Development of 3D Virtual Fashion Design E-module Using CLO3D Software to Improve 21st Century Skills in Fashion Design Education

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Abstract. This study aims to 1) evaluate the development of a 3D Virtual Fashion Design E-Module using Clo3D software, and 2) assess the quality of the e-module in enhancing the 21st Century Skills of students in the Fashion Design Education Program at Universitas Negeri Semarang (UNNES). This research employs the Research and Development (R&D) methodology, following the steps adapted from Borg and Gall's model. These steps include identifying potential problems, data collection, product design, design validation, product trials, design revisions, product implementation, and large-scale trials. The research resulted in creating an e-module focused on Clothing Pattern Making using Clo3D software. This e-module includes interactive content such as images, videos, and hyperlinks, providing direct access to instructional YouTube videos via QR codes. The module was evaluated by experts in both material and media, achieving an average score of 92.45% from material experts and 93.5% from media experts, both categorized as "Very Eligible." These results suggest that the 3D Virtual Fashion Design E-Module is highly suitable for use as an alternative learning resource in the Digital Fashion Pattern Making course, contributing to Improving 21st Century Skills.

Keywords: 3D Virtual Fashion, E-Module, Clo3D Software, 21st Century Skills, Fashion Design Education

1. Introduction

In the 21st century, education is becoming increasingly important to ensure students have the skills to learn and innovate, use media and technology, as well as

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the ability to work and survive using life skills [1]. The rapid advancements in technology have prompted educational systems to shift toward active learning, driven by discoveries that enable more interactive learning experiences [2]. His educational shift is also influenced by the changing landscape of work and industry. Since 2011, the world has entered the era of Industry 4.0, characterized by increased connectivity and interaction between humans, machines, and various resources through information and communication technologies [3]. The manufacturing sector, in particular, has been significantly impacted, employing approximately 18.25 million people and contributing 14.72% to the national workforce, with an increasing demand for workers who are proficient in digital technologies [4].

In the 21st century, education is no longer just about transmitting knowledge; it is about preparing students for a dynamic and rapidly changing world. According to Rotterdam & Willingham [5], students' success in the modern world increasingly depends on mastering essential 21st-century skills, which are critical for their future endeavors. These skills are not only academic but also social and cognitive competencies necessary for real-world problem-solving. As part of this, the *Partnership for 21st Century Skills* [6] identifies four key 21st-century competencies —critical thinking, problem-solving, communication, and collaboration. These competencies are often referred to as the "4C" skills, representing the essential knowledge and behaviors needed to thrive in today's global society. Furthermore, the National Education Association [7] argues that to succeed in a globalized world, students must go beyond traditional education and become experts in communication, creativity, critical thinking, and collaboration. In this framework, critical thinking and creativity play key roles, enabling students to analyze complex issues, innovate solutions, and adapt to change. According to Griffin & Care [8], these competencies are categorized into three broad areas: (1) ways to think, including knowledge, critical and creative thinking; (2) ways to learn, which encompass literacy and soft skills; and (3) ways to collaborate, covering personal, social, and civic responsibilities. This classification shows the interconnectedness of skills necessary for holistic student development.

The *US-based Partnership for 21st Century Skills* (P21) further emphasizes the importance of these 4C competencies, asserting that students must develop the ability to think critically, communicate effectively, collaborate with others, and think creatively to succeed in an increasingly digital and interconnected world [6]. According to Wagner [6], there are seven 21st-century skills which include: (1) critical and problem-solving abilities, (2) collaboration and leadership, (3) adaptability and agility, (4) initiative and entrepreneurial spirit, (5) effective communication, (6) the ability to access and analyze information, and (7) curiosity and imagination. In line with Wagner's opinion, learning based on 21st century skills according to (BSNP, 2006) includes (a) Critical thinking and problem-solving skills; (b) Communication and Collaboration Skills; (d) the Ability to communicate and collaborate; (e) Ability to create and renew; (f) Information and communications technology literacy; (g) Contextual learning skills, and (h) Information and media literacy skills, being able to understand and use various communication media to convey various ideas and carry out collaborative activities and interactions with various parties.

In the fashion industry, 3D animation technology has become widely used to create diverse videos and animated films that showcase clothing designs. Software such as *MakeHuman* for character creation, *Blender* for garment construction, and *Maximo* for animation and video editing are essential tools in this process. Mastering these tools, however, can be a significant obstacle for professionals in the fashion industry, as learning all of these software programs is not practical within the traditional fashion design and technology curriculum [9]. Moreover, this challenge highlights the need for specialized training in 3D fashion design software. 3D virtual fashion technology is defined as the creation of digital assets that offer a realistic representation of both the visual and physical properties of the products being produced [10]. Among the most notable advancements in this field is the application of Computer-Aided Design (CAD) techniques. These technologies have transformed the way designers approach the creative process, allowing them to visualize their designs quickly and realistically. Using 3D virtual design software, designers can simulate how garments fit and move on a digital avatar, offering a 360° view of the clothing in a virtual space [11]. This innovation enhances efficiency by streamlining the design process and providing valuable feedback on design elements, fabric choices, and sizing.

The scope of CAD technology in the fashion industry is broad. It encompasses tasks such as fabric selection, pattern making, design creation, and even product presentations [12]. Papachristou [13] asserts that CLO3D, a commercial software solution, exemplifies how 3D fashion technology can optimize the virtual fitting process. By inserting a 2D pattern into CLO3D and sewing it virtually on a 3D digital human model (avatar), designers can visualize how the garment fits before producing physical prototypes, which significantly reduces time and costs. Furthermore, 3D fashion technology offers several benefits to the fashion industry, such as increased design efficiency and a reduction in the need for physical samples. This is not only environmentally friendly by minimizing textile waste but also accelerates the product development cycle [14]. By moving away from physical samples, fashion companies can save resources and reduce their carbon footprint, addressing sustainability challenges that are becoming increasingly important in the global fashion market. Educational institutions must equip students with the knowledge and skills to effectively use these advanced design tools to stay competitive in the evolving fashion industry [15]. This research aims to explore the development of 3D virtual fashion design e-modules, utilizing CLO3D software, to enhance the competency of fashion design students and prepare them for the future of fashion technology.

In the Fashion Design Education Study Program at Universitas Negeri Semarang, there is a course dedicated to Digital Fashion Patterns (CAD), where students are expected to master the digital processes of pattern making, grading, and marking clothes using both 2D and 3D software. This course aims to equip students with skills that are directly applicable to the fashion industry. Learning in practical courses like this ideally means students not only understand the theoretical concepts but also the work procedures that professionals in the field follow. CLO3D is one such emerging technology that provides digital solutions to the design process. This technology aligns with the rapid technological advancements in the fashion sector and presents an opportunity for students to prepare for the industrial era 4.0, particularly in the textile and garment sectors [16]. Educational institutions must swiftly integrate 3D fashion technology, such as CLO3D, into their curriculum to meet the growing demands of the future fashion industry job market [17]. As fashion companies increasingly shift towards digitalization, students need to be proficient in using cutting-edge tools that enhance creativity and design efficiency [18]. The adoption of 3D fashion technology in education ensures that graduates are digitally competent and able to compete in the workforce.

Vocational education is known for its dynamic nature, continuously adapting the curriculum to meet the changing needs of the job market and advances in science and technology [19]. The shift from traditional classroom learning to more digital, technology-based methods has become inevitable. E-learning, which involves technology-based instruction, has become one of the primary methods to deliver teaching content. It utilizes electronic platforms to send teaching materials to students via computer networks, facilitating easier access and a more flexible learning experience [20]. E-modules, as a form of digital teaching material, support e-learning by making content more dynamic and engaging. These modules can include multimedia elements like images, videos, animations, and sound, which help enhance student engagement and improve learning outcomes [21]. E-modules allow students to learn independently or in a group setting while providing interactive and stimulating content that increases information retention and understanding.

Muhali [22] emphasizes the importance of equipping students with 21st-century skills to cope with the fast-paced changes in the global economy. To achieve this goal, selecting the right learning media is crucial. E-modules, with their interactivity and multimedia content, can be an effective tool in this endeavor. In the 21st century, the development of e-modules has become a critical component of modern education, particularly in vocational education programs, where practical, hands-on skills are required. These e-modules not only support learning but also foster critical thinking, creativity, and collaboration, which are key competencies needed in today's workforce [23].

Given these challenges and opportunities, the author conducted research titled "Development of a 3D Virtual Fashion Design E-Module using CLO3D software to

Improve 21st Century Skills in Fashion Design Education". The primary objective of this research is to develop e-modules that are suitable for learning and capable of enhancing 21st-century skills among students in the fashion design program. This research contributes to the digital transformation of fashion design education and aims to prepare students for the rapidly evolving demands of the fashion industry [24].

2. RESEARCH METHODS

2.1 Types of research

This study employs a Research and Development (R&D) methodology, specifically focusing on the development of a 3D Virtual Fashion Design E-Module using CLO3D software. The R&D method is chosen because it is well-suited for creating new educational products and improving existing ones, especially in the context of developing instructional tools for vocational education [25].

The steps used refer to the research and development method according to Borg and Gall which was modified by Sugiyono [26] as follows:

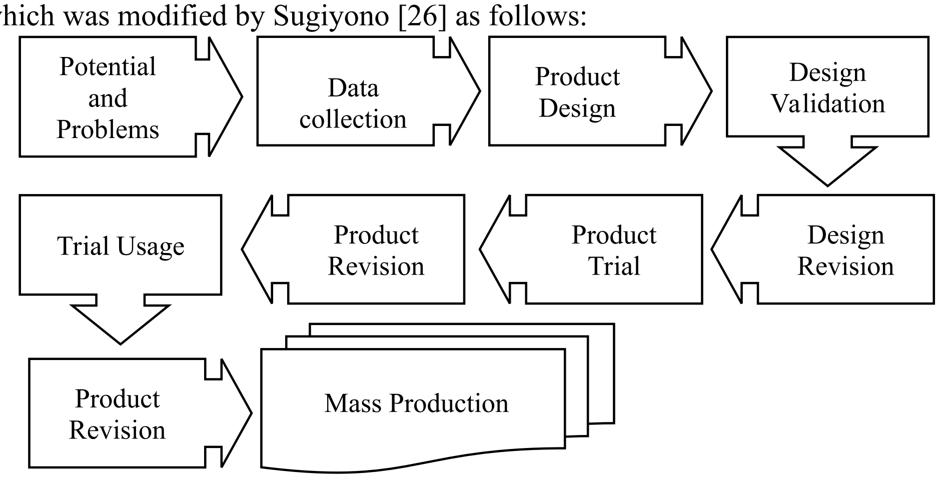

Figure 1. The steps used refer to the research and development method according to Borg and Gall

This research is limited to step 5, namely potential and problems, data collection, product design, design validation, and design revision. The research design includes the following steps: The first step involves identifying the needs of the students and teachers in the Fashion Design Education Study Program at Universitas Negeri Semarang (UNNES). This is accomplished through needs analysis, which focuses on the current curriculum, technological limitations, and the industry's evolving demands for 21st-century skills in fashion design education [27]. Surveys, interviews, or focus groups can be conducted with faculty and students to assess their competencies, learning difficulties, and expectations regarding the integration of 3D fashion design technology [28]. The second phase is the actual development of the e-module. In this step, the instructional content for the module is created, including the integration of CLO3D software for 3D fashion design. The design is structured to incorporate multimedia elements such as interactive 3D models, tutorials, assessments, and other resources that support student engagement [29]. The development also involves the iterative creation and testing of the e-module to ensure it is user-friendly and meets educational standards. The third step involves the implementation of the e-module in a small-scale classroom setting. In this phase, a group of students from the UNNES Fashion Design Education Program is selected to use the e-module as part of their curriculum. The students' engagement, usability of the tool, and their acquisition of 21st-century skills are carefully monitored [30]. The final step is evaluation. Data is collected from students and instructors on the effectiveness of the e-module in improving digital competencies and learning outcomes. Feedback is gathered through surveys, interviews, or testing performance metrics. Based on this evaluation, the e-module is revised to enhance usability and content [31].

2.2 Research variables

In research, variables are any elements that can be manipulated, measured, or categorized, and they are essential in determining relationships between different factors. According to Creswell [32], variables can be classified into dependent and independent categories, depending on their roles in the research design. Variables represent phenomena that can vary or change in form, quantity, or nature [32][33]. In this study, the focus is on a single variable: the feasibility of the e-module. Feasibility refers to the practical applicability and usability of the 3D Virtual Fashion Design E-Module, which will be evaluated by assessing its content, structure, and ease of use by students and instructors. Since the focus is on evaluating the module's quality, this is a single variable, meaning it does not influence or get influenced by other variables in the research model [25][26]. This variable serves as the outcome of the development process, measuring the module's effectiveness in enhancing students' competencies and their digital skills in fashion design. This research will employ the evaluation criteria for feasibility based on the opinions of subject matter experts and users (students and instructors). The criteria for feasibility will be broken down into several aspects, including content relevance, ease of use, and technological functionality. These criteria are integral to determining the module's effectiveness in the learning process [34][35].

2.3 Data Collection Techniques

According to [34], data collection can be conducted through various techniques such as observation, interviews, questionnaires, tests, and documentation. In this study, the primary methods employed are observation and documentation. These methods have been chosen to best capture the essence of the learning process and the development of the 3D Virtual Fashion Design E-Module.

1. Observation is a data collection technique that involves direct sensory engagement, primarily using the eyes and ears. It allows researchers to observe real-time processes, behaviors, and conditions in their natural setting [26]. This method is particularly effective for examining learning conditions, such as the teaching process, media utilization, infrastructure, and facilities within the fashion design classroom. Observations enable researchers to identify aspects of the environment that may impact the effectiveness and feasibility of the e-module. Furthermore, observation allows the researcher to gain a deeper understanding of how students engage with digital tools and resources in their learning process [37].
2. Documentation, on the other hand, involves collecting data from existing records and materials that provide insight into relevant processes, variables, and theoretical frameworks. According to Borg & Gall [25], documentation is critical for understanding the context and background in which the research occurs. In this study, documentation is used to gather information about the use of CAD fashion patterns, Clo3D software, and the specific competencies expected in the learning process. The documents and records reviewed include software manuals, course syllabi, previous research studies, and curriculum standards. This information will serve as a foundation for the development of the e-module, ensuring that it aligns with industry standards and educational objectives [33].

These two techniques complement each other, allowing the researcher to obtain both qualitative and quantitative data, contributing to the comprehensive development of the e-module [34][35].

2.4 Research and Development Subjects

The subjects of this research are material experts and media experts, who play a crucial role in evaluating and improving the developed 3D Virtual Fashion Design E-Module. Experts in both domains provide specific insights regarding the content and media aspects of the e-module to ensure its quality and effectiveness.

Material Experts: These experts are responsible for assessing the content of the e-module, particularly in terms of accuracy, relevance, and comprehensiveness of the fashion pattern CAD material. They evaluate whether the content aligns with the learning objectives and the competencies needed for fashion design students. According to Davis et al. [37], expert reviews of educational content help identify gaps, inaccuracies, and areas for improvement, ensuring that the materials meet academic standards. In this study, three material experts will evaluate the suitability and completeness of the e-module content. Their feedback will inform necessary revisions and help in refining the module to address any weaknesses [38]. Material experts will also offer suggestions for improving the structure and clarity of the instructional content, ensuring that it is suitable for the 21st-century skills being developed.

Media Experts: These experts assess the feasibility of the E-module's media components, including its usability, accessibility, and design. They evaluate how well the multimedia elements (e.g., videos, animations, and interactive features) enhance the learning experience. According to Merrill et al. [39], the effective use of media in educational modules improves student engagement and facilitates deeper learning, especially in practical subjects such as fashion design. Three media experts will evaluate the functionality and aesthetics of the e-module, focusing on its user interface and how easily students can navigate through the module's features. Feedback from media experts will also address any usability issues that may hinder students' interaction with the module [40]. Their assessments will play a key role in refining the visual and interactive components of the e-module, ensuring it is engaging and effective for students.

2.5 Data Collection Instruments

The instrument used in this study is designed to evaluate the quality of the developed e-module. In research, an instrument refers to a tool used to measure observed natural and social phenomena. According to Sugiyono [26], an instrument is essential for collecting accurate data to improve the effectiveness and efficiency of research. It serves to gather specific information, making the process more systematic, complete, and easier to analyze. Furthermore, Arikunto [41] emphasized that instruments serve as tools or facilities that researchers use to gather data, thus improving the precision and reliability of the collected data.

In this study, an expert feasibility test instrument was developed specifically for assessing the CAD fashion pattern e-module as a learning media. The expert feasibility test is designed to evaluate whether the developed e-module meets the established criteria for feasibility. It also aims to identify any areas that need improvement based on expert assessments. The feasibility test was conducted by two groups of experts: media experts and material experts. Media experts evaluated the multimedia elements of the e-module, including its functionality, usability, and design, while material experts assessed the accuracy and completeness of the content. This method aligns with Akker's [35] framework for curriculum and material development, which advocates the use of expert evaluations to ensure the quality and relevance of educational tools.

2.6 Instrument Validity

According to Suharsini Arikunto [41] a measure that shows the validity or level of validity of an instrument is validity. An instrument is said to be valid if it can be used to measure what is to be measured [26]. The extent to which the data collected does not deviate from the description of the intended validity can be seen from the level of validity of the instrument. Less valid instruments have low validity. Meanwhile, a valid or valid instrument has high validity.

Testing validity can be helped by using an instrument grid because this research is included in content validity testing. The technique used to find validity refers to Aiken's V formula which is formulated as follows:

Information:
V = Validity
s = r – lo
lo = The lowest research figure (in this study 1)
c = The highest research figure (in this study 4)
r = Number given by the appraiser
n = number of validators

The instrument validity results are then classified based on the interpretation guidelines in the following table:

Table 1. Interpretation of Validity Test

VALIDITY COEFFICIENTS	INTERPRETATION
>0.8	Very valid
0.4-0.8	Valid
<0.4	Less valid

(Source: Retnawati, 2014)

2.7 Instrument Reliability

An instrument that, when used several times to measure the same object, produces the same data is called a reliable instrument [41]. Reliability is seen from the extent to which the results of a measurement process can be trusted [26]. In this study, Cronbach's Alpha reliability was used because this technique was used for interval/essay data types. The Cronbach's Alpha reliability testing technique is formulated as follows [17]:

Information:
ri = instrument reliability
k = number of questions
∑ 〖 s_i 〗^2 = number of item variants
st2 = total variance
Variant formula:
〖 =

〖 =

Information:

〖 JK 〗 _i = Sum of squares of all item scores

〖 JK 〗 _s = Sum of squares of subjects

The classification of results obtained from instrument reliability testing is considered reliable if the alpha reliability value is >0.60. The instrument is considered unreliable if the alpha value is <0.60.

2.8 Data Analysis Techniques

The data analysis technique uses quantitative data analysis in the form of instrument scores from questionnaires using the Linkert scale. The questionnaire score is an assessment from material experts and media experts. Data obtained from the expert assessment sheet is used to measure the level of feasibility of the product being developed. Product feasibility testing is carried out to determine whether the product is suitable in terms of material and media or whether there is still something that needs to be improved. The level of product suitability is measured using analysis techniques according to Sugiyono (2016) as follows:

Information:

P = Percentage of multimedia feasibility

Σn = Total score of research aspects by experts

ΣN = Maximum total assessment score

The percentage that has been obtained is then converted into qualitative sentences. The suitability of aspects in developing CAD fashion pattern e-modules is guided by the following table:

Table 2. Percentage Rating Scale

Valuation Percentage	Interpretation
76 % - 100 %	Very Eligible
51 % - 75 %	Eligible
26 % - 50 %	Not Eligible
0 % - 25 %	Very not Eligible

(Source: Sugiyono, 2016))

3. RESULTS AND DISCUSSION

3.1 Research Results

3.1.1 Results of E-Module Development Procedures in the Computer Pattern Making Course

The research resulted in the development of an E-Module for 3D Visual Fashion Design in the Digital Fashion Pattern Making Course using CLO3D Software. This e-module was designed to assist students in independently learning how to create fashion patterns, whether or not they have a partner for collaboration. The e-module includes an introduction to Computer-Aided Design (CAD), instructions for CLO3D software installation, tutorials on basic tools, creating simple patterns using an avatar, pattern breaking, grading, markers, animation, and culminating in a virtual fashion show.

The Research and Development (R&D) methodology was employed to guide the process of developing the e-module. According to Borg and Gall [25], the stages of R&D include product design and expert validation, which were adapted for this study into five specific stages: (1) identifying potencies and problems, (2) data collection, (3) product design, (4) expert validation by media and material specialists, and (5) revision of the product based on expert feedback.

The first step is Potency and Problems. Potency and Problems involved identifying the existing issues in the current teaching methodology and fashion pattern-making learning. This was achieved through observation sheets distributed to students from the Fashion Education Study Program (class of 2020, 2021, and 2022), interviews with lecturers, and analysis of student grades. Preliminary observations were conducted to assess the needs and challenges in the current course, such as the lack of interactive and accessible learning materials for fashion pattern making. Based on the identified challenges, the researchers decided to create an e-module that integrates various media formats such as text, photos, videos, and hyperlinks to deliver content in a dynamic and accessible manner. The e-module is lightweight, easily accessible, and free from advertisements or malware that could disrupt its use. Given these factors, CLO3D Software was chosen to develop a 3D Virtual Fashion Design e-module, allowing students to experience an interactive and immersive learning process. This development process is a direct response to the challenges of integrating 21st-century skills into vocational education in the fashion industry, where the ability to use advanced technology like CAD and 3D design software is increasingly essential for students to stay competitive in the industry [42][43].

The second step is data Collection. In the data collection phase, the researcher gathered several materials that served as the foundation for the development of the 3D Visual Fashion Design e-module using CLO3D software. The collected data included:

a. RPS (Semester Lecture Plan) for the Digital Pattern Making Course at Universitas Negeri Semarang, which was used as a reference to align the e-module content with the learning outcomes expected in the course.
b. Course materials covered a wide range of topics related to CAD and CLO3D software, including installation instructions, tool introductions, basic pattern creation, pattern breaking, grading, markers, animation, and virtual fashion shows.

c. CAD tutorial videos available on the YouTube channel were used to complement the e-module and offer additional visual learning.
d. To assess possible weaknesses in CAD pattern design using CLO3D software, the researcher analyzed assignment outcomes and grades of fashion education students who had previously taken the Computer Pattern Making Course.
e. Images and visual content such as pictures and symbols from CLO3D software were gathered to enhance understanding, especially for clarifying garment grading processes.
f. The CLO3D software download link was made available through the official website to ensure students could access the tool needed to engage with the e-module.

The collection of this data served to ensure that the e-module would not only align with the course objectives but also address the practical needs and challenges students face when working with CLO3D software for pattern making. This thorough collection of materials laid the foundation for the content and design of the e-module, ensuring it met the learning objectives of the Digital Pattern Making Course.

The third step is product Design. The product design phase was conducted in several stages, including planning, drafting, development, and completion:

a. Planning and Drafting: The researcher gathered source materials from books, academic articles, and resources provided by supervising professors. These materials formed the basis for creating a storyboard, which provided an outline for the content of the e-module, ensuring it adhered to the RPS and supported the learning objectives of the course.
b. Graphic Design: Using CorelDraw software, the researcher created apparel graphics that accompanied assessment questions and pattern-breaking tutorials. This included designs for women's shirts, dresses with bell sleeves, and button-down skirts.
c. Video Production: Eight tutorial videos were produced as part of the e-module, covering topics such as the introduction to CLO3D, basic tools, body and sleeve patterns, skirt patterns, and grading patterns. The videos involved screen recording, adding voiceovers, video editing with Canva, and uploading the final videos to YouTube. The inclusion of video tutorials is particularly significant, as it leverages multimodal learning, which has been shown to improve student engagement and retention in digital design courses [44].
d. Drafting: The components were arranged in Microsoft Word, which was used to assemble the e-module layout, incorporating the images, videos, and text required to meet the learning objectives.
e. Development: The researcher created the draft e-module using Canva, integrating hyperlinks, photos, videos, and text. A QR code was included in the e-module to allow students to scan and access YouTube video content directly on their smartphones. To maintain user engagement, vivid colors such as purple,

pink, yellow, and orange were used, with a white background to ensure readability [45].

f. Finalization: The last stage involved final reviews, including checking the functionality of the QR codes, proofreading the text for errors, and ensuring that the layout, images, and videos were appropriately integrated. The e-module was finalized in PDF format, making it accessible on both desktop and mobile devices, which aligns with current trends in providing flexible learning environments for students [46].

The fourth step is the Validity test. In this study, a validity test was conducted to evaluate whether the instruments used, such as the questionnaire or observation sheet, were accurate and could measure what they intended to measure. According to [41], the validity of an instrument is determined by how well its items reflect the overall construct being measured. The validity of each statement item was found to be above 0.40, which is considered acceptable based on the criteria set by Fraenkel and Wallen [47]. This means that each item was valid and could be used for further analysis, indicating that the instrument was appropriate for use in this research [48]. By comparing the answers to each question or statement with the individual's overall score, the validity test establishes whether a questionnaire or observation sheet is valid for each item. Microsoft Excel was used for the validation testing process. Each statement item has a valid status, according to the validity test findings, which are > 0.40, indicating that the instrument is appropriate for use in research.

The fifth step is the Reliability Test. Reliability refers to the consistency and dependability of an instrument in producing the same results under the same conditions. To measure reliability, the Cronbach's Alpha coefficient was calculated using Microsoft Excel. A reliability coefficient greater than 0.60 is typically acceptable for social science research [49]. In this study, the calculated Cronbach's Alpha value was 0.6805, which is higher than the threshold of 0.60. Therefore, the instruments used in this study were considered reliable and can be trusted to consistently measure the constructs they were designed to assess [50].

The sixth step is Product Eligibility Validation. The Product Eligibility Validation stage is essential for ensuring that the e-module created is both pedagogically and technically suitable for its intended use. In this study, expert judgments were conducted by media and material specialists to assess whether the developed e-module for CAD fashion design, using CLO3D software, met the required standards for educational and media quality.

Three material specialists were assigned to review the content of the e-module. Their primary focus was on ensuring that the content met educational standards and aligned with the competency outcomes outlined in the course syllabus. The specialists provided the following key recommendations for improvement: Completion of Production Designs I and II: All designs or drawings, including the production designs, must be finished and fully representative of the learning objectives. Alignment of Evaluation Questions: The assessment questions should be carefully selected to reflect the competency achievements the students are expected to attain. Improvement in Grammar, Spelling, and Typography: Attention to detail in language use was advised to enhance the readability and professionalism of the content. These suggestions reflect the need for clear and comprehensive educational content that adheres to pedagogical principles, as discussed in previous research on content validity [51].

In addition to the content review, three media specialists evaluated the media aspects of the e-module. Their feedback focused on the usability and visual appeal of the e-module, ensuring that it provided an optimal learning experience for students. The media experts provided the following recommendations: Avoiding Pirated Software Links: The installation links provided for CLO3D software should direct users to legitimate sources, either offering a free trial or providing access to the original program. This ensures the legal and ethical use of the software [52]. Use of a More Modern Typeface: A recommendation was made to update the font to a more modern style, thereby improving readability and user engagement [53]. Optimizing Layout: The layout of the e-module could be further optimized for a better user experience, possibly with more intuitive navigation. Adding a Video Tutorial: A video should be included in the Introduction to CLO3D Tools chapter, which would enhance user understanding and engagement with the software. These findings underscore the importance of both content and media considerations in the design of educational materials, as highlighted in studies on multimedia learning [54][55]. After the product has been confirmed by media and material specialists, revisions are made based on their recommendations and comments to make the e-module even better.

3.1.2 Eligibility Test Results for E-Module Development in the Computer Pattern Making Course

The items to be examined are then handed to material experts and media specialists together with observation sheets that have been verified as authentic and credible. The product is called "CAD Fashion Pattern Using Clo3D Software," and it is an E-module. This is done to ensure the degree of product eligibility and to gather ideas for enhancing the e-module to the highest standard. The following are the product eligibility test findings that have been verified by media and material experts:

a. Expert material

The evaluation of the e-module's content eligibility, language, presentation, and instructional quality is carried out by material specialists. creation of content for Universitas Negeri Semarang's RPS (Semester Lecture Plan) Computer Making Pattern Course based on learning objectives. The quantitative data from each question item on the observation sheet that the material expert filled out, combined with comments and ideas for improvement, is the eligibility evaluation of the e-module. Table 3 below displays data from the materials experts' eligibility evaluation of the e-module materials.

Table 3. Data from Material Expert Assessment Results

Assessment Aspects	Rating percentage (%)
Technical Quality	97.2
ease of operation	91.7
Graphics	86.5
Instructional Quality	94.4

Average	92.45
Criteria	Very Eligible

The findings of the material expert's evaluation of the suitability of the researcher-developed E-Module for CAD Dress Patterns Using Clo3D Software are displayed in Table 3 above. According to Sugiyono (2016), the product eligibility % formula is used to calculate the material expert validation evaluation. The calculation results are then translated into a product eligibility percentage scale table. The material expert's evaluation yielded a score of 92.45%, indicating that it is "Very eligible."

b. Media expert

The e-module's technical quality, graphic quality, and instructional quality are all evaluated by media specialists. The video in the e-module was filmed during a Zoom conference, edited with Capcut, and posted to YouTube channel. The e-module's media was created using the Canva software. The quantitative data from every question item on an e-module completed by media experts, together with their comments and ideas for improvement, is used to determine the module's eligibility. Table 4 below displays information from the media suitability evaluation findings for the e-module conducted by material experts:

Table 4. Data from Media Expert Assessment Results

Assessment Aspects	Rating percentage (%)
Content Design	94.2
Display feasibility	89.4
Ease of use	93.2
Graphic feasibility	97.3
Eligibility Benefits	93.72
Average	93.5
Criteria	Very Eligible

The findings of the media expert's evaluation of the E-Module's suitability for CAD fashion designs created using Clo3D Software are displayed in Table 4. According to Sugiyono [26], the product eligibility % formula was employed in the media expert validation evaluation calculation. The computation's findings were then interpreted to create a product eligibility percentage scale table. According to the material expert's evaluation, the substance was deemed "Very Eligible" with a score of 93.5%. Product creation in the form of CAD Fashion pattern e-modules using Clo3D Software in computer-making Courses is extremely eligible to use as an alternative to independent learning media, according to the findings of the evaluation conducted by material specialists and media experts.

3.2 Discussion

3.2.1 Procedure for Developing E-Modules in Computer Pattern-Making Courses

The development of e-modules in the Computer Pattern Making Course aimed to provide an alternative form of instruction that students can access independently. The development process utilized Sugiyono's [26] five-phase model of product development, which includes data collection, product design, validation, revisions, and the final e-module delivery.

1. Initial Development Based on Potentials and Challenges
   The e-modules were developed in response to the challenges identified in initial student observations, interviews with lecturers, and analysis of student grade data. The Clo3D software was identified as a potential tool to address existing instructional challenges in pattern making, offering a promising opportunity to enhance the learning experience. Despite its limited availability in e-module form, the researcher found that Clo3D could bridge significant gaps in the course by providing a hands-on, virtual pattern-making experience [56].
2. Data Collection
   Data collection included various sources such as interviews, course materials, and student feedback. The e-module content was designed to address key learning objectives such as CAD basics, Clo3D tool usage, creating basic fashion patterns, pattern grading, and virtual fashion shows. These objectives were structured according to the Semester Lecture Plan (RPS) to ensure alignment with course goals. The final product consisted of text, photos, videos, and interactive links, packaged in a user-friendly layout that adhered to the principles of instructional design [57].
3. Product Design
   The design phase involved completing the planning, drawing, development, and finishing stages. The e-module integrates various media formats, including video tutorials linked to a YouTube channel. The PDF format was chosen due to its small file size (3.86MB), which makes it accessible on various devices, including computers and smartphones. The integration of multimedia content, such as videos and hyperlinks, enhances student engagement and understanding of Clo3D's CAD functionalities [58].
4. Validation
   To ensure the quality of the e-module, expert judgment from both media and material specialists was conducted. The validation process confirmed that the e-module met the standards for content accuracy, clarity, and usability. The content covered six main learning objectives, starting from an introduction to CAD and Clo3D software to more advanced topics like pattern grading and markers. Expert recommendations were incorporated into the final product, which included ensuring accurate software links and enhancing the user interface with a modern typeface [55].
5. Revisions and Final Product
   Following the validation, the e-module was revised to address the feedback from the experts. These revisions included adding a QR code to facilitate easy access to the video tutorials and refining the layout to improve readability. The e-module's final product was a self-contained, user-friendly resource that could be

accessed at any time, either independently or in conjunction with classroom instruction. It was designed to be used with minimal instructor intervention, providing students with flexibility in their learning [59].

The use of Clo3D software in creating fashion patterns has several advantages, as reflected in the e-module's design. The e-module, with its embedded multimedia content, offers an alternative learning medium that can be accessed anywhere, anytime. It provides:

1. Flexibility: Students can learn independently without needing to be physically present in class.
2. Cost-Effectiveness: Unlike traditional textbooks or software installations, e-modules are inexpensive to reproduce and distribute [58].
3. Ease of Use: The PDF format ensures that the e-module is lightweight and easily portable across devices, allowing students to access the material on computers or smartphones without difficulty [53].
4. Interactive Learning: Embedded videos guide students step-by-step in creating CAD fashion patterns using Clo3D, enhancing comprehension and engagement. Video tutorials align with previous research suggesting their effectiveness in promoting both foundational and supplementary education [60].

3.2.2 The Eligibility of E-Modules Development in Computer Pattern-Making Courses

The evaluation of the e-module's eligibility in the Computer Pattern-Making Course was conducted by three media experts and three material experts through expert judgment. The results revealed that the e-module was highly appropriate for use, receiving a 93.63% rating from media experts and a 97.02% rating from material experts. These high ratings confirmed the e-module's eligibility as an effective substitute learning tool. The instrument used for observation in this evaluation was also validated, demonstrating both validity and reliability in assessing the e-module's quality and suitability.

The study revealed that the e-module was developed to be appealing, methodical, and comprehensive. Its design aimed to engage students and facilitate their learning of CAD fashion pattern-making using Clo3D software, offering both independent and collaborative study options. As an e-learning tool, this module is accessible anytime and anywhere, providing students with the flexibility to review materials and catch up on missed lessons at their convenience. These features align with the findings of several previous studies that underscore the effectiveness of e-modules in enhancing student learning and engagement [61][62].

The findings of this research are consistent with other studies. For instance, Herdiningrum's [63] research on the development of e-modules for vocational education reported very high eligibility ratings of 84% from media experts and 90.69% from material experts. This suggests a similar high acceptance of e-modules in vocational education settings, affirming their potential as effective independent learning tools. Similarly, Patino's [64] study on basic chemistry practicum e-modules using the Canva design application highlighted the effectiveness of e-modules for both online and offline learning environments, with an emphasis on how multimedia components, such as QR codes, can enhance the learning process [64].

In addition, [61] research reported that the inclusion of QR codes in the learning materials positively influenced students' learning outcomes, further supporting the utility of multimedia elements in e-modules. This finding is echoed in [62] research on e-modules for chemical education, where the material expert eligibility test resulted in a 91.425% rating, highlighting the significant role of e-modules in improving student comprehension and performance in subjects that require practical applications [62].

Overall, the e-module developed for the Computer Pattern Making Course demonstrates that technology-enhanced learning tools, such as e-modules, can offer flexibility, accessibility, and engagement for students, consistent with previous research in the field of vocational education and digital learning tools. The ability to access learning materials on various devices at any time enhances students' opportunities to master content, especially in courses involving complex software like Clo3D [65][61].

4. Conclusions and recommendations

4.1 Conclusions

Based on the research conducted on the creation of CAD E-Modules for Fashion Pattern Making using Clo3D Software, the following conclusions can be drawn:

1. The development process of the CAD E-Module for Fashion Pattern Making was structured into five stages: (1) identification of potential and challenges through needs analysis, (2) data collection using documentation and observation methods, (3) product design which included script preparation, video creation, and design of the manufacturing process, (4) product validity testing by both material and media experts, and (5) revisions based on expert feedback.
2. The results of the product validity testing demonstrated that the CAD E-Module utilizing Clo3D Software received high ratings from experts. The module was evaluated at an average of 92.45% by three material experts and 93.5% by three media experts, indicating that it met the very eligible criteria for use in the Computer Pattern Making course. This suggests that the e-module is a highly appropriate and reliable alternative learning tool in fashion design education, specifically in CAD pattern making.

4.2 Recommendations

The researcher made the following recommendations in light of the findings of the study, Development of CAD Fashion Pattern E-Modules Using Clo3D Software in Computer Pattern Making Course:

1. Given that the e-module was developed based on the specific needs of students and the requirements of Universitas Negeri Semarang's Computer Pattern Making Course, it can serve as an effective guide for independent learning.

Students can use the e-module to enhance their understanding and skills in creating CAD fashion patterns using Clo3D software.

2. As the e-module has been highly rated by both material and media experts, it is recommended that educators integrate the e-module as an alternative learning medium in computer pattern making courses. This tool can complement traditional learning methods, offering flexibility and supporting various learning styles.

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