JURNAL bahasa rupa

JURNAL BAHASA RUPA | ISSN 2581-0502 | E-ISSN 2580-9997
Vol.08 No.03 – August 2025 | https://bit.ly/jurnalbahasarupa
DOI : https://doi.org/10.31598/bahasarupa.v8i3.1894
Publisher : Institut Bisnis dan Teknologi Indonesia

Rafflesia-Inspired Digital Fashion in Virtual Reality: A Biomimicry Approach for Gen Z in the Fashion 4.0 Era

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Received : May, 2025	Accepted : July, 2025	Published : August, 2025

Abstract

The phenomenon of digital fashion is undergoing a significant transformation in the global fashion industry, driven by internet advancements and a shift towards digital experiences as a hallmark of the Fashion 4.0 era. This research employs the Double Diamond methodology with a focus on visual exploration, applying biomimicry inspired by the morphology of the Rafflesia Rhizanthes Deceptor flower. Its aim is to formulate contextual visual strategies for introducing this flower to Generation Z through a virtual fashion show based on Virtual Reality (VR). The digital design process involved detailed modeling of garments and accessories using CLO 3D and Blender, subsequently realized within the Unreal Engine environment. VR revolutionizes audience interaction with fashion through immersive visual narratives. In this virtual space, elements such as light direction, color contrast, and animation serve as a semiotic system to guide audience perception. Although VR offers 360° viewpoint flexibility, designers strategically direct audience focus using dominant visual cues. Overall, this research contributes to the development of nature-inspired digital fashion design and the construction of imaginative visual narratives that align with immersive media, opening new opportunities for the fashion industry within the rapidly evolving digital landscape.

Keywords: *digital fashion, biomimicry, rafflesia rhizanthes deceptor, virtual reality, digital accessories, digital fashion show*

Abstrak

Fenomena fesyen digital mengalami transformasi signifikan dalam industri mode global, didorong oleh kemajuan internet dan pergeseran menuju pengalaman digital sebagai ciri khas era Fashion 4.0. Penelitian ini menggunakan pendekatan metodologi Double Diamond dengan fokus pada eksplorasi visual, serta menerapkan biomimikri dari morfologi bunga Rafflesia Rhizanthes Deceptor. Tujuannya adalah merumuskan strategi visual kontekstual untuk memperkenalkan bunga tersebut kepada Generasi Z melalui fashion show virtual berbasis Virtual Reality (VR). Proses perancangan digital melibatkan pemodelan detail busana dan aksesori menggunakan CLO 3D dan Blender, kemudian diwujudkan dalam lingkungan Unreal Engine. VR merevolusi interaksi penonton dengan fesyen melalui narasi visual yang imersif. Dalam ruang virtual ini, elemen seperti arah cahaya, kontras warna, dan animasi berfungsi sebagai sistem penanda untuk memandu persepsi audiens. Meskipun VR menawarkan fleksibilitas eksplorasi sudut pandang 360°, desainer tetap strategis mengarahkan fokus audiens dengan isyarat visual (visual cues) dominan. Secara keseluruhan, riset ini berkontribusi pada perancangan desain digital berbasis alam dan pembentukan narasi visual imajinatif yang relevan dengan media imersif, membuka peluang baru bagi industri fesyen dalam ranah digital yang terus berkembang.

Kata Kunci: *fesyen digital, biomimikri, rafflesia rhizanthes deceptor, virtual reality, aksesori digital, Peragaan Busana Digital*

1. INTRODUCTION

The phenomenon of digital fashion is now expanding into the global fashion industry, driven by the growth of the internet. In post-industrial networked societies, the Fashion 4.0 era is characterized by a shift from physical products to digital experiences [1]. Digital fashion, which initially emerged as an experimental medium, has now evolved into virtual assets that enable limitless creative exploration beyond the constraints of physical materials. Despite their immaterial form, these assets are still regarded as part of material culture recognized for their existence and value within the digital realm [2]. The progression from simple virtual forms to complex and multidimensional systems reflects a significant shift in how humans perceive, create, and present fashion through various digital platforms and technologies [3]. In general, the more imaginative and less constrained the virtual space is from reality, the greater its potential to stimulate creativity and profound aesthetic experiences. This has important implications for the development of digital fashion, fashion education and information, as well as opening new opportunities for emerging designers and enhancing user experiences [4]. In addition, technologies such as Virtual Reality (VR) can serve as a medium for simulating garments, providing an immersive space for fashion showcases, a platform for exploration, promotion, and education, as well as an inclusive arena for participation [4]. As demonstrated in a study conducted by Nugroho [5], a fashion show simulation using Virtual Reality at Obeda Boutique Salatiga proved to be effective and suitable for publication as a presentation medium. This finding opens up further opportunities to explore VR as a visual promotional tool capable of simulating fashion.

Building on this potential, this study aims to introduce the *Rafflesia Rhizanthes Deceptor* flower as the primary source of inspiration in digital fashion design, specifically targeting Generation Z an audience accustomed to visual and immersive technological approaches. This species belongs to the *Rafflesiaceae* family and is found in the tropical forests of Sumatra at elevations ranging from 500 to 700 meters above sea level [6]. The Rafflesia flower was chosen for its unique morphology, its symbolic value as a rare national blossom, and its potential to introduce Indonesia's rich biodiversity to a global audience through the medium of digital fashion. This concept aligns with the practice of contemporary designers such as the brand Auroboros, which presented a biomimicry based digital ready-to-wear collection at London Fashion Week and marketed its products through digital fashion platforms [7]. Biomimicry is an innovative approach that draws inspiration from nature to solve human challenges. The term was popularized by Benyus. J in book Biomimicry: Innovation Inspired by Nature (1997), derived from the Greek words "bios" (life) and "mimesis" (to imitate) [8]. Biomimicry design in the form of abstract drawings does not explicitly represent natural forms, but rather adopts the morphology, colors, and textures of nature to create works that enable free visual exploration and experimentation [9].

There are steps in the Biomimicry Design Spiral/ Nautilus Shell, consisting of six iterative stages: (1) Define, identifying the primary function of the design; (2) Translate, converting that function into biological terms based on natural context; (3) Discover, finding strategies used by living organisms to perform similar functions; (4 Abstract, reinterpreting those strategies into a technical framework for design application; (5) Emulate, applying them in human-centered design; and (6) Evaluate, assessing the design based on initial goals and nature’s life principles to ensure sustainability [10]. In the realm of fashion, this approach is manifested through the design of garments and accessories that reflect the structures, patterns, and functions found in nature [11].

This study employs the Double Diamond methodology with a focus on visual exploration. Biomimicry is applied to examine the

morphological potential of the *Rafflesia Rhizanthes Deceptor* as inspiration for form, texture, and composition in digital fashion design. The process does not involve user testing, as it concentrates solely on visual experimentation. The aim of this research is to formulate a contextual visual strategy for Generation Z, grounded in local flora, and to present it in VR as a medium for aesthetic expression through a virtual fashion show. The contribution of this study lies in enriching nature-inspired digital fashion design and crafting imaginative visual narratives that are relevant to immersive visual media and well-suited for Generation Z.

2. RESEARCH METHOD

This study adopts a qualitative approach using the Double Diamond method, which consists of four stages: Discover, Define, Develop, and Deliver. The main focus of the research is the visual exploration of the morphological form of the *Rafflesia Rhizanthes Deceptor* flower as a source of inspiration for digital fashion design based on VR technology. This study does not involve direct user testing; however, future research may focus on measuring aspects such as narrative immersive experience, movement engagement during interaction with the stimulus, and the level of comfort in using VR technology.

In the Discover stage, interviews, literature review, and visual analysis were conducted. This analysis aimed to identify the flower's visual characteristics such as petal shapes, textures, and dominant colors as the foundation for design exploration. The Define stage involved compiling and filtering biomimetic elements to be translated into digital fashion designs. Initial visualizations were created as alternative sketches using Procreate, in order to conceptualize potential forms of garments and accessories inspired by biomimicry. The Develop stage focused on the digital production process, starting with garment modeling in CLO 3D to build the pattern structure and select appropriate digital fabrics. A real-time 3D simulation was generated as the first sample. The design of digital accessories such as headpieces, avatars, and animations was carried out using Blender, and then integrated into CLO 3D to produce a unified visual simulation as the second sample.

These design assets were later exported to Unreal Engine to construct a virtual runway environment that embodies an immersive and futuristic visual atmosphere, tailored to appeal to Generation Z aesthetics. In the Deliver stage, the digital fashion collection was fully visualized in a Virtual Reality space using Unreal Engine. The final result presents the transformation of the *Rafflesia Rhizanthes Deceptor's* forms and textures into digital fashion formats, culminating in a three-dimensional virtual fashion show. This visualization incorporates principles of lighting, spatial composition, and 360° freeviewing perspectives, functioning as an experimental visual artifact that can serve as both a design reference and an informative medium suited for Generation Z.

3. RESULT AND DISCUSSION

3.1 Discover

The Discover stage of this study began with an interview conducted on May 16, 2024, with Dian Rosleine, an ecologist and biosystematics researcher at ITB. The interview revealed that the Rafflesia flower possesses a unique morphology as a parasitic plant lacking stems and leaves. It absorbs nutrients from its host plant, *Tetrastigma*, through a specialized organ called the *haustorium*. In addition, the Rafflesia emits a foul odor, which functions to attract natural pollinators such as flies. A subsequent interview was conducted on June 14, 2024, with Arifin Surya Dwipa Irsyam, a botanist, who explained that the survival of the Rafflesia is highly dependent on the condition of its host and the surrounding environment. Additional insights were provided by Sofyan, a representative from Komunitas Peduli Puspa Langka Bengkulu (KPPLB) on October 4, 2024, who noted that various species of Rafflesia can be found in the Bengkulu region not only *Rafflesia Arnoldii*, but also *Rafflesia Hasseltii, Rhizanthes Deceptor*, and others each with its own distinct visual characteristics. For the researcher, these findings offer a compelling foundation for introducing the diversity of Rafflesia species and the rich biodiversity of Bengkulu. This topic aligns with current fashion trends, as highlighted in Lee's study [12], which

explored fashion trend elements and characteristics inspired by digital technology using text mining-based big data analysis. The study revealed that empathy toward both humanity and nature has emerged as a core value influencing design expression in digital fashion trends [13].

Picture 1. *Rafflesia Rhizanthes Deceptor*
[Source: Kompasiana.com, 2016. https://www.kompasiana.com/sofianrafflesia/552e48256ea8344f388b457e/rhizanthes-deceptor-apaan-sih]

Picture 1 shows *Rafflesia Rhizanthes Deceptor,* a parasitic plant that lacks leaves, stems, roots, and photosynthetic tissue. This flower grows by attaching itself to the roots of *Tetrastigma*, a type of climbing plant from the grape family (Vitaceae). *Rafflesia Rhizanthes Deceptor* features a white base color with reddish-brown tips and measures approximately 15 to 27 centimeters in diameter [14].

3.2 Define

Digital fashion design inspired by nature can begin by studying the biomimicry concept of the *Rafflesia Rhizanthes Deceptor* flower, using the Design Spiral/ Nautilus Shell theory:

1) Distill / Identify:

The petals are white, covered with fine hairs, and the tips of the perigon petals resemble dangling roots.

2) Translate (Translating the Idea into a Solution):

The shape of the petals can be applied in designing an A-line silhouette dress with large trailing structures downward, while the elongated perigon petal structure serves as an additional reference for other dress silhouettes. The white color with brown tips on the petals can be translated into fabric colors and cuts.

3) Discover (Identifying Natural Models):

The flower's long straight silhouette lines are interpreted into pleated fabric textures, creating a lengthening line effect. The tetrastigma tendril structure on the Rafflesia host can be applied in accessory designs such as headpieces.

4) Abstract (einterpreting those strategies into a technical framework for design application):

The natural strategies observed from the morphology and characteristics of the *Rafflesia Rhizanthes Deceptor* flower are reinterpreted into a technical design framework to generate visual solutions in the form of digital fashion that can be interactively simulated in virtual space.

5) Emulate (Imitating Natural Models in Garment Design):

The A-line silhouette and cutting use a widening dress shape that trails backward, resembling the petals of *Rafflesia Rhizanthes Deceptor*. Motifs and colors utilize a combination of white and brown as the primary elements in textile design. Textures and materials employ fabrics with elongated, straight effects, such as pleated materials.

6) Evaluate (Evaluating the Fashion Design):

The final stage is to evaluate how the design inspired by *Rafflesia Rhizanthes Deceptor* can be applied in the fashion world. Testing involves assessing visual appeal and responses from users or target audiences, which are crucial considerations in refining this biomimicry-based fashion collection.

Picture 2. Sketch Based on Biomimicry *Rafflesia Rhizanthes Deceptor*
[Source: Qatrunnada, 2025]

After several stages of design iteration and evaluation, two final designs were selected, with Design A ultimately chosen for realization in the form of a three-dimensional model using the digital design software CLO 3D.

Picture 3. Alternative Dress Sketches
[Source: Qatrunnada, 2025]

Look A explores a stylized silhouette derived from the structure of the *Rafflesia Rhizanthes Deceptor* flower, translated into a gown that merges organic elements with geometric lines. White is used as a neutral base color, reinforcing a sense of magic and elegance while reflecting the flower's natural hue. Pleated fabric textures introduce rhythmic vertical line repetitions, adding visual dimension and guiding the viewer's gaze upward. These straight-line elements subtly contrast with the circular silhouette referencing the Rafflesia's floral crown, creating a dialogue between rigidity and fluidity. The result is a visual composition that conveys both grace and structural strength, capturing the essence of nature within a digital fashion form.

To strengthen the visual representation of the Rafflesia flower, additional accessories are featured at the waist and head. The headpiece is designed to resemble the tendrils of *Tetrastigma*, the host plant of Rafflesia, with *Rafflesia Rhizanthes Deceptor* inspired floral elements at the tips symbolizing the harmonious relationship between host and parasite within the tropical ecosystem. Echoing the headpiece, the chest and waist areas of the garment are adorned with accessories patterned after *Tetrastigma* tendrils. Specifically, the waist accessory mimics the shape of *Rhizanthes* petals, blending botanical forms with garment structure. All accessories are rendered in silvery white tones, evoking a futuristic and clean aesthetic that contrasts with the primary fabric while optimizing light reflectivity in 3D and VR simulations.

3.3 Develop

The next stage involves modeling the design virtually in CLO 3D to construct the pattern, select digital fabrics, and adjust the garment's colors, motifs, and visual details. Unlike conventional pattern making, digital patterning allows for real-time simulation on an avatar, providing a highly realistic visualization that enables designers to envision the final outcome of the design [15]. The first step is to determine the appropriate avatar, starting with the avatar's gender, height, and body measurements. In this study, a female avatar was manually customized with the following dimensions: height 186 cm, bust circumference 77.17 cm, waist 54.21 cm, hips 94.56 cm, arm length 24.84 cm, collar size 35.46 cm, and thigh circumference 54.21 cm. A neutral pose was used for the initial fitting stage, which could later be adjusted to a dynamic pose during the

design presentation. In addition to pose adjustments, designers can also modify the avatar's measurements using the custom features available in the software. Digital pattern technology allows for precise control over garment size and shape while significantly reducing the need for physical prototyping. However, because digital fabrics are virtual, the ability to physically sense or feel the fabric's texture remains limited [16].

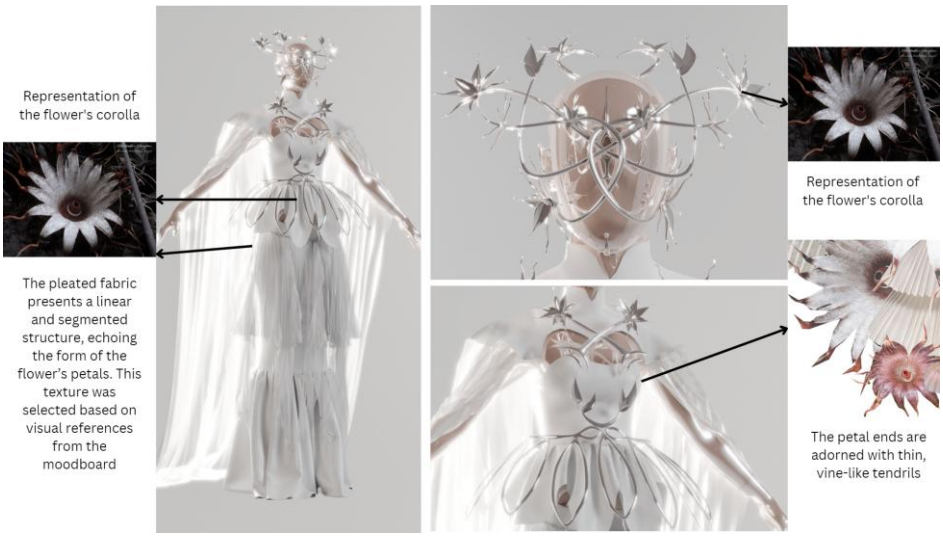
Next, the dress was drafted in 2D panels adjusted to fit the avatar's measurements, then assembled and simulated in a 3D space in real time. Material adjustments were applied to achieve realistic fabric visuals and movement. The creation of digital fabric patterns and textures was carried out through three methods: using Photoshop, the Fabric Generator in CLO 3D, or an AI Fabric Generator. In this study, the third method was used scanning physical fabrics and uploading them to an AI platform to generate seamless textures along with complete texture map files. After accessing the AI Fabric web platform, the researcher configured the material type and labeled the scanned fabric. While this method is efficient, the quality of the output heavily depends on the scanning device, which can affect the accuracy of the digital texture. Fabric selection and property adjustments are crucial elements in both visualization and simulation stages. Design A utilized two types of fabrics: Cotton Terry Cloth, a soft and thick material (±300–400 g/m²), was chosen to create volume and a sense of density, while pleated fabric (Plisket), with a sharp texture (150–200 g/m²), was selected for its rhythmic visual effect and ability to shape a structured, elegant silhouette. Texture maps such as base maps and normal maps generated by AI were used to enhance visual detail, including fabric coloration and raised decorative stitching such as embossed topstitching that defines the bustier area.

Next, to view the simulation of the first sample, the design can be observed in real time. Designers can use 3D simulation to determine the fabric's drape direction, closely resembling real-life behavior. Rendering is also essential, as it allows designers to examine the fabric's texture in detail since certain material properties only become fully visible during the rendering process.

Picture 4. the simulation of first sample
[Source: Qatrunnada, 2025]

Accessories were rigged to the mannequin to ensure they follow its movements when reintegrated into CLO 3D. This enables the digital garments and accessories to exhibit responsive behavior aligned with physical motion dynamics, including realistic fabric drape, natural folding, and dynamic texture movement. For simple accessories such as buttons or zippers, direct placement in CLO 3D is sufficient. However, custom accessories with

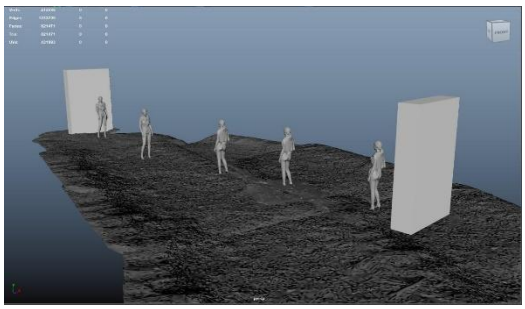
intricate details were created in Blender. The integration of both software platforms maximizes their respective strengths: CLO 3D for digital pattern drafting, and Blender for accessory creation, scene setup, and professional lighting to achieve optimal rendering results [16]. In this process, interoperability between software like CLO 3D and Blender can cause technical issues, especially during file export and alignment of the mannequin with the garment design. The position of the mannequin and fabric must be adjusted accurately to ensure proper results.



Picture 5. the simulation of the second sample
[Source: Qatrunnada, 2025]

The simulation process in this second sample stage produced a highly realistic visualization of the garment in motion, which is particularly useful for testing the flexibility and aesthetic quality of the design prior to production or presentation in a VR medium. Once the garment, character, and animations were finalized, all assets were exported from CLO 3D in compatible formats such as FBX or Alembic (.abc), including textures and materials.

These assets were then imported into Unreal Engine to construct a complete virtual fashion show environment featuring lighting, visual effects, sound, and dynamic camera movements. The final output was rendered as a 360°, video to provide an immersive presentation experience. The rendering process begins with creating a Camera Actor, which is arranged in a Level Sequence to control movement and scene duration. For panorama or VR output, a Pano Camera Component is added as the main camera. Exposure is set to 10.0, followed by creating a Movie Render Queue (MRQ) to render the Level Sequence into panoramic frames. This process requires precision and adequate hardware, with challenges such as long rendering times, complex camera setup, and potential configuration errors.



Picture 6. The scene setup in Unreal Engine
[Source: Qatrunnada, 2025]

The scene setup in Unreal Engine began with the arrangement of essential environmental elements such as the runway stage, lighting, and camera positions to optimize viewing angles. The animated avatar was then integrated into

the virtual runway. This fashion presentation was designed with a dramatic approach, featuring a surreal atmospheric visual style by incorporating soft fog and dim lighting. These elements created a transition between reality and imagination.

Spot lighting added a magical effect, while selective light beams were used to highlight the texture details of the garments. Glass elements were employed as portals for the models' entrances and exits, effectively enhancing the sense of an imaginative world and inviting the audience into an intuitive and emotional visual experience.

3.4 Deliver

The final stage involves bringing the digital fashion inspired by *Rafflesia Rhizanthes Deceptor* into a VR environment using Unreal Engine, creating an immersive visual presentation space. In VR, the visual environment itself forms a narrative, serving as a central instrument for delivering a viewing experience that differs significantly from conventional fashion show formats.

Within this immersive space, designers utilize visual storytelling elements such as lighting direction, color contrast, and animated objects (including garments and avatars) to convey a cohesive narrative. VR also offers the flexibility to explore unique viewing angles, allowing the audience to independently observe details and transcend the limitations of physical space [4]. Although viewers have the freedom to explore a 360° environment in VR, designers can strategically guide their attention to ensure that highlighted fashion elements remain the central focal points. This is achieved through the use of dominant visual cues, such as pronounced movement in garments or avatars, or more intense and focused lighting compared to the surrounding environment naturally drawing the audience's gaze toward the intended object.

Moreover, within the VR space, users experience a heightened sense of presence, as though they are physically attending the fashion show. This facilitates a deeper aesthetic interaction, where runway garments are interpreted through the ambiance of the virtual environment, creating a strong sense of immersion and presence within the space.

Picture 7. Digital Fashion Show
[Source: Qatrunnada, 2025]

Ultimately, this study demonstrates how the integration of multiple software platforms can optimize digital fashion design, from garments to accessories. This approach opens up broader possibilities within the digital fashion industry. Its applications extend to customizable fashion products one commerce platforms, promotional or digital advertising media, fashion themed film production, integration into interactive gaming environments, and various other digital media formats [17]. Advancements in digital technology have significantly transformed the

way fashion shows are presented, driving a paradigm shift in how designers showcase their work and engage with audiences [18]. Today, an increasing number of fashion labels are leveraging digital technology to simulate and present their collections in virtual formats. In addition, this strategy is used to strengthen brand identity, supported by technologies capable of producing highly realistic 3D garment visualizations and providing consumers with immersive, interactive experiences across various digital platforms [16].

4. CONCLUSION

This study highlights the transformation of digital fashion in the era of Fashion 4.0 into an immersive experience made possible by technological advancements, where design works now hold value within virtual spaces. As a contribution to this evolving field, the research explores *Rafflesia Rhizanthes Deceptor*, a rare Indonesian flower, as a source of biomimicry inspiration an approach that remains relatively underexplored in previous digital fashion studies. In contrast to prior research that focuses on wearable technology or digital textiles, this study emphasizes nature inspired visual design, presented through an animated virtual fashion show in a Virtual Reality (VR) simulation, aiming to deliver both knowledge and a narrative immersive experience for Generation Z.

The design process adopts the Double Diamond methodology, starting with morphological exploration of the flower, followed by digital modeling using CLO 3D and Blender, and culminating in a final presentation within the Unreal Engine environment. The use of VR technology offers the potential to enhance the fashion viewing experience through immersive 360° environments enriched with narrative elements such as lighting, color contrast, and animation, which strategically guide the audience's visual focus. The key findings demonstrate that integrating biomimicry with digital fashion in VR strengthens visual storytelling while conveying deep symbolic and aesthetic values. Moreover, this study presents a cross-software workflow integrating CLO 3D, Blender, and Unreal Engine, serving as a valuable reference for designers in developing virtual fashion presentations. It also promotes Indonesia's natural heritage through digital media, while emphasizing the importance of sustainability and the role of indigenous biodiversity in driving digital fashion innovation. The use of these software tools also supports a more efficient and environmentally friendly design process, as it eliminates physical pattern waste and reduces the need for excessive manual work. The limitations of this study include the absence of direct user testing with audiences, as well as technical challenges encountered during the design process, such as interoperability issues between software (CLO 3D and Blender), the need for precise alignment of the mannequin and garment, and the complexity of the VR rendering process, which requires adequate hardware and meticulous technical setup. Some material characteristics in CLO 3D are not fully visible during the initial simulation stage and only become apparent after the rendering process, which can extend the overall design evaluation timeline. These limitations may serve as a foundation for future development and further evaluation. Future research could investigate user testing and perception to evaluate emotional responses and explore real-time personalization of digital fashion in VR environments.

STATEMENT OF APPRECIATION

The author expresses sincere gratitude to the Ministry of Education, Culture, Research, and Technology through the Beasiswa Unggulan scholarship 2023 program for providing financial support and the opportunity to complete this research. This support has been invaluable in facilitating the smooth progress of writing this article. The author also thanks all the informants and parties who have assisted and made important contributions throughout the research process.

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