion blur or frame skipping. |
| 2 | Texture Realism | Detailed Texture | Assesses the level of detail in surface textures, such as fabric, skin, or object materials. |
| | | Flat Texture | Identifies areas with low or unrealistic texture detail. |
| | | Lighting Artifacts | Highlights issues with shadows, reflections, or inconsistent lighting across frames. |
| 3 | Visual Composition | Framing | Analyzes the placement of objects or characters within the scene to achieve visual balance. |
| | | Depth Perception | Evaluates the use of perspective to create a sense of depth in the scene. |
| | | Symmetry | Identifies balanced and harmonious arrangements within the frame. |
| 4 | Animation Realism | Frame-to-Frame Coherence | Assesses consistency in movement, lighting, and texture across frames. |
| | | Natural Physics | Evaluates adherence to physical laws, such as gravity, inertia, and collision. |
| | | Emotional Expression | Analyzes the expressiveness of characters or objects, such as facial movements or gestures. |
| 5 | Narrative Support | Visual Storytelling | Identifies how the animation supports the overall narrative or storytelling. |
| | | Scene Continuity | Evaluates the logical progression and coherence of scenes within the animation. |
| | | Artistic Intent | Explores the creative or artistic purpose behind visual choices in the animation. |

Second, a peer review process was carried out by involving animation experts and GAN developers to assess the interpretation of the data. Input from these experts helped identify potential biases or errors in the analysis and ensured more objective and reliable results.

Third, re-analysis was performed by repeating the coding process on the dataset to verify the accuracy and consistency of the findings. This step ensures that every visual element identified in the study is based on strong and reliable evidence.

### Limitations

This study has several limitations that should be noted. First, the data used comes from specific GAN models, such as MoCoGAN and StyleGAN3. While these models are widely recognized, the study's findings may not reflect the full spectrum of available GAN technology. Second, the qualitative analysis approach employed yields interpretative findings.

Therefore, these results cannot be widely generalized to all GAN applications, particularly outside the context of realistic animation. Third, the focus of this study is limited to the analysis of visual elements such as motion, texture, and composition. This research does not include audience responses or user perceptions of GAN-generated animations, which could be an important area for future exploration.

## Result

### Motion Quality

Motion quality is one of the key indicators of realism in animations generated by GANs. The analysis shows that most animations exhibit smooth motion and consistent frame-to-frame transitions. This is particularly evident in animations involving simple movements, such as facial expressions or slow body position changes. This smooth motion creates an effective illusion of realism, especially when supported by appropriate textures and lighting.

However, some animations were found to display jerky or unnatural movements, particularly during sudden position changes or complex actions such as jumps or rotations. These jerky movements create an artificial impression that can detract from the visual experience of the audience. Additionally, motion artifacts, such as shadows that shift abruptly or visual elements that disappear in certain frames, were also detected in a small portion of the animations. Table 2 shows the motion quality analysis. These findings indicate that, while GANs can generate realistic motion, there are technical limitations that need to be addressed for more complex motion scenarios.

**Table 2**

Motion Quality Analysis

| No | Motion Quality | Freq. (%) | Observation |
|---|---|---|---|
| 1 | Smooth Movement | 68 | Smooth frame-to-frame transitions, especially in slow or simple movements such as walking. |
| 2 | Jerky Movement | 20 | Movements appear jerky, for example, during sudden position changes or extreme rotations. |
| 3 | Motion Artifacts | 12 | Visual artifacts are observed in unstable shadows or objects that suddenly disappear in certain frames. |

### Texture Realism

Realistic textures are a crucial element in creating convincing animations. The analysis results indicate that GANs can generate highly realistic texture details on primary elements, such as clothing or character skin surfaces. This is evident in the presence of fabric folds, light reflections on materials, and natural color gradients. These textures provide visual depth that enhances the overall impression of realism.

However, in background elements, textures often appear flat and lack detail. Areas such as walls, floors, or secondary objects tend to receive less attention during GAN model training. Additionally, lighting artifacts frequently occur in transition areas between shadows and light, creating visual inconsistencies.

Table 3 shows the texture realism analysis. These shortcomings indicate that, although GANs have successfully captured texture details for primary elements, further optimization is needed for background elements and complex lighting scenarios.

**Table 3**

Texture Realism Analysis

| No | Texture Realism | Freq. (%) | Observations |
|---|---|---|---|
| 1 | Detailed Texture | 70 | Textures on primary elements, such as clothing or skin surfaces, appear realistic and detailed. |
| 2 | Flat Texture | 20 | Background elements, such as walls or floors, often look flat and lack sufficient detail. |
| 3 | Lighting Artifacts | 10 | Inconsistencies in lighting are detected, such as uneven shadow transitions or incorrect reflections. |

## Visual Composition

The visual composition in GAN-generated animations tends to utilize effective framing, where key elements are strategically placed to create visual harmony. Perspective is also frequently employed to convey a sense of depth, thus creating a convincing illusion of three-dimensional space. This is particularly evident in animations involving interactions between characters and their environment.

However, symmetry in the arrangement of visual elements is often lacking, especially in scenes with numerous objects or extreme perspective changes. This imbalance can reduce the aesthetic appeal of the visuals, although it does not significantly impact the sense of realism. Table 4 shows visual composition analysis. These findings indicate that GANs have significant potential for creating compelling visual compositions, but there is room for improvement in the arrangement of more complex layouts.

**Table 4**
Visual Composition Analysis

| No | Visual Composition | Freq. (%) | Observations |
|---|---|---|---|
| 1 | Framing | 55 | Key visual elements are strategically placed to create good visual harmony. |
| 2 | Depth Perception | 30 | Perspective is used to provide the illusion of three-dimensional space, particularly in forward or backward movements. |
| 3 | Symmetry | 15 | An imbalance in the layout of elements is observed in some scenes, reducing visual harmony. |

## Frame-to-Frame Coherence

Frame-to-frame coherence is a critical aspect that ensures smooth and consistent transitions in animations. Most animations exhibit high visual coherence, especially in small movements such as facial expressions or hand gestures. Table 5 shows frame-to-frame coherence. These transitions create a natural visual flow and enhance the audience's perception of animation realism.

However, in major scenario changes, such as character movements or lighting transitions, some inconsistencies were observed. For example, lighting in one frame might differ significantly from the next frame, creating an unnatural impression. This indicates that GANs need to be trained with a broader variety of scenarios to improve frame-to-frame coherence in major changes.

**Table 5**
Frame-to-Frame Coherence

| No | Frame-to-Frame Coherence | Freq. (%) | Observations |
|---|---|---|---|
| 1 | High Coherence | 75 | Frame-to-frame transitions appear consistent, especially in small movements such as changes in facial expressions. |
| 2 | Low Coherence | 25 | Inconsistencies are observed during major changes, such as lighting shifts or large-scale movements. |

## Narrative Support

The narrative elements in GAN-generated animations show varying results depending on the complexity of the story being presented. In simple scenarios, such as characters moving within a static environment, the animation effectively supports the narrative. Character movements, framing, and lighting contribute to visual storytelling.

However, in more complex scenarios, such as interactions between multiple characters or dynamic environmental changes, visual narratives sometimes lose continuity. This is due to inconsistencies in visual elements across scenes, such as differences in lighting or illogical changes in character positions. Despite these challenges, the potential of GANs to support visual narratives remains evident, particularly if model training is focused on specific story scenarios.

# Discussion

### Relationship Between Motion Quality and Texture Realism with Visual Realism

The findings of this study indicate that motion quality and texture realism play a crucial role in creating realistic animations. Smooth motion and consistent frame-to-frame transitions provide the fluidity illusion that is essential in GAN-based animations. Approximately 68% of the analyzed animations demonstrated smooth movement, while 20% exhibited jerky motion, and the remainder contained visual artifacts. These findings align with prior research by (Tran, Bach & Doan, 2020), which emphasized the importance of motion coherence in GAN-based animation.

However, the results also reveal weaknesses in some animations, particularly during rapid position changes or complex lighting scenarios. Realistic textures were found on primary elements, such as characters and foreground objects, but flat textures in the background often diminished the overall effect.

This observation is consistent with the findings of (El-Nasr et al., 2009; Kubiak, 2024; Vecchio et al., 2024), which identified that background textures are often overlooked in GAN training. These challenges can be addressed by incorporating more diverse datasets and more advanced GAN models.

### Influence of Visual Composition on Aesthetic Perception

Visual composition, such as framing and depth perspective, also significantly contribute to the aesthetics of the generated animations. Approximately 55% of the analyzed animations utilized strategic framing, while depth perspective appeared in 30% of the total data. However, only 15% of the animations demonstrated symmetrical layouts, reducing visual harmony in some scenes.

These findings align with (Rakshitha et al., 2024), who stated that depth perspective and framing can significantly enhance visual perception. However, the results differ from (Kanuri et al., 2024), who argued that symmetry tends to be more effective in capturing the audience's attention. In the context of GANs, the challenge of maintaining symmetry and visual harmony highlights the need for further optimization in model architecture.

### Narrative Support Through Frame-to-Frame Coherence

Frame-to-frame coherence is a key element in supporting visual narratives. Animations with smooth frame-to-frame transitions can create a coherent and easily followed storyline. In this study, 75% of the analyzed animations had high levels of frame-to-frame coherence, but 25% showed inconsistencies, particularly in lighting changes or large movements. These findings support the visual narrative theory proposed by (Hussain et al., 2024; Manovich, 2016), which highlights the importance of frame-to-frame transitions in creating a seamless visual experience.

### Contribution

This research makes significant contributions to understanding how GANs can be used to create realistic animations. The study highlights the relationship between visual elements—such as motion quality, realistic textures, and visual composition—and aesthetic and narrative perception in animations. Thus, this research extends previous literature by demonstrating how these elements can be applied in GAN-based animation production. Practically, these findings can serve as a guide for animators, designers, and technology developers seeking to leverage GANs to create more compelling and convincing animations. The combination of smooth motion, detailed textures, and balanced visual composition has proven to be an effective tool in enhancing animation quality.

### Limitations and Future Research

While this research provides valuable insights, several limitations must be acknowledged. First, the data used originates from specific GAN models (MoCoGAN and StyleGAN3), which may not represent the capabilities of all available GAN models. Second, the analysis is limited to visual elements without considering audience perceptions of the generated animations. Future research can expand the scope by involving audience perception analysis to understand how they respond to GAN-based animations. Additionally, future studies can use more diverse datasets to explore the potential of GANs in more complex animation scenarios, including character and environment interactions.

## Conclusion

This study reveals that Generative Adversarial Networks (GANs) hold significant potential in producing realistic animations with smooth motion quality, detailed textures, and aesthetically pleasing visual compositions. By analyzing outputs from models such as MoCoGAN and StyleGAN3 using a qualitative approach, it was found that elements like frame-to-frame motion smoothness, depth perspective, and realistic textures contribute to the perception of animation realism.

However, the study also identified weaknesses, such as visual artifacts and lighting inconsistencies, which frequently appear in scenarios involving complex movements or significant changes within animations. These findings underscore that while GANs are promising, further optimization is needed to meet the high standards of visual realism.

The results of this research provide an important contribution to the literature on GAN-based animation by exploring visual elements that influence aesthetic and narrative perception. This study not only fills a knowledge gap but also offers practical guidance for designers, animators, and technology developers in utilizing GANs for animation production. However, the limited focus on visual elements without considering audience perceptions indicates room for further research, which could include analyzing audience responses or exploring GAN applications in more dynamic and complex animation scenarios.

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# Authorship disclosure and consumer perception of AI-generated graphic design


## ABSTRACT

*The increasing integration of artificial intelligence (AI) into graphic design and advertising has raised pressing questions about the role of authorship, trust and aesthetic judgement. This study examines how consumers perceive AI-generated versus human-created advertising visuals in the context of jewellery advertising. Two online surveys (n = 127) were conducted to compare participants' preferences under the conditions of disclosed and undisclosed authorship. The results show that while AI-generated visuals were sometimes rated favourably when authorship was hidden, human-created content was clearly preferred overall – especially when authorship was disclosed. A gender analysis revealed that female participants were especially sensitive to authorship cues, favouring human-created visuals. Logistic regression further confirmed that authorship disclosure, gender and design features such as human presence and serif typography were significant predictors of preference. Qualitative responses suggest that while AI visuals are technically competent, they lack emotional authenticity and narrative resonance. These findings emphasise the importance of transparency, emotional design and collaboration between humans and AI in visual communication. The study contributes to ongoing debates about machine creativity, aesthetic value and ethical disclosure, and offers practical implications for designers and marketers using AI in emotionally-driven contexts.*



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## Introduction

The increasing integration of artificial intelligence (AI) into the creative industry has triggered an intense debate about the role of human authorship, aesthetic value and authenticity in visual communication. Generative AI tools such as Midjourney, DALL·E 2, Adobe Firefly and Stable Diffusion enable users to create complex, high-resolution visual content from textual prompts within seconds.

These tools are transforming workflows in advertising, design and media production — traditionally human-dominated spaces where emotion, intuition and storytelling are valued as core assets. While these technologies offer unprecedented access to scalable content creation, they also raise critical questions about audience perception. How do viewers respond to visuals generated by machines rather than human designers? Does knowing the origin of a visual — AI or human—alter its perceived authenticity, appeal or emotional value? These questions are central to understanding the limits and possibilities of machine-generated content in contexts where aesthetics intersect with persuasion and meaning.

Some researchers and practitioners are increasingly sceptical about AI-generated content in emotionally sensitive areas.

This reluctance seems particularly acute in visual advertising, where the emotional connection between brand and viewer is often mediated by subtle design choices. As generative AI tools improve, so does the need to understand not only their technical capabilities, but also their psychological and cultural reception.

This study contributes to this understanding by investigating how consumers perceive AI-generated versus human-created advertising visuals, specifically in the jewellery sector. Two online surveys were conducted with 127 participants who were shown pairs of images of AI and human designs, with authorship either disclosed or undisclosed. In addition to the quantitative preference data, participants provided qualitative insights into their decisions, allowing for a deeper interpretation of underlying motivations.

In visual communication, authorship operates as a metatextual message — part of the semiotic system through which viewers interpret meaning and intent. Disclosure of artificial intelligence (AI) authorship functions not only as factual information but also as a symbolic cue that shapes perceptions of authenticity, creativity, and emotional value. Authorship can influence not only what audiences see but also how they relate to the creative process behind the image. As AI increasingly permeates the creative industries, researchers have intensified their focus on how audiences perceive AI-generated visuals, particularly in the fields of advertising, branding and communication design. Two parallel streams of research dominate the literature: a technical one, which traces the development of generative systems, and a psychological one, which examines the cognitive, emotional and social impact of machine-created content.

From a technical perspective, the fundamental development of Generative Adversarial Networks (GANs) (Goodfellow et al. 2014) marked a decisive change in the capabilities of AI in image creation. GANs introduced the adversarial training method, which enabled models to simulate increasingly realistic images. More recently Dhariwal & Nichol (2021) introduced diffusion models that outperform GANs in generating naturalistic visuals, particularly in terms of texture and lighting fidelity.

These advances have enabled designers and marketers to produce high-quality visuals with unprecedented efficiency. However, technical fidelity does not automatically equate to viewer trust or emotional engagement.

A growing body of research shows that audience reactions to AI-generated content depend significantly on whether authorship is disclosed or not. Gangadharbatla (2021) found that participants who were told that an artwork was generated by an AI received lower ratings in terms of creativity and emotional value than when authorship was not disclosed.

Similar effects were reported by Bauer et al. (2024), who demonstrated that disclosure of generative AI triggered cognitive dissonance and reduced creative ratings. Kučinskas (2025) also confirmed that explicit AI attribution reduces perceived brand authenticity and consumer intention in advertising contexts.

The importance of authorship framing is further confirmed by institutional research. A study by Musitić & Varga (2024) found that even minimal information about authorship significantly changes the interpretation of and trust in graphic media messages. Messer (2024) and Tigre Moura, Castrucci & Hindley (2023) emphasised that works created in collaboration with AI were perceived more positively than those produced solely by algorithms, supporting the idea that emotional resonance and narrative coherence are still perceived as human characteristics.

In response to such prejudices, researchers have explored hybrid creative frameworks that combine human and AI contributions. Haupt, Freidank & Haas (2024) argued that positioning AI as a collaborator rather than an autonomous creator helps to reduce aversion to algorithms in content creation. Lee & Kim (2024) came to similar conclusions in fashion design, where consumers viewed AI-assisted outputs more favourably when human oversight was made explicit. These results emphasise the potential of framing strategies to restore trust in AI-mediated design.

Demographic factors, particularly gender, also influence responses to AI-generated content. Groundbreaking research by Meyers-Levy & Sternthal (1991) as well as Fugate & Phillips (2010), found that women respond more strongly to emotional and narrative dimensions in visual content. In a recent AI context, Černáková & Comová (2024) reported that female respondents evaluated AI-generated marketing content less favourably, suggesting that emotional resonance remains an important factor in gender-specific aesthetic preference.

Beyond cognitive framing and gender, perceptual research offers further insights. Ahtik (2023) compared AI-generated gaze heatmaps with actual human eye-tracking data. While the AI was relatively successful at predicting generalised zones of attention, it struggled to identify emotionally salient regions, supporting the argument that AI lacks the nuanced understanding of context that human perception brings. Califano & Spence (2024) similarly found that human-labelled food images were consistently rated higher in terms of visual appeal, even when the AI images were more technically polished.

On a broader psychological level, aversion to algorithms remains a persistent barrier. Castelo, Bos & Lehmann (2019) defined "task-dependent algorithm aversion" to describe the public's distrust of AI in domains that require subjective judgement or emotional sensitivity. This is particularly relevant in marketing and advertising, where storytelling and authenticity are central to brand trust. Pieters, Rosbergen & Hartog (1996) added that visual attention and repetition are critical components of advertising effectiveness, both of which can be undermined if AI-generated visuals fail to establish emotional engagement. Arvaj, Šubic & Ahtik (2025) confirmed that viewers are more critical of AI-generated product images when emotional or cultural relevance is essential, such as in the case of meat product advertising.

Overall, the literature reviewed emphasises that while AI-generated visuals has made considerable progress in terms of technical execution, it still faces perceptual and emotional challenges in real-world applications.

Authorship transparency, human co-creation, demographic sensitivity and psychological framing all play a crucial role in how such content is received. These findings form the conceptual foundation of this study, which aims to empirically investigate the influence of authorship disclosure and participant identity on consumer preferences for AI- and human-generated visual advertising.

# Materials and methods

The research utilised a mixed-methods experimental design involving the creation and evaluation of advertising materials created using both artificial intelligence (AI) tool and traditional graphic design techniques.

The aim was to assess how the different originsof visual content affects consumer perception and preference, especially when the authorship of the content is either disclosed or undisclosed. This section outlines the methodological framework, including the creation of the stimuli, the structure of the survey, participant demographics, and analytical procedures.

## Stimuli Design

The experimental material consisted of 24 pairs of advertising visuals for the same jewellery product — Calla Lily earrings by designer Ekart Katarina. Each pair featured two images: one designed using traditional graphics tools (Adobe Photoshop 26.7.0, Adobe Lightroom 14.3.1 and a Nikon D5300 DSLR camera) and one created using ChatGPT 4o in combination with DALL·E. The images differed systematically in four visual variables (Table 1):

- Composition (central or top-bottom layout),
- Background (plain or textured),
- Typography (serif, sans- serif, or handwritten),
- Presence of a human model (yes or no).

**Table 1**

Combinations of variables used for preparing advertising visuals

| No. | Composition | Background | Typography | Human model |
|---|---|---|---|---|
| 1 | central | plain | serif | yes |
| 2 | central | plain | serif | no |
| 3 | central | plain | sans-serif | yes |
| 4 | central | plain | sans-serif | no |
| 5 | central | plain | handwritten | yes |
| 6 | central | plain | handwritten | no |
| 7 | central | textured | serif | yes |
| 8 | central | textured | serif | no |
| 9 | central | textured | sans-serif | yes |
| 10 | central | textured | sans-serif | no |
| 11 | central | textured | handwritten | yes |
| 12 | central | textured | handwritten | no |
| 13 | top-bottom | plain | serif | yes |
| 14 | top-bottom | plain | serif | no |
| 15 | top-bottom | plain | sans-serif | yes |
| 16 | top-bottom | plain | sans-serif | no |
| 17 | top-bottom | plain | handwritten | yes |
| 18 | top-bottom | plain | handwritten | no |
| 19 | top-bottom | textured | serif | yes |
| 20 | top-bottom | textured | serif | no |
| 21 | top-bottom | textured | sans-serif | yes |
| 22 | top-bottom | textured | sans-serif | no |
| 23 | top-bottom | textured | handwritten | yes |
| 24 | top-bottom | textured | handwritten | no |

Each combination of these variables was applied to both AI-generated and human-designed visuals to ensure comparability. All visuals had an aspect ratio of 9:16 and were exported in high-resolution PNG format.

## AI Generation Process

The AI-generated visuals were created through iterative prompting using ChatGPT 4o with integrated DALL·E functionality. Each prompt specified the desired visual features (e.g. background type, composition, text, presence of a model) and included the Calla Lily earrings as a reference.

The generative model demonstrated the ability to learn from the correction prompts and improve fidelity and consistency across multiple iterations. Nevertheless, due to platform limitations, it was not possible to use real product photos alongside the generated human figures to avoid potential misinformation. The final advertising visuals we generated are shown in Figure 1.

## Conventional Visual Creation

The human-designed ads were developed using professional photography and Adobe Creative Suite tools. The photos of the models wearing the Calla Lily earrings were taken under controlled lighting conditions with a Nikon D5300 DSLR camera. The images were edited in Adobe Lightroom (only basic light and colour corrections were needed to process the RAW data captured by the camera) and finalised in Adobe Photoshop, with typography and layout matching the parameters used for the AI-generated counterparts. This ensured a controlled comparison where only the method of content creation differed. The final advertising visuals that were created are shown in Figure 2.

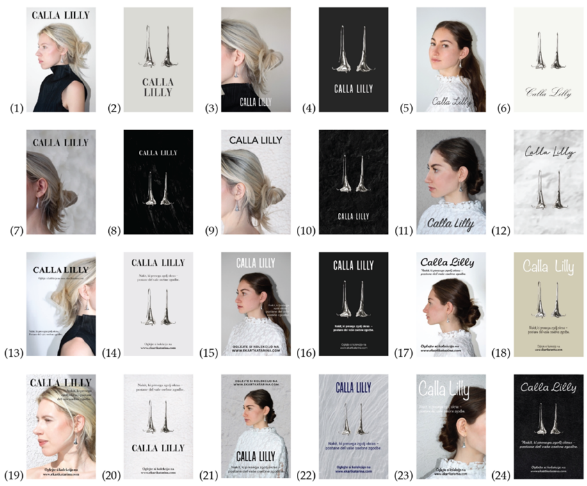
## Survey Structure

Two separate online surveys were created via the platform Fototeka.si, developed for subjective testing of digital image materials:

- Survey A (Undisclosed Authorship): Participants viewed 24 pairs of ads without being told which ones were AI-generated. They were informed that one image in each pair was AI-generated, but the specific identity of each image was not disclosed.
- Survey B (Disclosed Authorship): Participants were shown the same ad pairs, but each AI-generated image was clearly labelled as such.

In both surveys, participants were asked to select the more aesthetically appealing advert from each pair. The order of ad presentation (left/right) was randomised to eliminate position bias (Figure 3). Each participant completed only one version of the survey to avoid learning or comparison effects.


» **Figure 1:** *Advertising visuals generated using ChatGPT 4o (see Table 1 for description of used variables for each image)*




» **Figure 2:** *Advertising visuals designed from photographs (see Table 1 for description of used variables for each image)*


» **Figure 3:** *An example of image pair presented in a Survey B where the authorship was disclosed (translation of the text on the right image: "advert has been generated using artificial inteligence (AI)")*

## Participants

A total of 127 valid responses were collected:

- Survey A: 57 in total, 48 female and 9 male participants,
- Survey B: 70 in total, 38 female and 32 male participants.

Participants were recruited via social media platforms and university mailing lists. All respondents confirmed their consent and voluntary participation.

# Results and Discussion

In both surveys participants were shown visual pairs of images featuring jewelry products—each pair consisting of one AI-generated and one human-generated image—and asked to select the image they perceived as more appealing. Preferences were recorded as either AI-generated or human-generated images.

Results are presented and analysed in various ways, where the influence of gender, age and disclosure of authorship are closely observed.

## Demographics

The participant pool consisted of a total of 3,048 responses (127 respondents) gathered through two survey variants—Survey A (undisclosed authorship) and Survey B (disclosed authorship). The participants were predominantly from Slovenia and were approximately 67.7% female and 32.3% male. The respondents represented a wide age range. Survey A had a gender breakdown of 48 females and 9 males. The median age among females in Survey A was 32.9, while males had a median age of 33.8. In Survey B, there were 38 female and 32 male respondents. The median age for females in this group was 28.8, and for males, it was significantly higher at 41.1.

Most of the responses came from people aged between 20 and 39, who made up more than 65% of the total sample. This demographic structure provides a representative basis for understanding generational and gender-specific trends in the perception of visual content.

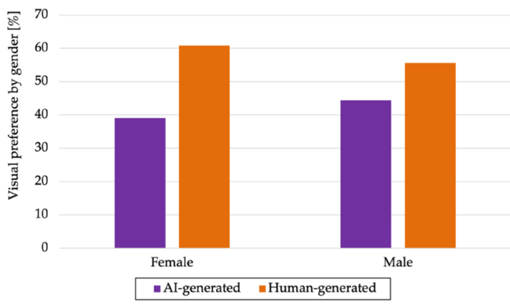
Although the sample tended to include younger and female participants—which limits generalisability - this group also represents the primary target group for the advertised products. Therefore, the results remain relevant for sales-orientated design evaluation, although future studies should include more balanced samples to strengthen external validity.

## Overall Preferences

Of the total 3,048 comparisons, 1,250 (41.0%) indicated a preference for AI-generated images, while 1,798 (59.0%) favoured images created by a human designer. This indicates a clear overall preference for human-generated content, although a significant proportion of the sample expressed a positive preference for AI images.

## Gender-Based Preferences

When disaggregated by gender, female respondents (n = 86) chose AI-generated visuals in 830 cases (40.2%) and human-generated visuals in 1,234 cases (59.8%). Male respondents (n = 41) chose AI visuals in 420 cases (42.7%) and human visuals in 564 cases (57.3%). These results indicate that both genders tend to favour human visuals, but men show a slightly greater openness to AI-generated content (Figure 4).

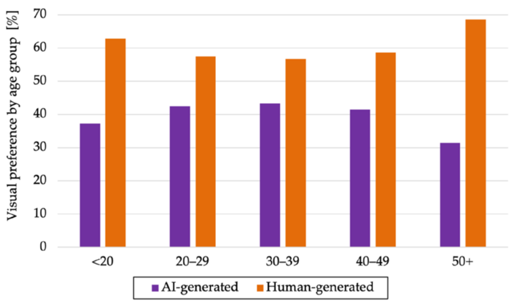



» **Figure 4:** *Visual preference distribution by gender*

## Preferences by Age Group

An age-related breakdown shows that the percentage preference in the different age groups was relatively stable and ranged between 38 and 44% AI preference depending on the group.

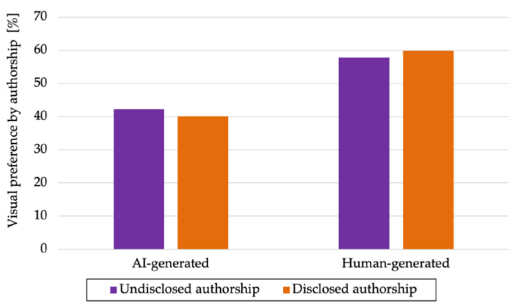
This is consistent with the regression results and supports the interpretation that age does not significantly influence visual preference. This distribution is summarised in Figure 5.




» **Figure 5:** *Visual preference distribution by gender*

## Authorship disclosure

Survey A (in which the authorship of the images was not disclosed) resulted in 577 AI preferences (42.2%) and 791 human preferences (57.8%). In Survey B (where authorship was disclosed), respondents indicated 673 AI preferences (40.1%) and 1,007 human preferences (59.9%). This slight decrease in preference for AI visuals when authorship was disclosed supports the hypothesis that transparency about generative origin can influence audience favourability. The distribution of preferences by authorship disclosure is shown in Figure 6.



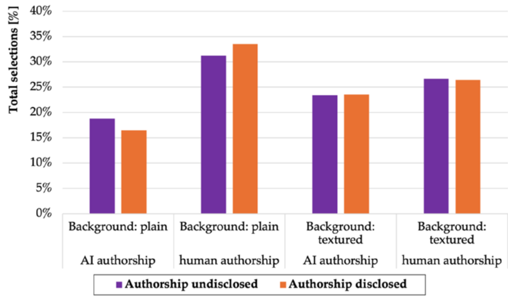

» **Figure 6:** *Visual preference comparison by the effect of authorship disclosure*

## Influence of Visual Features on Preference

To assess how specific visual design characteristics affected participant choices between AI- and human-generated visuals, we analysed responses based on four main features: Background, composition, presence of a human model, and typography. Each variable was further broken down by authorship (AI or human) and authorship disclosure (Survey A: undisclosed vs. Survey B: disclosed).

### Background Texture

The selection proportions based on background type (plain vs. textured), authorship and disclosure conditions is shown in Figure 7. The results show a clear and consistent trend: human-authored images with a monochrome background were selected most frequently in both versions of the survey, peaking at 33.3% in the disclosed version. Conversely, AI-authored images with a plain backgrounds had the lowest selection rates, particularly under the disclosure conditions (16.2%). Interestingly, textured backgrounds showed a more balanced distribution between AI and human visuals, suggesting less bias due to authorship.

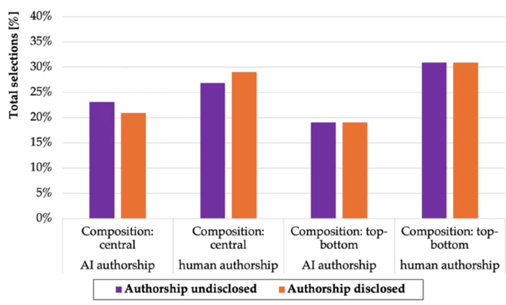



» **Figure 7:** *Preference distribution based on background style and authorship, comparing disclosed vs. undisclosed conditions*

### Composition Style

Top-bottom compositions by human authors were selected most often, with a selection rate of over 30% in both surveys. In contrast, AI-generated top-bottom compositions consistently received the lowest selection (~18%).

For centrally composed visuals, human-authored images were again ahead in both surveys, although AI-generated central compositions performed slightly better in undisclosed conditions (22.7%) than in disclosed conditions (20.6%). These results indicate a perceptual advantage for human-created compositions — especially for traditional vertical layouts (Figure 8).

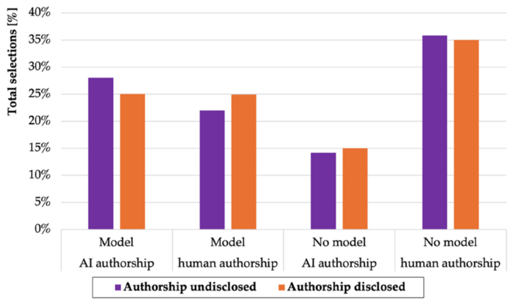



» **Figure 8:** *Total selection rates by image composition (central vs. top-bottom), authorship, and disclosure*

### Presence of Human Model

A strong preference for visuals that included a human model, particularly when paired with human authorship, is observed in Figure 9. Notably, AI-generated images featuring a model were more accepted than AI images without a model, especially in the undisclosed survey (27.7% vs. 13.6%).

This confirms earlier statistical analysis showing a significant association between model presence and AI preference. Across both surveys, human-authored images with no model were selected most often—suggesting a base-level preference for minimalism or product focus when origin is trusted.

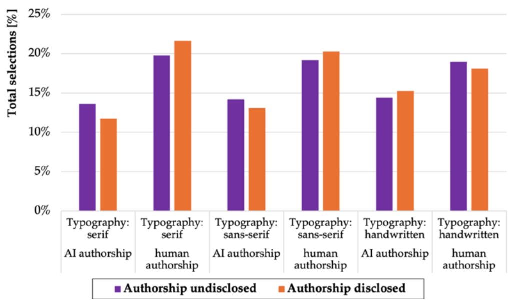



» **Figure 9:** *Percentage of image selections grouped by model presence, authorship, and disclosure condition*

### Typography Style

The findings reveal a modest but notable inclination toward human-authored serif visuals, especially in the disclosed version (21.7%). AI-authored visuals with serif fonts performed worst when authorship was revealed (11.9%).

Sans-serif and handwritten fonts produced more balanced results, with human-authored handwritten visuals achieving the second-highest selection rate overall (~19.4%). This may suggest that handwriting and modern sans-serif elements signal authenticity and design intent more strongly than AI typically conveys (Figure 10).




» **Figure 10:** *Selection percentages by typography type and authorship/disclosure condition*

## Interaction Effects

This section explores how gender, age group, authorship disclosure, and now visual design features interact to influence participant preferences for AI- versus human-generated visuals.

**Gender × Authorship disclosure:** Female participants were more sensitive to disclosure. Their AI preference decreased from 42.4% (undisclosed) to 37.5% (disclosed). In contrast, male respondents slightly increased their preference from 41.2–43.1%.

**Age × Authorship disclosure:** Notably, the age group 40–49 exhibited the highest AI preference under undisclosed conditions (50.4%) but dropped to just 32.3% when authorship was revealed. Meanwhile, the 30–39 group showed relatively high AI acceptance in the disclosed version (45.8%).

**Gender × Survey Interaction:** As previously observed, female participants were more sensitive to authorship disclosure: their preference for AI-generated visuals declined from 42.4% in the undisclosed Survey A to 37.5% in the disclosed Survey B. In contrast, male respondents slightly increased their AI preference from 41.2–43.1% when authorship was disclosed. This indicates a potential gender-based difference in how trust or familiarity with AI is processed—possibly linked to perceived risk, confidence in technology, or aesthetic priorities.

**Age × Survey Interaction:** Participants aged 40–49 showed the strongest aversion to AI when disclosure was present, with AI preference dropping from 50.4% (undisclosed) to 32.3% (disclosed). By contrast, younger participants aged 20–29 maintained relatively stable AI preference across survey types, suggesting a generational shift toward normalizing AI-generated content. The 30–39 age group was the only one to increase AI selection under disclosure (from 39.8–45.8%), indicating potential segmentation in consumer openness by age and media literacy.

**Visual Features × Disclosure × Authorship Interaction:**
→ Figures 7–10 introduce additional nuanced interactions between visual characteristics and participant behavior:

- **Background** (Figure 7): Human-authored visuals with plain backgrounds dominated preferences, regardless of disclosure. However, when authorship was revealed, AI-generated visuals with textured backgrounds outperformed AI visuals with plain backgrounds—suggesting that texture may act as a compensating design element, softening negative effects of AI attribution.
- **Composition** (Figure 8): Top-bottom compositions by human authors were consistently favored, whereas AI-authored versions were less accepted, particularly when authorship was disclosed. Interestingly, centrally composed AI visuals were more competitive when authorship was not disclosed, indicating that composition layout interacts with both authorship and transparency in shaping perceptions.
- **Human Model** (Figure 9): This figure highlights a strong three-way interaction. While human presence boosted visual preference across the board, AI visuals featuring models were notably

- more accepted under undisclosed conditions. Conversely, AI visuals lacking a human model were substantially penalized, especially under disclosure. This suggests that human presence may be interpreted as a cue for design intentionality or emotional appeal, which counters AI skepticism.
- **Typography** (Figure 10): Among typography styles, serif fonts enhanced credibility of human-generated visuals, particularly under disclosure, while AI-generated visuals with serif fonts were least trusted when authorship was revealed. Sans-serif and handwritten styles showed more balanced performance, suggesting these may be perceived as more neutral or contemporary, and therefore less risky for AI authorship.

These insights highlight a complex interaction between visual design, authorship, and audience characteristics.

Participants do not evaluate visuals solely on stylistic grounds or authorship, but based on how specific visual cues align (or conflict) with expectations of authenticity, emotional engagement, and artistic control. Disclosure appears to activate these judgments, especially in visuals where style implies intentionality (e.g., serif fonts, model inclusion).

This study, based on more than 3,000 survey responses, demonstrates that the perceived origin of visual content significantly shapes audience judgment in advertising and design. Human-generated visuals were consistently preferred (59.0%) over AI-generated alternatives (41.0%), and this preference was even stronger when authorship was disclosed.

These findings confirm that evaluation goes beyond surface aesthetics to include authenticity, emotional resonance, and perceived creative intent. At the same time, the relatively high acceptance of AI visuals indicates that audiences are increasingly tolerant of machine authorship, pointing toward an evolving visual literacy that is reshaping expectations of creative production.

Demographic analysis further revealed subtle but meaningful differences. Female respondents showed a stronger bias toward human-created visuals, whereas male respondents were somewhat more receptive to AI content. These results align with prior research in visual psychology and consumer behavior, suggesting gender differences in sensitivity to visual cues and trust in automated systems.

Such patterns indicate that audience demographics may influence how AI-generated content is received, and that creative strategies will need to account for these distinctions if they are to resonate effectively across diverse groups.

Another central finding concerns the role of disclosure. In line with previous studies, transparency about AI authorship slightly reduced acceptance, lowering preference for AI visuals from 42.2% to 40.1%. Though modest, this effect highlights the ongoing challenge of authenticity in AI-assisted creativity. It also reflects the double-edged nature of disclosure: while ethically necessary and aligned with responsible communication practices, transparency may lower engagement unless it is balanced by strong design, clear narrative coherence, or an emphasis on the human role in guiding the creative process.

## Conclusions

This study offers valuable insights for the creative industry as generative artificial intelligence reshapes design workflows and aesthetic expectations. Although AI has become a powerful tool for visual creation, it should be used carefully in contexts where identity, emotion, and authenticity are central to audience trust. Designers must consider not only the technical quality of AI outputs but also the visual rhetoric present in composition, style, and human presence. Presenting AI use as co-creation rather than replacement may help strengthen credibility and preserve emotional connection, especially in domains where human oversight and artistic intention are still valued. Acceptance of AI-generated content will likely vary by context: utilitarian and high-turnover environments such as e-commerce may embrace automation, while emotionally charged or luxury sectors will continue to prioritize human authorship.

From a theoretical perspective, this study connects creative practice and empirical perception testing by showing that authorship disclosure serves as a psychological framing device influencing perceived authenticity and aesthetic trust. Methodologically, it introduces a controlled comparative design that isolates visual and demographic variables, providing a replicable framework for future studies of audience response to AI-generated visuals.

The findings provide practical guidance for designers and marketers integrating generative AI into creative production. In addition to output quality, compositional and stylistic choices – such as including human figures, textured backgrounds, or hand-drawn typography – can reduce skepticism toward AI-generated visuals. When disclosure of AI involvement is required, it should be accompanied by strong emotional or narrative framing that emphasizes human intentionality in the creative process.

An important open question arising from this research is whether AI can develop a distinct and recognizable visual style that audiences perceive as authentic in its own right. Currently, generative systems tend to emulate human aesthetics rather than display a coherent, autonomous style.

As these technologies advance, future studies should examine whether an identifiable “AI aesthetic” emerges one that audiences value as an independent creative language, not merely as a derivative of human design.

Overall, the results support a multidimensional understanding of visual judgment, where perception is shaped by image quality, authorship, disclosure, and audience characteristics. Future research should examine cross-cultural and contextual differences, as well as experimental techniques such as eye-tracking or biometric measurement, to reveal the cognitive and emotional mechanisms underlying visual preference. Although AI has not replaced human designers in areas requiring narrative depth, emotional credibility, or authenticity, it is becoming an increasingly influential collaborator. As audiences grow more accustomed to generative visuals and as AI tools become more responsive to human nuance, the boundaries between machine and human creativity will continue to blur, ushering in a hybrid creative paradigm. Understanding where, why, and for whom authorship continues to matter will be essential to navigating this evolving landscape of visual communication.

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# Integrating AI image generation into the designer's creative process for mascot creation

**ABSTRACT**

*AI-generated image tools are an innovation that can significantly impact the design process by increasing productivity and generating a wide range of complex design exploration results. Although AI-generated image tools have many advantages and diverse features, research is still needed to assess the suitability of the images produced in the ideation process carried out by designers. The purpose of this study is to compare and assess the influence of the ideation process carried out by student designers in a mascot creation project with and without the use of AI-generated image tools. The method for this study is an experimental design by compares the ideation process using AI-generated images with the ideation process without using AI-generated images. The design analysis of the final design was conducted by expert designers using a blind review technique. The results of this study do not yet show that the use of AI in the ideation process is superior to conventional methods, but it is known that AI-generated images tools can be a reference and a competent choice of ideation media to use. This research has implications for the method of extracting ideas in the mascot design process and also provides evidence that the use of AI in the ideation process should not be feared or avoided.*

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artificial intelligence, creative strategy, graphic design, character design, conceptual design

## Introduction

The launch of Society 5.0 on January 21, 2019, focused on the use of technology and information to solve social problems and improve the quality of life, one of which is through the help of Artificial Intelligence (AI) (Roblek, Meško & Podbregar, 2021). The integration of AI into the design field has garnered significant attention, greatly transformed traditional practices and pushed toward new creative paradigms. Despite its speed and risks, AI in the design field is currently widely used.

The effectiveness of AI has also opened up opportunities to create a more inclusive design process for everyone by creating creative content more easily and instantly (Satrinia, Firman & Fitriati, 2023). However, the ease of AI in creating designs carries the potential to reduce designers' creativity in generating ideas. There is considerable resistance to the use of AI in the design context. The other side, AI image generative tools offer various alternatives for design and the development of ideas to be processed into various design explorations (Ardhianto & Nababan, 2023). The use of AI tools can influence the design process by increasing productivity (Thomson, Thomas & Matrich, 2024).

Generative deep learning can also influence the cognitive thinking of their users through diverse input processes, which can ultimately impact the resulting designs.

In visual communication design (VCD), AI-image generative devices can create a wide variety of engaging visuals, including photos, logos, cartoons, comics, audiovisuals, and mascots.

The superiority and speed of AI in processing text commands into visuals are increasingly questioning the design education and the design profession. However, AI technology still needs supervision and even further development with existing design techniques (Longhurst, 2024). The Indonesian Visual Communication Design Professional Association (AIDIA) believes that designers in the current AI era need to focus on creating value through problem-solving. This shift addresses doubts about the future of designers, who have shifted from focusing on visual creation to value creation (Zafar, 2024). This value creation process requires training in designers' critical thinking and empathy for problems that generate ideas through the ideation process.

Currently, there is little research on the use of AI-image generative in visual communication design case studies. According to Fareed, Bou Nassif & Nofal (2024), further research is needed to assess the suitability of the generated images, taking into account the knowledge and critical thinking of users (Fareed, Bou Nassif & Nofal, 2024). Striking a balance between human thinking and AI capabilities is crucial.

This research conducts a comparative study focusing on the ideation process using non-AI reference media and using AI image generative tools. The aim of this study to examine how the ideation process using AI image generative tools can influence the suitability of the design work obtained from the given brief. Therefore, the results of this study acknowledge the need for an ideation process that utilizes the features of AI image generative tools effectively and positively. This points back to the importance of using AI to help improve human life and professions by combining human intelligence and technology to enhance the creative process.

# Theoritical basis

## Design Thinking in Education: Perspectives, Opportunities and Challenges

Design thinking is an approach and mindset process that is done collaboratively to find and design a solution to big problems in various aspects. According to Panke (2019) complex problems have unlimited scope of complexity and are impossible to solve completely. With this, design thinking aims to go beyond the limits of existing problem challenges (Panke, 2019).

The process of design thinking in education is to make the students think and work like an expert designer (Ferguson et al., 2017; Sharples et al., 2016). The process can be applied to creates an innovative product according to the people's needs.

Furthermore, design thinking process develop a deep interest and understanding of the people we're designing by developing our empathy, and the five phase of design thinking according to Standford Design Schools are empathise with users, define the problems and needs, ideate the challenges, prototyping the solutions, and test the solutions (Razzouk & Shute, 2012; Sreenivasan & Suresh, 2024). This research encourages the VCD students to think deeply about understanding their behaviour, needs, and represent it through the mascot they created, practicing the design thinking process to make a more effective work like an expert designer.

## A Design Ideation Method for Novice Designers

Ideation is one of design thinking process stages. According to Kim (2020), ideation is an important step in the design thinking process (Kim, 2020). Ideation processes the design brief to be re-generated into various designs as problem solutions (Cheng, 2023). The importance of understanding ideation fundamental and capabilities is developing design environments, which will enable a more complex design form.

The process of ideation is used to guide designers to think effectively in order to create a creative outcome according to the brief or specific criteria (Cheng, 2015). In the industrial design engineering, ideation is described as a set activity of creation and development of directed ideas (Gonçalves & Cash, 2021). The success rate of the designer's ideation process in this research is determined by how they manage to visualize the creative process of their work.

## The Potential of AI in Creativity Creating a Design

Artificial Intelligence is able to explore more deeply everything in the creative world of design, including creating art in the form of paintings, 3D images, and even an influencer. AI helps designers to create new and interactive design explorations, and make the work process efficient. The effectiveness generated by AI has also opened up opportunities to make to make a more inclusive design process for everyone with an easier and instant creation of creative content (Satrinia, Firman & Fitriati, 2023).

Kim & Maher (2023) research shows that AI inspiration design process can produced more novelty, variety, and quantity which can influenced and improved the pattern of designer's ideation process (Kim & Maher, 2023). The collaboration of human and AI is a dynamic process since AI can adapt to user feedback, behaviours, preferences and needs, this will allow AI to improve their performance and match with the user expectations (Usmani, Happonen & Watada, 2023).

It is important to gain a better understanding of AI potential and its dynamic process with designers, and how effective it is compared with other conventional media in this research.

### Realizing Society 5.0 Through the Utilization of Artificial Intelligence Technology

Society 5.0 represents a transformative vision of future society characterized by the integration of digital technologies such as AI, the Internet of Things (IoT), and big data with social systems. Society 5.0 emphasizes inclusivity and adaptability to preemptively address societal challenges through advanced technological solutions, in line with the emphasis on human-centered design in AI development, as highlighted in recent discussions on ethical principles and practical strategies in AI governance (Sigfrids et al., 2023).

The rapid development of technology opens up the possibility for society to keep up with the flow of advancement. The start of society 5.0 in 2019 by the Japanese government which is based on the use of technology and information, Society 5.0 is here to solve social problems and improve the quality of people's work, one of which is with the help of the use of AI (Choudhry et al., 2024).

The advancement of AI in society 5.0 benefits in improving the manufacturing world and increasing business efficiency, but also aims to develop renewable energy so it may benefit in sustainability as well (Adel, 2022).

With this, the industry is improving effectively through the perfection of machine work and human workers. Society 5.0 is important aspect of improving the futures of many industries, and designers may contribute by the use of its information and technologies, making it easier to focus on improving their creativity by the effectiveness of smart technologies and machines.

## Method

In this study, we used experimental research through observation and testing of 34 VCD students, giving them the same task. The students were randomly divided into two groups of 17 students each (group A and group B). Group A completed the task using AI, while Group B completed the task using other reference media without AI.

### Participants and Task

Students in 2 groups were asked to create a non-human mascot to represent Soegijapranata Catholic University (SCU) VCD program. The characters created are prohibited from using stationery or painting properties with the intention of showing difference between VCD and fine arts study program. The character must also be considered in order to be a Virtual YouTubers (VTubers) that can be used as a visual asset for digital purposes (Hermawan et al., 2024). VTubers are virtual personas that employ real-time motion capture and AI to animate characters and engage audiences through live-streaming platforms and utilize 3D or 2D models to create content, reflecting both individual identity construction and broader cultural expressions (Yuan, 2025).

### Procedure and Work Scheme

Students were given a piece of paper and a total of one hour to create a character as in the brief. In the process, both groups were assigned to two different locations. Each group was allowed to use any reference media. Observations were also made by checking the progress time of the work every twenty minutes to determine the stages completed by each student.

There was no time limit for the ideation process and design work as long as everything could be completed within one hour. This was done to observe the ideation time process, including the characteristics and details of each participant's work. The result of the design ideation process was done by drawing a final sketch of the character that had been made on the paper given. At the end, participants must draw the final sketch of the character on the given paper, as a result of the design ideation process that have been done.

### Data Analysis

To test the comparative study in this research, the author uses a qualitative method with data reduction to process the results of the design comparison study that has been conducted with participants. Data reduction is a process of summarizing, selecting key things and focusing on important things and then looking for themes and patterns (Mezmir, 2020). The data reduction process was carried out with the assistance of a design expert, namely Mrs. Agnes Indah Suciani Kristanti, as a lecturer in charge of the Semantic Design Studio course at the Soegijapranata Catholic University and has experience teaching topics relevant to this research since 2016. The expert analyzed and assessed using a blind review technique, so the expert did not know the identity of the designer.

Furhtermore, the expert will analyse which work are the best in implementing the brief that has been given to students. This is important to determine the character chosen by each student, along with its meaning, and to identify which best aligns with the image of SCU's VCD program. The analysis process with the expert is conducted through a blind review, in which the author does not tell the expert the differences between Group A and Group B whether they used AI or not. The following is the data reduction process carried out by the author.

## Results

In this study, participants were free to use their own preferred reference media to design their mascots. Table 1 is a summary of the media used by each student. By observing the time and process carried out by each student ideation process. The researcher made a scheme of the process carried out by each participant by writing the behaviour code in table 2 and dividing the three stages of work, Pre-Process, Mid-Process, and Post-Process into figure 1 and figure 2. Pre-Process is carried out in the first 20 minutes of the participants process, the next 20 minutes are categorized as Mid-Process, and the last 20 minutes of are categorized as post-process. Each students experienced different times and ideation process at each stage.

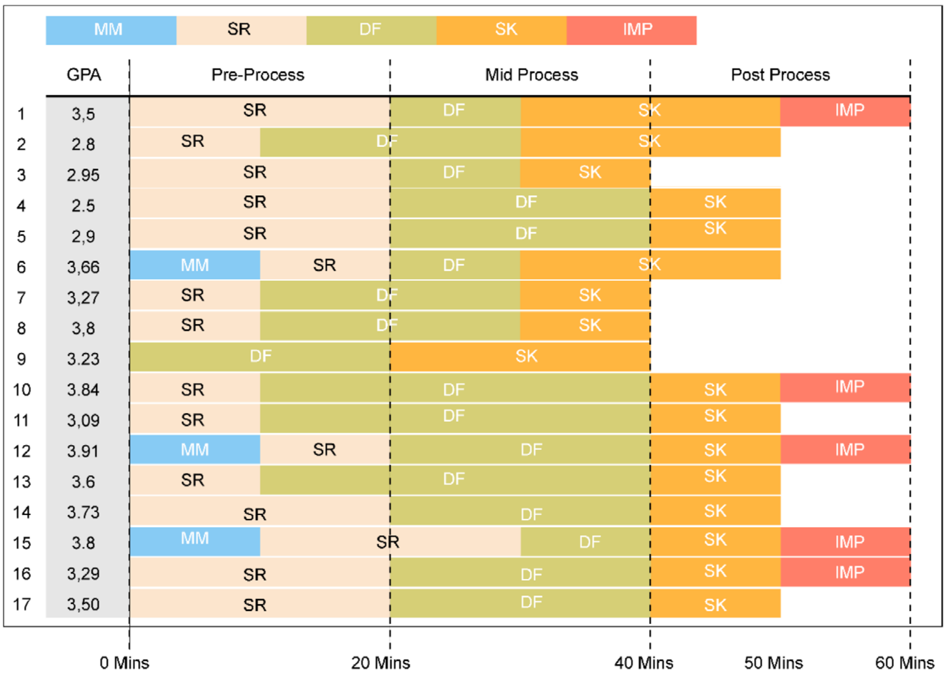
The expert was asked to select 15 out of 34 works first. the selected works are considered to have good semiotic meaning to be used as a mascot for the SCU's VCD program, according to the brief with good visual as well. Refer to table 3, it showed that the selected works from group A are works belonging to participants with numbers 1, 6, 8, 12, 14, 15, 16, 17. while the selected works from group B are works belonging to participants with numbers 18, 25, 26, 29, 31, 32, 33. it can be observed that group A had 8 selected works, while group b had 7 selected works, making group a superior by one selected work.

**Table 1**

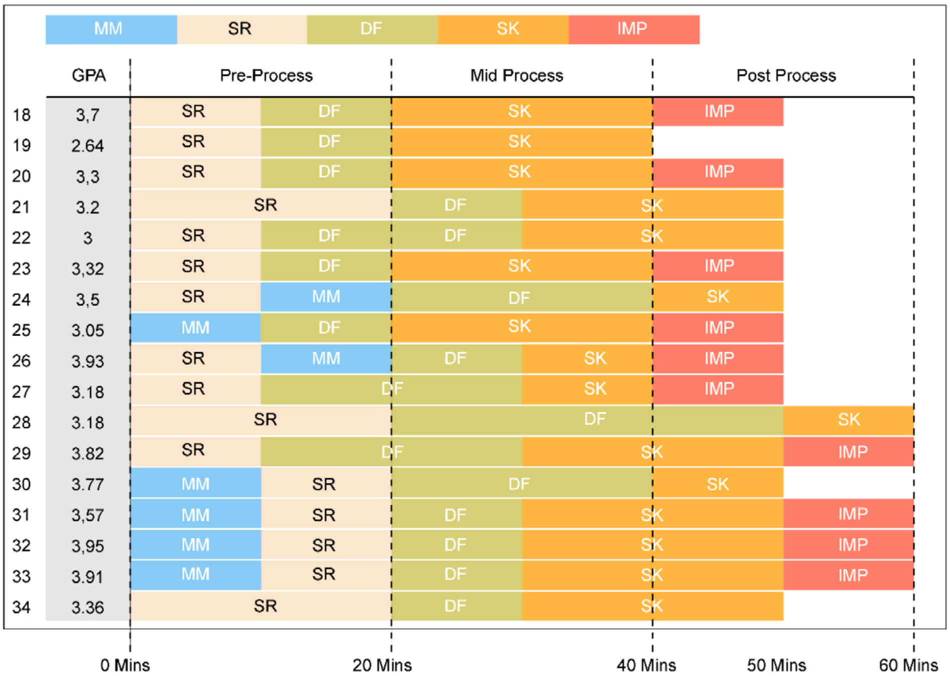
Participants Ideation Process

| GROUP A – AI GENERATIVE IMAGE TOOL IDEATION | | | | | |
|---|---|---|---|---|---|
| | | MEDIA | | | |
| NO. | GPA | Bing AI | Copilot | Leonardo AI | ChatGPT |
| 1 | 3,5 | ✔ | ✔ | | |
| 2 | 2.8 | | | | |
| 3 | 2.95 | | ✔ | | |
| 4 | 2.5 | | ✔ | | |
| 5 | 2,9 | ✔ | | | |
| 6 | 3,66 | | | ✔ | |
| 7 | 3,27 | | | ✔ | |
| 8 | 3,8 | | | ✔ | |
| 9 | 3.23 | | | ✔ | |
| 10 | 3.84 | ✔ | ✔ | ✔ | |
| 11 | 3,09 | | | ✔ | |
| 12 | 3.91 | ✔ | | | ✔ |
| 13 | 3.6 | | | ✔ | |
| 14 | 3.73 | ✔ | | | ✔ |
| 15 | 3.8 | ✔ | | | ✔ |
| 16 | 3,29 | ✔ | | | ✔ |
| 17 | 3,50 | ✔ | | | ✔ |
| | Total | 8 | 4 | 7 | 5 |

| GROUP B – NON AI IDEATION | | | | |
|---|---|---|---|---|
| | | MEDIA | | |
| NO. | GPA | Pinterest | Google | Instagram |
| 18 | 3,7 | ✔ | | |
| 19 | 2.64 | ✔ | | |
| 20 | 3,3 | ✔ | | |
| 21 | 3.2 | ✔ | | |
| 22 | 3 | ✔ | ✔ | |
| 23 | 3,32 | ✔ | | |
| 24 | 3,5 | ✔ | ✔ | |
| 25 | 3.05 | ✔ | ✔ | |
| 26 | 3.93 | ✔ | ✔ | |
| 27 | 3.18 | ✔ | | |
| 28 | 3.18 | ✔ | | |
| 29 | 3.82 | | ✔ | |
| 30 | 3.77 | | ✔ | |
| 31 | 3,57 | ✔ | ✔ | ✔ |
| 32 | 3,95 | ✔ | ✔ | |
| 33 | 3.91 | ✔ | ✔ | ✔ |
| 34 | 3.36 | ✓ | | |
| | Total | 16 | 9 | 2 |




» **Figure 1:** *Behaviour Code of Group A*




» **Figure 2:** *Behaviour Code of Group B*

**Table 2**

Code and Definitions

| Behaviour Code | Description |
|---|---|
| MM (Mind Map) | Brainstorming process by creating a series of information images |
| SR (Search) | The process of searching for references to gather the information needed |
| DF (Define) | Building an understanding and desire from the information that has been collected |
| SK (Sketch) | The process of making the final drawing based on the understanding and desire |
| IMP (Improve) | Adding or correcting details to complete the sketch |

## Working Scheme

Based on the analysis of the participants workflow in Figure 1 and Figure 2, it can be observed that Group A spent more time on the search and define process compared to Group B, which focused more on the sketching and design improvisation process.

It was also found that the define process in Group A differed from that of Group B. Group A performed the define process by repeatedly generating images until they found an alternative visualization that suited their needs before proceed to the sketching process.

In contrast, Group B conducted the define process by deeply researching the selected character type, followed by making rough sketches before developing the final sketch.

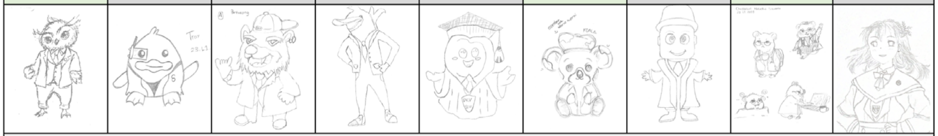
Reviewing the workflow of the 15 selected works, it was found that 8 out of 15 students used mind mapping during the pre-process stage. Additionally, 11 out of 15 students made improvisations to their work to make it more refined and aligned with their objectives. The workflow of the 15 selected works is presented in Figure 3.

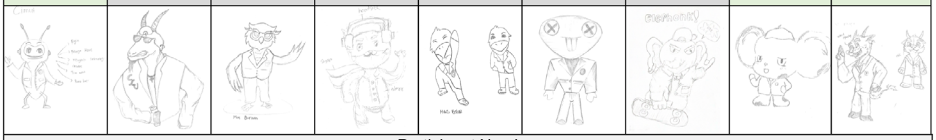
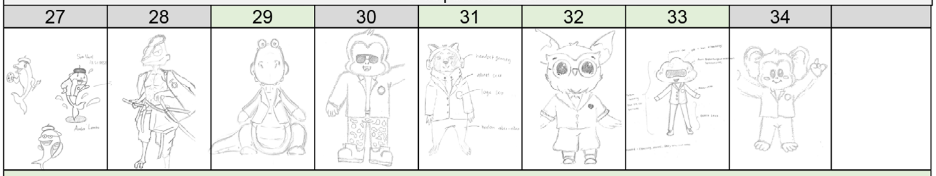
It can be observed in Figure 2 that Group B spent more time on the sketching process. Then based on the analysis of 34 sheets of collected design work, it was found that none of the participants in Group A created rough sketches or on the provided paper. In contrast, in Group B, 8 out of 17 students did the sketching, problem solving and mind map process on the paper sheet given. Table 4 presents the findings related to Group B's sketching process.

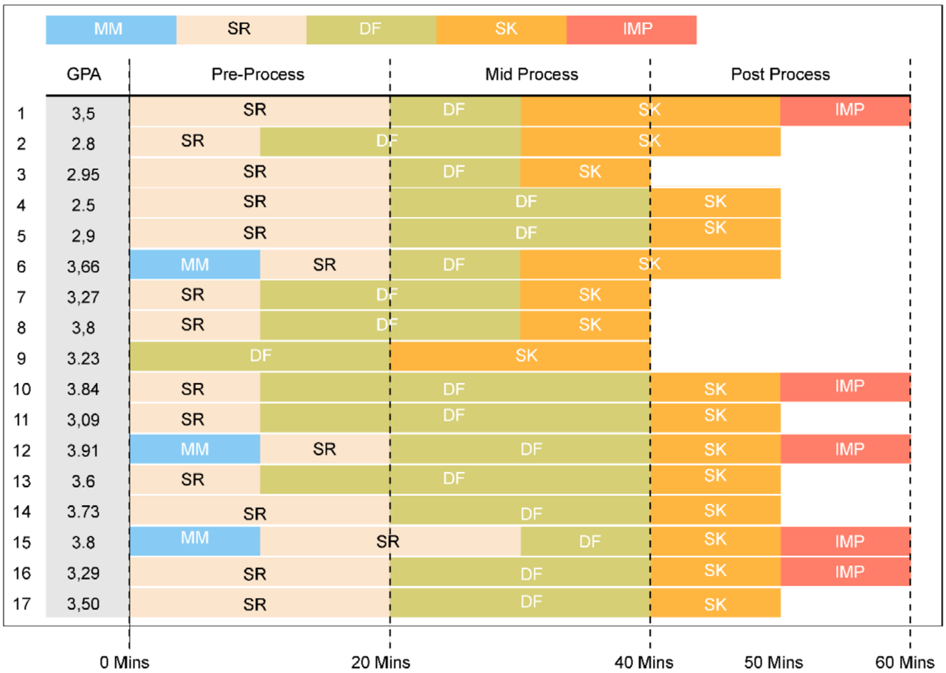
## References Media

It was found in Group A, that 8 students used Bing AI, 4 students used Copilot, 7 students used Leonardo AI, 5 students used ChatGPT, and 1 student used Meshy AI. This indicates that Bing AI is the most frequently used tool, with 8 users.  Meanwhile, in the ideation process conducted by Group B, 16 out of 17 students used Pinterest, 9 students used Google Images, and 2 students used Instagram. This shows that Pinterest is the most preferred reference platform for the ideation process, with 16 students using it.

**Table 3**
Design results

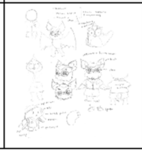
| Group A - Ideation with AI Generative Image | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Participant Number | | | | | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|  | | | | | | | | |
| Participant Number | | | | | | | | |
| 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | |
|  | | | | | | | | |
| Selected Works | | | | | | | | |

| Group B - Ideation with Non AI Media | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Participant Number | | | | | | | | |
| 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 |
|  | | | | | | | | |
| Participant Number | | | | | | | | |
| 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | |
|  | | | | | | | | |
| Selected Works | | | | | | | | |




» **Figure 3:** *Behaviour Code of 15 Participants with Selected Works*

**Table 4**
Group B findings in sketching process

| Participants Number | | | | | | | |
|---|---|---|---|---|---|---|---|
| 18 | 21 | 25 | 29 | 30 | 31 | 32 | 33 |
|  |  |  |  |  |  |  |  |

## Discussions

Based on the research on the working process and the final works, the author with the expert, conducted a re-evaluation of the existing data and performed data reduction.

## Best Work

From 15 selected works deemed suitable by the expert, further data reduction was carried out by selecting the 3 best works that are considered the most suitable as SCU's VCD mascot.

These selections were based on good visual, alignment with the brief, and creative meanings.
As a result, the works of participants numbered 6 and 12 from Group A, and participant number 33 from Group B were selected. This again makes Group A superior by one selected best work.

1. Participant Number 6 (Figure 4)


» **Figure 4:** *Participant's Work Number 6*

The selected mascot, a koala character is illustrated with a body that is splashed with colour, the character wears a beret hat, smiles while holding the university's alma mater jacket. This koala was chosen as it symbolizes SCU's VCD students, who can adapt to any situation with ease. Holding the alma mater jacket can also represent students' readiness to face challenges.

Koalas are known for their lazy nature and long sleeping hours, becoming active from dusk to night, and even at dawn. This fact is quite similar to the habits of many VCD students who tend to prefer to do assignments and activities late at night, and often staying up until dawn. Wearing a hat is a common thing for VCD students, but a beret hat is reflecting students' personality and desire to be unique and eccentric, especially with paint spill ornaments on the character's body as a symbol of creativity.

2. Participant Number 12 (Figure 5)


» **Figure 5:** *Participant's Work Number 12*

The chosen mascot, represented by a chibi wolf character, smiling while clenching his hands, symbolizing perseverance. Based on the information added by participants, this character is interpreted as a brave and tough character. A detail shows that the tail on this character is also splashed with colour.

The wolf is a representative of students who tend to be more active at night and have a habit of gathering with their packs. Wolf is considered as a wise leader in the packs, good adaptation skill and problem solving. Wolf are suitable characters to portray a brave nature that willing to face challenges.

With a splash of colour on its tail, this can give the impression that the wolf mascot is a character who is willing to accept creative challenges.

3. Participant Number 33 (Figure 6)

» **Figure 6:** *Participant's Work Number 33*

The chosen mascot is a cloud character. The mascot is portrayed with a smiling, wearing glasses, and splashed with color. Based on the information written by the participants, the cloud symbolizes freedom in creativity, with details of color splashes on the face. The character is also described as having a sleek body, modern clothing, and wearing a VR headset, which shows that SCU's VCD program embraces learning and innovation in art, design, and technology. This character is considered suitable to illustrate SCU's VCD positive, cheerful, free spirit, and technology literacy in creativity.The use of VR shows emphasizes advancements in technology and knowledge.

## Working Process Factor

It was found that 8 out of 15 students whose work was selected used the mind mapping process during the pre-process stage. Additionally, 11 out of 15 students made improvements to make it more suitable.

In contrast, among the 19 students whose work was not selected, only 2 students applied the mind mapping process, and only 4 out of 19 made improvements to their designs.

This indicates that mind map process and improvisation help the students' thinking process to be more thoughtful in determining what kind of work they will create in order to become a good and appropriate work (Jones & Morrison, 2021). The use of mind mapping methods can help the users to improve their critical thinking skills in processing creativity because mind mapping helps users in categorizing and organizing visual information and creativity, which will be useful in the process of solving existing problems (Chiu & Hwang, 2024).

## High Achievement Factor

Among the 15 students with selected works, it was found that 13 of the 15 students have high achievement in their academic performance.

The form of high achievement is known through their Grade Point Average (GPA) being above 3.5, with the overall average GPA of students with selected works being 3.67. Additionally, two students with the best selected works have excellent high achievement by achieving a GPA of 3.91. Meanwhile, 2 out of the 13 students with selected works had mid-level academic achievement, with GPAs of 3.29 and 3.05.

The author also conducted an analysis of students whose work was not selected. It was found that the average GPA of this group is 3.19, indicating a mid-level academic achievement. It can be concluded that students with selected works have a good academic achievement (Purnomo & Chen, 2025). GPA is one of the factors that support students in the design thinking process of creating more refined and high-quality work (Povinelli, 2023).

## Reference Media Factor

In Group A, Bing AI was found to be the most widely used AI generative image engine by students, likely due to its features and output quality. Meanwhile, in Group B, the majority of students used Pinterest for their ideation process, with 16 out of 17 students using this platform during the search and definition process. This finding suggests that many students consider Pinterest their preferred reference platform due to its efficient features and immediate visual image references (Scolere, 2023).

The integration of AI into the creative process, particularly in mascot design ideation, represents a significant evolution in design, particularly in terms of timeliness and big data (Ardhianto, Santosa & Pusparani, 2023). However, AI ideation methods require prompting skills with good language structure, good visual taste for supervise the result from the AI, and need basic skill in computing and internet access. The emergence of generative AI technology allows designers to explore a wide range of artistic possibilities (Xiao, 2025).

Generative AI fosters a collaborative dynamic that combines human ingenuity with computational capabilities, empowering designers to see visual data that might not have initially emerged during manual ideation. Therefore, AI is more of an idea-stimulating tool, as the majority of output is derived from data the machine has stored and trained.

While traditional ideation methods typically rely on human creativity and intuition, these are actually key to generating creative ideas. Humans can combine information and context into visual ideas because of their intuition and aesthetic experience. However, they cannot generate images as quickly as AI. This trend aligns with the increasing use of AI in various creative fields and underscores the importance of understanding AI tools as an enhancement to human creativity, not a replacement.

## Conclusions

Through a series of data reduction processes conducted to curate the best works, it was found that Groups A and B differed only in one selected design and the best work. This slight difference does not indicate that the use of AI in the ideation process is superior to other conventional media. However, it does indicate that AI-generated image tools can be a competent reference and ideation tool.

This study also revealed that students whose works were selected had high academic achievement. This is a supporting factor in how high-achieving students are able to think more critically to produce work that meets the brief. These high-achieving students often engage in the ideation process using mind maps and improvisation, which can help users think more critically in determining the suitability of the work. This occurs because these processes help designers organize visual information and context more effectively. Critical thinking is a crucial aspect of ideation that can influence the suitability of the work.

## Future works

The ideation process, with or without the use of AI generative tools, must always be approached with critical thinking in processing information. Furthermore, while AI is only a tool, visual sense derived from aesthetic experience is crucial in visual design and the determination of which visuals will be published.

One method of organizing visual information during the ideation process is through the use of mind maps. While AI can produce high-quality results, its effectiveness can be further optimized by incorporating the user's critical thinking processes.

A recommendation for future research is to focus on how AI generative tools can produce more innovative visual work (Alayrac et al., 2022), taking into account the complexities of various design styles and current trends. This approach could increase the acceptance of AI in everyday life and society.

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