Jurnal Inovasi Teknologi Pendidikan
Volume 11, No. 3, September 2024 (338-351)
Online: http://journal.uny.ac.id/index.php/jitp

Development of interactive media sheet metal design modeling based on software Autodesk Inventor Professional 2023

Deni Kusuma Adi Pangestu, Widiyanti *, Poppy Puspitasari, Agus Suyetno
Universitas Negeri Malang, Indonesia.
***** Corresponding Author. E-mail: widiyanti.ft@um.ac.id

ARTICLE INFO

Article History
Received:
27 April 2024;
Revised:
25 July 2024;
Accepted:
13 August 2024;
Available online:
30 September 2024.

Keywords
Media interactive; Borg and Gall; Sheet metal design modeling; Computer-aided design (CAD)

ABSTRACT

This research and development aims to produce learning media products presented interactively and practically based on Autodesk Inventor Professional 2023 student version software and analyze the feasibility level of learning media for CAD Manufacturing Drawing Techniques subjects to improve competence in the field of machining techniques at SMK Negeri 1 Kediri. The type of research used is research and development (R&D) using the Borg and Gall model, It involved 6 students for the small-scale testing and 32 students for the large-scale testing. Based on the data obtained and descriptive analysis, among others, the results of media expert validation were 98.44%, material expert validation was 89.28%, small-scale trials were 92.08%, and operational trial results were 91.09%. These results indicate that the interactive learning media product sheet metal design modeling meets the criteria very well and can be utilized as a learning tool.

How to cite:
Pangestu, D. K. A., Widiyanti, Puspitasari, P. & Suyetno, A. (2024). Development of interactive media sheet metal design modeling based on software Autodesk Inventor Professional 2023. *Jurnal Inovasi Teknologi Pendidikan*, *11*(3), 338-351. https://doi.org/10.21831/jitp.v11i3.72805

INTRODUCTION

The phenomenon of the Industrial Revolution 4.0 currently shows the speed of technological development (Saleem et al., 2024). Everything seems to be connected to the internet system, where accessing information from the outside world feels very real given the role of technological advances today (Pratama et al., 2023). The world of education by improving its quality always adapts to changes and technological advances inherent in learning to be able to compete in the era of globalization (Ardianti & Susanti, 2022). Technology innovation and development are needed to improve the effectiveness of the current learning process integration (Myori et al., 2019). One of them is the making of learning materials which is a crucial element of the learning process, aiming to create meaningful learning, and encouraging students to develop the skills needed in the 21st century, which is a must in education (Daryanes et al., 2023).

Through education, it becomes an effort to develop Human Resources (HR) which must always be upgraded every year to improve the quality and skills that can be highly competitive (Mardhiyah et al., 2021). Various kinds of technology should be applied to learning (Miaz et al.,

2019). In the era of Education 4.0, educators must create innovative and creative learning approaches based on technology (Maolani et al., 2022; Sagita, 2019). Vocational High Schools (SMK) are educational institutions that focus on improving skills and preparing students to enter the industrial world (Kristian et al., 2023). Making Indonesia 4.0 industry manufacturers should use technology in their production process (Santika, 2021). Therefore, the use of technology in the field of engineering has become an absolute necessity and must be applied since vocational secondary education such as SMK (Fathoni & Marpanaji, 2018). Currently, most industries use computer-aided design or CAD for drawing (Pelliccia et al., 2021). The use of CAD facilitates the product design process in industry, with computers and CAD software communication through the language of images becomes more effective (Bagyo & Ngadiyono, 2020). The time required for drawing becomes shorter and the storage of drawing archives becomes more efficient, has a very important role in CAD, in line with the opinion of Gondoputranto & Purnomo (2020) said that CAD has helped optimize the manufacturing process through an integrated and intelligent computer system as the brain in operating a manufacturing industry.

The purpose of the Mechanical Engineering qualification in vocational schools is to provide knowledge about what is in the industry, and produce a competent and disciplined workforce, ready to enter the workforce and be productive (Noviyanta & Ngadiyono, 2019). One of the subjects in SMK competency in Mechanical Engineering that must be taken is Manufacturing Drawing Engineering/CAD (TGM CAD), which uses Autodesk Inventor software (Rohman et al., 2023). This subject is the basis for several applications of other subjects, such as CAM (Computer Aided Manufacturing) which require optimization and effectiveness in the learning process (Berselli et al., 2020). Skills in this subject are considered very important because it is expected that after graduating students can apply knowledge from TGM CAD subjects when continuing to the next level or when involved in the world of work (Shih & Sher, 2021).

When conducting observations, several problems were found in learning TGM CAD class XI SMK Negeri 1 Kediri, including the use of conventional learning methods such as lectures, step-by-step demonstrations of material limited to 18 meetings, and job sheets. Consistent with research by Yunus & Fransisca (2020) the method is less effective in encouraging students' active participation as well as difficult in achieving more complex skills. The complexity of CAD material related to other subjects such as Entrepreneurship Creative Products (PKK) which focuses on plate fabrication and welding work. While the use of CAD software versions 2018 to 2020 that have not been updated is one of the obstacles, on the other hand, version 2023 has appeared with the latest updated features. From observations and interviews, it is concluded that innovation in learning methods, more structured lesson plans, integration of CAD materials with other subjects, and updating CAD application software are needed.

Supported by previous research Ramadhan (2023) has developed an interactive learning product in the form of a comprehensive electronic module with video tutorials for class XI students majoring in Mechanical Engineering at Vocational High Schools 1 Kediri. The feasibility of the media is determined through four stages of product evaluation, namely material expert validation, media expert validation, small-scale testing, and operational testing. The test results concluded that the electronic module and video media products were declared suitable for use with very good assessment criteria. Based on the results of interviews with TGM CAD teaching teachers to improve the competence of students, it is necessary to develop the material discussed in the module to integrate with other subjects related to sheet metal drawing, because sheet metal is included in the design engineering material which is also taught in TGM CAD subjects. Sheet metal material is relevant to subjects such as PKK (Entrepreneurial Creative Products) to make products from plate fabrication and welding processes. This research offers a new approach by integrating sheet metal design modeling material based on Autodesk Inventor 2023 into an interactive learning module. This development not only presents more practical and up-to-date material but also connects theory with real applications in the industry. This is expected to increase students' attraction to the machining engineering program and motivate them to develop skills relevant to the needs of modern industry.

The purpose of this research is to create variations in learning TGM CAD subjects at Vocational High Schools 1 Kediri through materials formulated based on the flow of learning

objectives (ATP) and then determine the feasibility of the resulting facilities practically, effectively and interactively using learning videos synchronized with E-Modules. The product results of sheet metal design modeling development research will be presented in the form of a complete video tutorial starting from the introduction of CAD, and 3D modeling which includes 2D sketch, 3D sheet metal model, assembly, drawing, frame generator, 3D weldment and equipped with user experience using Autodesk Inventor Professional 2023 application. The media is said to be practical because it is in the form of an E-Module (PDF) that can be accessed easily via smartphone or computer without time and location restrictions, efficient because the document processing module has content that is synchronized with learning videos available on YouTube, and interactive by utilizing WhatsApp discussion groups and YouTube open comments that allow users to discuss directly. The contribution of the application of learning media development with Autodesk Inventor 2023 software is expected to improve users' understanding and retention of information through more interesting sheet metal design modeling learning materials through e-books synchronized with video tutorials on YouTube, motivating them to continue learning, while improving the quality of Vocational High School graduates of machining techniques to compete in the industry and support the realization of Indonesia 4.0.

METHOD

This research uses a type of research and development or education Research and Development (R&D). Research and development (R&D) is a research method used to design new products, test the effectiveness of existing products, and develop and create new products (Yuliani & Banjarnahor, 2021). The product developed is an interactive learning media sheet metal design modeling based on Autodesk Inventor Professional 2023 which is packaged in the form of video tutorials synchronized with electronic modules. The research procedure carried out applies the stages of the Borg and Gall development model (Sugiyono, 2013). The Borg & Gall model is taken into consideration because the model passes a series of validation processes by experts and field trials more than once so that the development product has a high level of validity and can be adjusted to the direct needs in the field (Gall et al., 2003). The research and development process will outline the stages that must be followed hierarchically in order to achieve the set goals (Siregar, 2023). The following ten stages of Borg & Gall development are described in Figure 1.

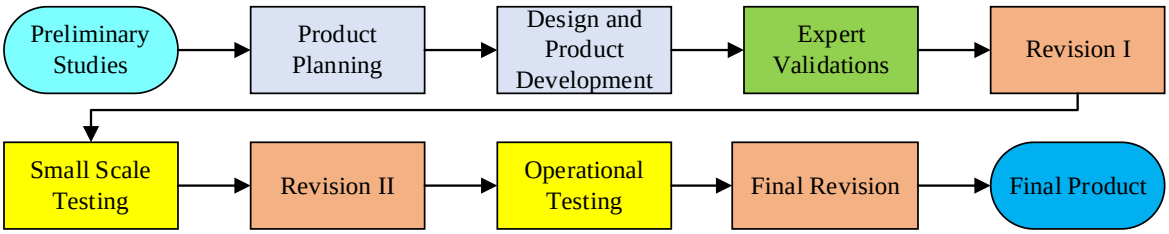

Figure 1. Research and Development Procedure

1. The purpose of the preliminary stage is to identify problems, collect relevant information to solve the problems and evaluate the products to be developed. Problem identification also involves interviews and direct observations with teachers and TGM CAD students of Vocational High School 1 Kediri to determine the media format and substance content used as guidelines for developing learning media. This process also deepens the final competency target by referring to the material items and learning objectives.
2. The product planning stage is structured by designing according to the findings of the preliminary study and literature, including product design and materials as well as the development of existing modules, based on needs analysis from interviews with teachers and students. Product planning will be implemented in the form of video tutorials and e-modules.
3. The design and product creation stage begins with the preparation of a script or storyboard as a guide for the video tutorial content. The preparation of the storyboard is based on the material items from the Flow of Learning Objectives (ATP). Next, the electronic module content material is compiled, followed by the process of recording a demonstration video that explains the material

and the steps of the task. Video making is done as interesting and clear as possible so that users can easily understand the content presented.

4. The expert validation stage is conducted to validate the product through evaluation from experts. The validation of learning products includes aspects of material quality and media quality aspects. The two types of learning media validated are electronic modules and video tutorials.
5. Revision Stage I, the aim is to improve and refine the weaknesses of the product design, based on input from media experts and material experts with student needs.
6. The next step is a small-scale trial with 6 students as subjects to get feedback. Selected students in this trial will be asked to provide comments and input on the product that has been distributed by answering the questionnaire. Representatives of small or limited groups should reflect the actual purpose of the test (Amin et al., 2023). If the evaluation of the use of learning media shows weaknesses, then improvements are needed.
7. Revision Phase II was conducted if there were still weaknesses or shortcomings identified during the small-scale testing. The product is intended to be refined before undergoing testing on a larger scale.
8. The Operational testing stage was conducted after product refinement, to obtain feedback from a wider scale of subjects.
9. Final Revision Stage, the results of feedback and recommendations obtained from the operational trial were used with the aim of refining the product before it was implemented in the learning process.
10. The Final Product stage is the final result of the development process, in the form of video tutorials and electronic modules that have been improved based on reviews, feedback, and evaluations of the previous trial and development stages.

Product Testing

To evaluate the overall feasibility of the product, product testing is needed which includes several aspects including validation tests, trial design, trial subjects, types of data, data collection tools, and data analysis methods.

Validation Test

The validation test uses a questionnaire assessment sheet given to lecturers of the Department of Mechanical and Industrial Engineering, Faculty of Engineering, State University of Malang as media and material expert validators to carry out the validation test stage of interactive learning media products. Improvements will be made immediately if the material expert or media expert provides suggestions or corrections after the review.

Product Test Design

The product feasibility trial was divided into two stages, feasibility trial on a smaller subject scale and operational trial on a larger subject scale. In the first stage, the product is tested by preparing a validation sheet that includes assessment aspects such as coloring, use of words and language, screen display, presentation, animation, and sound for media expert validators, as well as content, presentation, and contextual feasibility for material expert validators. The second stage includes the implementation of product testing by preparing a questionnaire on the results of product development, distributing products, and distributing questionnaires to students.

Test Subject

The subjects of the small-scale trial were 6 students in class XI TPM (Mechanical Engineering) Vocational High School 1 Kediri 4th semester of the 2023/2024 academic year. This sampling technique, according to Sugiyono (2013) indicates that the member sampling process is carried out randomly without regard to the educational level of the class population. The large-scale or operational test involved 32 students in class XI TPM 2 (Mechanical Engineering) Vocational High School 1 Kediri in semester 4 of the 2023/2024 academic year, chosen with the consideration that all students have uniform characteristics.

Data Collection Instruments

This process includes various methods, such as interview guides, submission of questionnaires in Google Form format shown in Table 1 Media Expert Validation Instrument, Table 2 Material Expert Validation Instrument and Table 3 User Instrument, document acquisition to document the learning process, as well as taking photos during research and observation activities to find out how teachers and students interact directly in TGM CAD learning.

Table 1. Media Expert Validation Instrument

No.	Aspects and Indicators	Answers			
		1	2	3	4
A	**Colorations**				
1	Media Coloration Does Not Interfere With Understanding The Material.				
2	Interesting Color Combination.				
B	**Use of Words and Language**				
3	The Video Used Good And Correct Indonesian Language.				
4	Language Compatibility With The User's Level Of Thinking.				
5	The Politeness Of Language Use.				
C	**Display on Screen**				
6	The Use Of Font Type And Size Is Appropriate And Easy To Read.				
7	The Video Editing Method Gives A Positive Impression That Attracts Interest In Learning.				
D	**Presentation**				
8	The Material In The Video Is Coherent With The CAD Material.				
9	Video Media Presentation Supports User Participation In Learning.				
10	Images Are In Line With The Material Presented.				
11	Short Duration (<15 Minutes) So As Not To Bore The User.				
E	**Animation and Sound**				
12	There Is A Transition Effect in the Video To Attract Attention.				
13	There Is An Explanatory Voice On The Video To Make It Easier To Understand.				
14	The Explanation Voice Is Clear And Facilitates The Learning Process.				
15	Background Music Adds Interest And Avoids Boredom.				
16	The Accuracy Of The User's Voice With The Text And Video Material.				

Table 2. Material Expert Validation Instrument

No	Aspects and Indicators	Answers			
		1	2	3	4
A	**Content Feasibility**				
1	The Material In The Learning Media Supports The Competencies To Be Achieved.				
2	The Material Presented Is Coherent Starting From The Introduction Of Concepts, Definitions, and Procedures To Implementation.				
3	The Terms Used In The Learning Media Are Appropriate.				
4	The Material Presented Can Attract Interest In Learning.				
B	**Presentation Feasibility Aspect**				
5	The Material Presented Starts From Easy Material To Difficult Material.				
6	Practice Problems Can Be Used To Hone Skills.				
7	The Materials In The Learning Media Are Interactive And Participatory.				
8	Learning Media Materials Are Adapted To The Cognitive Level Of Users.				
9	Explanations In The Learning Media Reflect The Content Of The Material.				
10	Explanations In The Learning Media Are Simple And Easy To Understand.				
C	**Contextual Feasibility Aspects**				
11	The Material In The Learning Media Is Related To The Reality In The Industrial World.				
12	The Material In The Learning Media Is Relevant To Industrial Reality.				
13	Exercise Problems Are Organized From Simple To Complex According To The Order Of The Material.				
14	The Way The Exercise Is Completed Adds Insight To Knowledge.				

Table 3. User Instrument

No.	Aspects and Indicators Assessed	Answers			
		1	2	3	4
A	**Display Aspect**				
1	Display Responses From The E-Modules And Video Tutorials.				
2	Attractiveness And Consistency Of Color Usage.				
3	Simplicity And Easy To Read.				
4	Create A Positive Impression So That It Can Attract Interest In Learning.				
5	Ease Of Language In Presenting The Material.				
B	**Effective and Efficient Aspects**				
6	The Duration Of The Video Tutorial Material Is Not Too Long So It Is Not Boring.				
7	Flexibility Of Media Use.				
8	Learning Motives For CAD In The Media Influence Respondents' Learning Attitudes And Responses.				
9	The Existence Of Tips And Tricks Can Make It Easier To Learn CAD				
10	The Presentation Of Material In The Electronic Modules And Video Tutorials Is Related To The Relevance Of Other Subjects At SMKN 1 Kediri.				
C	**Interactive Aspects**				
11	Practice Exercises Come With An Answer Key For Users To Follow.				
12	There Is An Explanatory Voice On The Video So That It Is Easier To Understand.				
13	Video And Module Materials Can Introduce New Ways Of CAD Drawing.				
14	Video Materials And Electronic Modules Can Encourage Learners To Read Technical Drawings.				
15	Modules And Video Tutorials Allow You To Follow The Steps Of CAD Drawing Directly.				
16	The Comment Section On Each Video Can Help Users Ask Questions Or Get Feedback.				
D	**Acceptability Aspect**				
17	Electronic Modules And Video Tutorials Can Foster Enthusiasm In Learning CAD.				
18	Electronic Modules And Video Tutorials Can Make Learning CAD Less Boring.				
19	The Electronic Modules And Video Tutorials Are Easy To Understand.				
20	Electronic Modules And Video Tutorials Can Support Mastery Of Manufacturing Engineering Drawing (CAD).				
E	**Critique and Suggestion Aspects**				
21	Things That Need To Be Improved/Eliminated In The Presentation Of Sheet Metal Design Modeling Learning.				
22	Things That Are Interesting When Using This Media.				

Data Analysis Techniques

There are two data analysis methods used, namely qualitative descriptive analysis and quantitative analysis. Qualitative data is obtained from observations, interviews, and documentation of test subjects or experts in their fields, and is used to strengthen the results of quantitative data. The formula for analyzing quantitative data comes from the results of questionnaires given to material experts, media experts, and test subjects. The following Formula 1 formula for analyzing data refers to Juliana & Sulistyowati (2023).

$$P = \frac{\Sigma n}{\Sigma N} \times 100\% \quad (1)$$

Description P is a percentage assessment of the evaluation of the test subjects, Σn is the total value of the answers given by respondents and ΣN is the total maximum score from the answers given.

From the evaluation conducted by material experts, media experts, and trial subjects, the results of the percentage assessment are obtained, and the criteria for determining the percentage evaluation as a guideline for evaluating the feasibility of learning materials are grouped according to Table 4 which refers to Purniawan & Sumarni (2023) below.

Table 4. Criteria for Assessment of Questionnaire Score Percentage

No.	Value Scale	Intervals	Categories
1	4	81.25% < Skor < 100%	Very Good
2	3	62.50% < Skor < 81.25%	Good
3	2	43.75% < Skor < 62.50%	Less Good
4	1	25.00% < Skor < 43.75%	Not Good

RESULTS AND DISCUSSION

Results

Results of Initial Product Development

The product being developed is an interactive learning media for sheet metal design modeling based on Autodesk Inventor 2023 software, in the form of video tutorials integrated with electronic modules. Competency outcomes are based on the formulation of the TGM CAD Learning Objectives (ATP) for the Machining Engineering Expertise Competency at SMKN 1 Kediri obtained from the 2022 Merdeka Curriculum. The competency outcomes include (1) Explanation of the use of CAD applications in the context of learning; (2) Modeling of product components (manufacturing design) in 2D and 3D formats using CAD applications; (3) Organizing the process of assembling components into a single unit (assembly) using CAD applications; (4) Preparation of drawing documents required for the manufacturing process.

Based on the ATP formulation, some additional materials have been incorporated into the learning media being developed to expand learners' knowledge in the use of CAD applications, including (1) Creating sheet metal designs through manufacturing processes; (2) Utilizing the frame generator feature available in the assembly menu; (3) Using the welding and symbol features in making components through the welding process available in the assembly menu; (4) Adding user experience as part of the product, which aims to share experiences in using Autodesk Inventor professional 2023 software to improve performance in the design process.

Results of Item Formulation and Storyboarding

The results of the formulation of interactive learning media material items sheet metal design modeling using Autodesk Inventor 2023 software, there are 8 sections of material including (1) Introduction to CAD; (2) 2D sketch; (3) 3D sheet metal model; (4) Assembly; (5) Drawing; (6) Frame Generator; (7) Weldment; (8) User Experience. The materials compiled have been adjusted to the various menus and features in the Autodesk Inventor Professional 2023 software. The material is also enriched with practice questions from various sources, including a collection of CAD practice questions from CAD course lecturers at DTMI, Faculty of Engineering, State University of Malang, and sources of practice from YouTube and Instagram platforms. To increase motivation and make it easier for users, this media is equipped with motifs or examples of CAD products, tips, and tricks in drawing, as well as links to the help website (Autodesk help) and interactive learning videos.

Result of Interactive Learning Media Product Sheet Metal Design Modeling

The results of the development of interactive learning media products for sheet metal design modeling based on Autodesk Inventor Professional 2023 software are presented in the format of video tutorials integrated with electronic modules (E-Modules). Each tutorial video section has a URL link that leads to the video on the YouTube platform. The tutorial videos are divided into two playlists, namely tutorials (9 videos) and exercises (12 videos and 15 practice questions). The practice questions are more focused on the concept of 2D sketching and 3D creation to improve students' practical skills in reading drawings. The following are Figure 2, Figure 3, and Figure 4 Displays of the developed interactive learning media.

(a) (b)

Figure 2. (a) E-Module Front Cover Design, (b) E-Module Back Cover Design.

Figure 3. A thumbnail of Tutorial Video

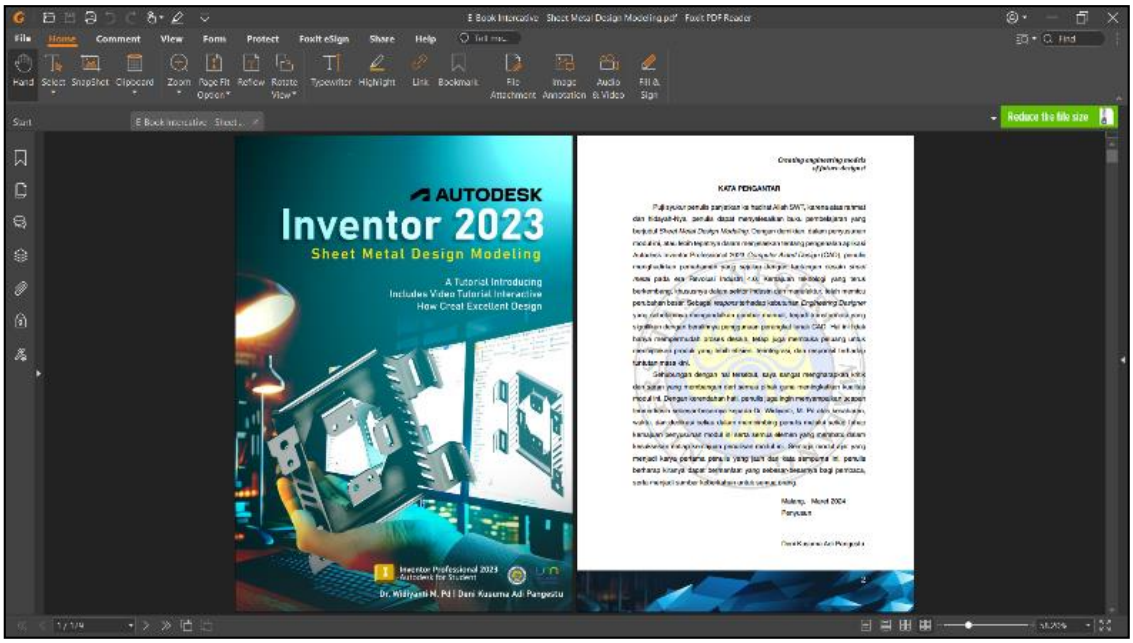

Figure 4. Display of E-Module on Computer/PC

How to Use Learning Media

This learning media can be used with various devices, such as smartphones, computers, or laptops. Video tutorials can be accessed through the YouTube app or a frequently used web browser. Meanwhile, the electronic module (e-module) can be accessed using a PDF reader or similar application. The following Figure 5 shows the procedure of using interactive learning media for sheet metal design modeling.

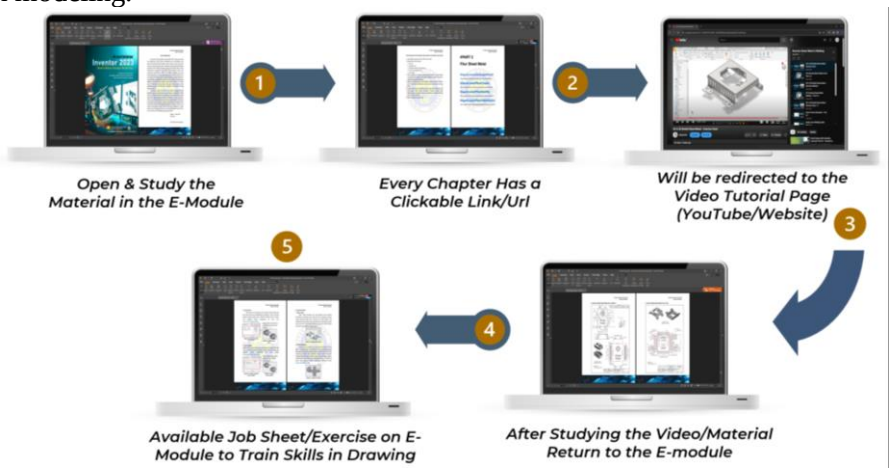

Figure 5. How to Use Learning Media

Results of Media Expert Validation

Information data regarding the results of media validation by media experts are presented in graphical form in Figure 6 below.

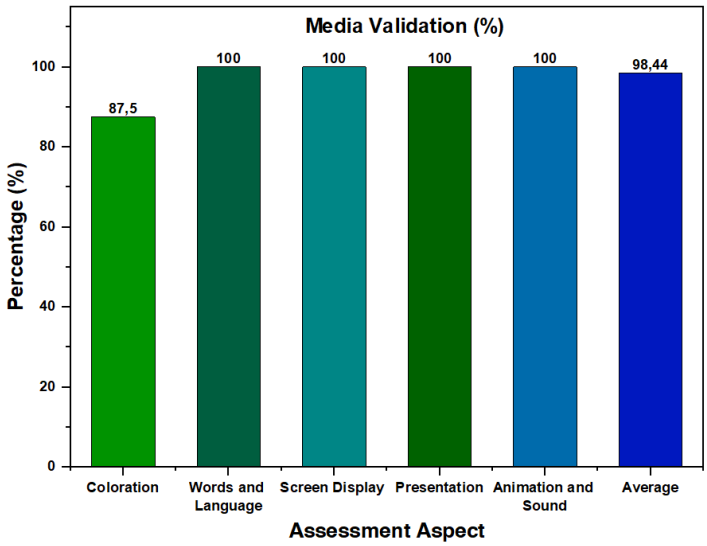

Figure 6. Media Expert Validation Results

The results of the media validation are shown in Figure 6, the total average of 5 aspects of the assessment received a score of 98.44% from 16 validation instrument items. For the aspect of coloration, as much as 2 points get an average of 3.5, for the aspect of words and language as much as 3 points gets an average of 4, for the aspect of screen display as much as 2 points gets an average of 4, the aspect of presentation as much as 4 points gets an average of 4, the aspect of animation and sound as much as 5 points gets an average of 4. Based on the results of expert validation, it is concluded that the interactive learning media for sheet metal design modeling based on Autodesk Inventor 2023 software is suitable for use and field testing with minor improvements such as color selection in the 3D cover design.

Results of Material Expert Validation

Informative data related to the results of material validation conducted by material experts are presented graphically in Figure 7.

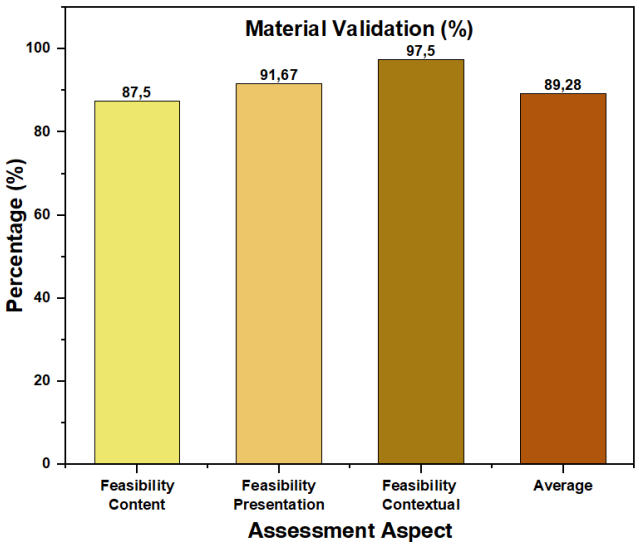

Figure 7. Material Expert Validation Results

The results of the material validation shown in Figure 7 above, the total average of the 3 aspects of the assessment received a score of 89.28% from 14 validation instrument items. The content feasibility aspect of 4 points gets an average of 3.5, the presentation feasibility aspect of 6 points gets an average of 3.66, and the contextual aspect of 4 points gets an average of 3.5. Based on the validation results, the interactive learning media sheet metal design modeling based on Autodesk Inventor 2023 software is feasible to continue with several revisions from material expert validators such as adding competency achievements in the introduction section of the E-Module, adding specific job descriptions related to sheet metal design in the industry.

Results of Product Testing

The results of product testing are classified into two stages, namely small-scale testing and operational testing, with the data presented graphically in Figure 8.

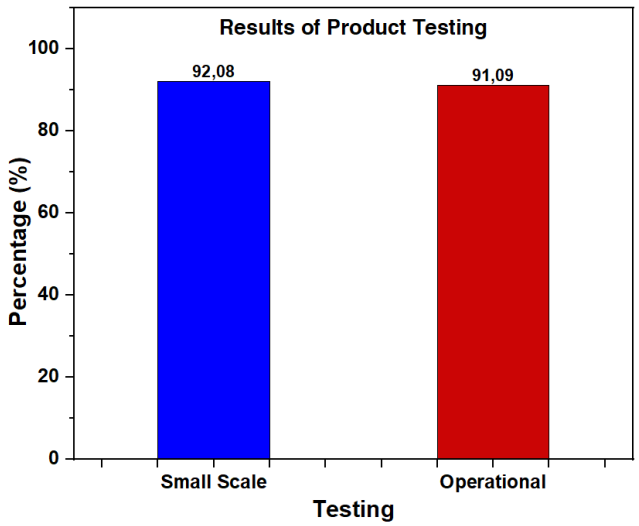

Figure 8. Results of Product Testing

Based on the data from Figure 8 of the product testing results, the score obtained from the small-scale testing was 92.08%. Referring to the assessment criteria listed in Table 1, these results are categorized as very good. Making interactive learning media sheet metal design modeling based on Autodesk Inventor 2023 software is considered feasible to proceed to operational testing.

After conducting a small-scale test, the operational testing continued for 4 days, consisting of 3 days of online interactive discussions through the WhatsApp application guided by the TGM CAD teaching teacher, followed by one offline meeting at the CAD Laboratory of Vocational High Schools 1 Kediri. The testing process involved 32 students in class XI TPM 2 who were taking TGM CAD learning and obtained operational testing results with a score of 91.09%. Referring to the assessment percentage criteria set out in Table 1, these results are categorized as very good. Making interactive learning media products sheet metal design modeling based on Autodesk Inventor 2023 software is considered feasible and can be used as a learning tool.

Discussion

The success of an interactive learning media development product is supported by several factors, including the suitability of needs analysis and applying the correct development steps (Putra & Salsabila, 2021). In addition, the success of the product is also related to the term user friendly, which means that the product or media is designed to facilitate users and make them feel comfortable (Listiyono et al., 2022). Products that include instructional videos integrated into electronic modules can provide accessibility because they can be accessed anywhere and anytime (Yang & Xia, 2023). Research shows that effective use of interactive media in learning can increase student engagement with the material and result in a more effective learning experience (Aulia et al., 2024). It fits the context of the TGM CAD topic, which emphasizes practice and skill demonstration and is efficient for use in both hands-on and self-paced learning (learn from home).

The utilization of the developed E-Module gives the impression of interactivity in which there is material on the steps of designing complex sheet metal, instructional videos, barcode group discussions, user experience, and jobsheets that can increase engagement and understanding. The utilization of technology-based interactive media is expected to be able to produce intensive communication between students and educators (Haleem et al., 2022; Fakhruddin et al., 2024). The product has gone through a validation process by material expert validators and media expert validators to ensure that the content meets the set standards.

The benefits of Interactive E-Modules include making learning more interesting and interactive, reducing teaching time, improving learning quality, enabling learning anywhere and anytime, and improving students learning attitudes (Permitasari et al., 2022). The results of product testing with students show that the presentation aspect still has shortcomings, so providing suggestions and input from students is important as a reference for improving the final product to improve its quality. Suggestions and input that are considered relevant are considered and implemented in product revisions based on expert validation and field testing results. In addition, the positive response from students to the products made shows that users are very enthusiastic and interested in using interactive learning media sheet metal design modeling based on Autodesk Inventor 2023 software. This product successfully fulfills the expectations and needs of the learning activities of students.

CONCLUSION

The conclusions that can be drawn from the research objectives of developing interactive learning media for sheet metal design modeling based on Autodesk Inventor 2023 software are as follows: 1) The product is produced by utilizing video tutorials integrated with a complete E-Module from the introduction of CAD, 3D modeling which includes 2D sketch, 3D sheet metal model, assembly, drawing, frame generator, 3D weldment and equipped with a user experience that can be accessed anytime and anywhere. 2) The research and development model applied follows the stages contained in the Borg & Gall development model. 3) E-Module products through the media validation stage, presented validation results with a value of 98.44% with very good assessment percentage criteria and revision notes in several parts. 4) E-Module products go through the validation stage for the material, presented validation results with a score of 89.28% in the criteria

for very good assessment percentage, and revision notes in several parts. 5) This E-Module product was also tested on a small scale of 6 respondents from students of class XI TPM 1 and obtained a score of 92.08%. According to the predetermined assessment percentage criteria, these results fall into the very good category. 6) The E-Module product was also tested on a large/operational scale as many as 32 respondents from students of class XI TPM 2, stated the results obtained with a score of 91.09%. These results fall into the category of very good and very feasible to be utilized as a learning tool, based on the assessment criteria.

For the next research, it is suggested to improve the quality of interactive learning media for sheet metal design modeling based on Autodesk Inventor 2023 by adding materials that improve students' competencies, such as cable and harness, tube and pipe, surface design, inventor studio, and mold design. It is also recommended to improve the user experience and add exercises or jobsheets that are complex and integrated with real products in the industry. Educators are expected to develop and utilize this media to improve student learning outcomes.

ACKNOWLEDGEMENTS

Thank you to the Faculty of Engineering, especially the Deputy Dean 1, Deputy Dean 3, Head of the S1 Mechanical Engineering Education Program, and the research supervisors, especially in the Mechanical Engineering Education study program at the State University of Malang for their support and assistance during the research process. Thank you to Vocational High Schools 1 Kediri for facilitating researchers while conducting research.

REFERENCES

Amin, N. F., Garancang, S., Abunawas, K., Makassar, M., Negeri, I., & Makassar, A. (2023). Konsep umum populasi dan sampel dalam penelitian. *Jurnal Pilar: Perspective of Contemporary Islamic Studies* , *14*(1), 15–31. https://journal.unismuh.ac.id/index.php/pilar/article/view/10624

Ardianti, T. R., & Susanti, S. (2022). Pengembangan media pembelajaran interaktif berbasis Android pada mata pelajaran akuntansi keuangan SMK. *Edukatif : Jurnal Ilmu Pendidikan*, *4*(2), 2879-2892. https://doi.org/10.31004/edukatif.v4i2.2618

Aulia, H., Hafeez, M., Mashwani, H. U., Careemdeen, J. D., Mirzapour, M., & Syaharuddin. (2024). The role of interactive learning media in enhancing student engagement and academic achievement. *International Seminar on Student Research in Education, Science, and Technology*, *1*, 57–67. https://journal.ummat.ac.id/index.php/issrectec/article/view/22378

Bagyo, R., & Ngadiyono, Y. (2020). Relevansi kurikulum CAD SMK bidang keahlian teknik pemesinan dengan kebutuhan dunia usaha dan industri. *Jurnal Dinamika Vokasional Teknik Mesin*, *5*(1), 51–56. https://doi.org/10.21831/dinamika.v5i1.30995

Berselli, G., Bilancia, P., & Luzi, L. (2020). Project-based learning of advanced CAD/CAE tools in engineering education. *International Journal on Interactive Design and Manufacturing*, *14*(3), 1071–1083. https://doi.org/10.1007/s12008-020-00687-4

Daryanes, F., Darmadi, D., Fikri, K., Sayuti, I., Rusandi, M. A., & Situmorang, D. D. B. (2023). The development of Articulate Storyline interactive learning media based on case methods to train student's problem-solving ability. *Heliyon*, *9*(4), 1-14. https://doi.org/10.1016/j.heliyon.2023.e15082

Fakhruddin, M. T., Sahrina, A., Hari Utomo, D., & Deffinika, I. (2024). Development of digital learning media based on the GlideApps. *Jurnal Inovasi Teknologi Pendidikan*, *11*(2), 132–145. https://doi.org/10.21831/jitp.v11i2.60995

Fathoni, M. I., & Marpanaji, E. (2018). Pengembangan e-book interaktif mata pelajaran teknologi informasi dan komunikasi (TIK) untuk SMK kelas X. *Jurnal Inovasi Teknologi Pendidikan*, *5*(1), 70–81. https://doi.org/10.21831/jitp.v5i1.17149

Gall, M. D., Borg, W. R., & Gall, J. P. (2003). *Educational research* (7th ed.). Library of Congress Cataloging-in-Publication Data.

Gondoputranto, O., & Purnomo, J. (2020). Implementasi pemakaian sistem CAD dan CAM pada industri apparel. *pp*. 67–75. https://dspace.uc.ac.id/bitstream/handle/123456789/5764/Paper5764.pdf?sequence=3&isAllowed=y

Haleem, A., Javaid, M., Qadri, M. A., & Suman, R. (2022). Understanding the role of digital technologies in education: A review. *Sustainable Operations and Computers*, *3*, 275–285. https://doi.org/10.1016/j.susoc.2022.05.004

Juliana, I., & Sulistyowati, R. (2023). Pengembangan e-modul interaktif berbasis aplikasi book creator mata pelajaran produk kreatif dan kewirausahaan kelas XII BDP SMK PGRI 13 Surabaya. *Jurnal Pendidikan Ekonomi (JUPE)*, *11*(3), 328–334. https://doi.org/10.26740/jupe.v11n3.p328-334

Kristian, D., Yoto, Y., & Widiyanti, W. (2023). Evaluasi pelaksanaan teaching factory SMK swasta di Kota Malang. *Jurnal Teknik Mesin Dan Pembelajaran*, *6*(1), 1-10. https://doi.org/10.17977/um054v6i1p1-10

Listiyono, H., Sunardi, S., Utomo, A. P., & Mariana, N. (2022). Pengaruh kemudahan penggunaan dan kemanfaatan learning management system (LMS) terhadap niat penggunaan e-learning. *Jurnal Sisfokom (Sistem Informasi dan Komputer)*, *11*(2), 208–213. https://doi.org/10.32736/sisfokom.v11i2.1419

Maolani, I., Sumardi, K., & Berman, E. T. (2022). Media pembelajaran perpipaan sistem refrigerasi berbasis aplikasi Android. *Jurnal Inovasi Teknologi Pendidikan*, *9*(3), 267–276. https://doi.org/10.21831/jitp.v9i3.54103

Mardhiyah, R., Aldriani, S., Chitta, F., & Zulfikar, M. (2021). Pentingnya keterampilan belajar di abad 21 sebagai tuntutan dalam pengembangan sumber daya manusia. *Lectura : Jurnal Pendidikan*, *12*(1), 29–40. https://doi.org/10.31849/lectura.v12i1.5813

Miaz, Y., Helsa, Y., Zuardi, Yunisrul, Febrianto, R., & Erwin, R. (2019). The development of interactive multimedia-based instructional media for elementary school in learning social sciences. *Journal of Physics: Conference Series*, *1321*(3), 1-5. https://doi.org/10.1088/1742-6596/1321/3/032107

Myori, D. E., Chaniago, K., Hidayat, R., Eliza, F., & Fadli, R. (2019). Peningkatan kompetensi guru dalam penguasaan teknologi informasi dan komunikasi melalui pelatihan pengembangan media pembelajaran berbasis Android. *JTEV (Jurnal Teknik Elektro Dan Vokasional)*, *5*(2), 102-109. https://doi.org/10.24036/jtev.v5i2.106832

Noviyanta, R., & Ngadiyono, Y. (2019). Pembuatan media pembelajaran video tutorial mata pelajaran gambar manufaktur di SMK N 2 Pengasih. *Jurnal Pendidikan Vokasional Teknik Mesin*, *7*(3), 151–160. https://doi.org/10.21831/teknik%20mesin.v7i3.15203

Pelliccia, L., Bojko, M., Prielipp, R., & Riedel, R. (2021). Applicability of 3D-factory simulation software for computer-aided participatory design for industrial workplaces and processes. *Procedia CIRP*, *99*, 122–126. https://doi.org/10.1016/j.procir.2021.03.019

Permitasari, M. A., Hartono, H., & Sugito, S. (2022). Pengembangan modul multimedia interaktif pendidikan kewirausahaan pada industri rumahan untuk SMALB Tunagrahita. *Jurnal Inovasi Teknologi Pendidikan*, *9*(1), 49–60. https://doi.org/10.21831/jitp.v9i1.44927

Pratama, M. P., Ruruk, S., & Karuru, P. (2023). Validity of interactive learning media in computer basics course. *Jurnal Inovasi Teknologi Pendidikan*, *10*(4), 353–362. https://doi.org/10.21831/jitp.v10i4.60376

Purniawan & Sumarni, W. (2023). Analisis respon siswa pada pembelajaran daring di masa pandemi COVID 19. *Jurnal Keguruan dan Ilmu Pendidikan (JKIP)*, *1*(3), 228–232. https://doi.org/10.61116/jkip.v1i3.179

Putra, A. D., & Salsabila, H. (2021). Pengaruh media interaktif dalam perkembangan kegiatan pembelajaran pada instansi pendidikan. *Inovasi Kurikulum*, *18*(2), 231–241. https://doi.org/10.17509/jik.v18i2.36282

Ramadhan, M. I. (2023). *Pengembangan media pembelajaran interaktif design engineering menggunakan software Autodesk Inventor Professional 2023 pada mata pelajaran teknik gambar manufaktur SMKN 1 Kediri*. Skripsi tidak diterbitkan. Jurusan Teknik Mesin, Fakultas Teknik, Universitas Negeri Malang.

Rohman, A. F., Widiyanti, W., & Suyetno, A. (2023). Pengembangan modul pembelajaran inventor berbasis contextual teaching and learning (CTL) pada mata pelajaran teknik gambar manufaktur di SMK Negeri 1 Singosari. *Jurnal Teknik Mesin dan Pembelajaran*, *6*(1), 19-28. https://doi.org/10.17977/um054v6i1p19-28

Sagita, M., & Nisa, K. (2019). Pemanfaatan e-learning bagi para pendidik di era digital 4.0. *Jurnal Sosial Humaniora Sigli*, *2*(2), 1–7. https://doi.org/10.47647/jsh.v2i2.169

Saleem, S., Dhuey, E., White, L., & Perlman, M. (2024). Understanding 21st century skills needed in response to industry 4.0: Exploring scholarly insights using bibliometric analysis. *Telematics and Informatics Reports*, *13*, 1-12. https://doi.org/10.1016/j.teler.2024.100124

Santika, I. G. N. (2021). Grand desain kebijakan strategis pemerintah dalam bidang pendidikan untuk menghadapi revolusi industri 4.0. *Jurnal Education and Development*, *9*(2), 369–377. https://journal.ipts.ac.id/index.php/ED/article/view/2500

Shih, Y. T., & Sher, W. (2021). Exploring the role of cad and its application in design education. *Computer-Aided Design and Applications*, *18*(6), 1410–1424. https://doi.org/10.14733/cadaps.2021.1410-1424

Sugiyono, D. (2013). *Metode penelitian kuantitatif, kualitatif, dan tindakan*. Alfabet Bandung.

Siregar, Torang. (2023). Stages of research and development model research and development (R&D). *DIROSAT: Journal of Education, Social Sciences & Humanities*, *1*(4), 142–158. https://doi.org/10.58355/dirosat.v1i4.48

Yang, Y., & Xia, N. (2023). Enhancing students' metacognition via AI-driven educational support systems. *International Journal of Emerging Technologies in Learning (IJET)*, *18*(24), 133–148. https://doi.org/10.3991/ijet.v18i24.45647

Yuliani, W., & Banjarnahor, N. (2021). Metode penelitian pengembangan (RND) dalam bimbingan dan konseling. *Quanta*, *5*(3), 111–118. https://doi.org/10.22460/q.v5i3p111-118.3051

Yunus, Y., & Fransisca, M. (2020). Analisis kebutuhan media pembelajaran berbasis Android pada mata pelajaran kewirausahaan. *Jurnal Inovasi Teknologi Pendidikan*, *7*(2), 118–127. https://doi.org/10.21831/jitp.v7i1.32424