Educational Administration: Theory and Practice
2024, 30(5), 6674-6683
ISSN:2148-2403
https://kuey.net/
Research Article

The Innovation Of Welding Virlab Apps For Pre-Practicum Students To Improve Learning Experiences

Purnomo[1*], Tuwoso[2], Duwi Leksono Edy[3], Johan Wayan Dika[4]

[1*]Engineering Faulty, Universitas Negeri Malang. purnomo@um.ac.id
[2]Engineering Faulty, Universitas Negeri Malang. tuwoso.ft@um.ac.id
[3]Engineering Faulty, Universitas Negeri Malang. duwi.leksono.ft@um.ac.id
[4]Engineering Faulty, Universitas Negeri Malang. johanwayandika@gmail.com

***Corresponding Author:** purnomo@um.ac.id

Citation: Purnomo, et al (2024), The Innovation Of Welding Virlab Apps For Pre-Practicum Students To Improve Learning Experiences, *Educational Administration: Theory and Practice*, *30*(5), 6674-6683, Doi: 10.53555/kuey.v30i5.3996

ARTICLE INFO

ABSTRACT

This study's goal is to develop learning media based on the Virtual Laboratory of Welding (VirLab of Welding) which is integrated with game-based learning to improve learning experiences. The development model used is the waterfall. VirLab of Welding was developed with steps including (1) needs analysis; (2) product design; (3) Coding using Adobe Flash software; and (4) testing. The participants for this research are 204 respondents in 2022 middle to beginning of 2023. Therefore, VirLab is used as a breakthrough to provide virtual-based practicum (pre-practicum) experiences. The results obtained were based on media and material expert validation tests, respectively, with scores of 98.3% and 85%. Thus it can be seen that VirLab of Welding can be used as a pre-practicum learning medium in the very good category. This research has implications and conclusions that the module demonstrates its potential to revolutionize welding education and provide students with a more engaging and efficient learning platform by focusing on enhancing the learning experience through attractive visuals, structured content delivery, and user convenience. Students who use this application have better welding competency and experience abilities.

Keywords: VirLab of Welding, Pre-Practicum, Students, Vocational High School

INTRODUCTION

The implementation of limited Face-to-Face Learning was implemented to prevent or reduce COVID-19 cases, however, after it was implemented COVID-19 cases continued to increase. So the Ministry of Department of Education and Culture Indonesia Republic took quick action to implement 100% online learning in areas experiencing an increase in COVID-19 cases (Farrasasih, 2022). Implementing 100% online learning will impact student learning activities and competencies. The students who feel the impact of implementing limited face-to-face learning (PTM) and 100% online learning are Vocational High School (SMK) students with welding engineering competency skills. Despite learning during the Covid-19 pandemic, (Hargiyarto, Marwanto and Djatmiko, 2015) explained that vocational school students with skill competencies still experience deficiencies in understanding welding requirements, selecting welding current, selecting electrodes based on the type and thickness of the workpiece, welding procedures, errors in setting up the SMAW machine, as well as finishing the weld results.
Practical learning at Vocational High Schools before the COVID-19 pandemic had left problems, namely a lack of competency which has been explained by (Hargiyarto, Marwanto and Djatmiko, 2015) . Moreover, the implementation of limited PTM, or 100% online learning, can worsen or make student competence even lower. An effort to minimize the impact of learning during the COVID-19 pandemic is by developing virtual laboratory-based welding technique learning media integrated with game-based learning.

Welding Engineering is one of the skill competencies found in Vocational High Schools. Based on the National Education System Law, article 3 explains that vocational education is secondary education that seeks to prepare students to work in certain fields. In this skill competency, you will at least learn about

SMAW welding (Daryanto, 2012). The SMAW welding technique is divided into two, namely SMAW welding for welding plates and pipes (Ardin and Mujiyono, 2016) (Rose et al. , 2015) (Thakur and Chapgaon, 2017). In detail, the SMAW welding technique for plate welding consists of four positions, namely 1G, 2G, 3G, and 4G, while for pipe welding it consists of four positions with details of 1G, 2G, 5G, and 6G (Pereira and de Melo, 2020) (Dadi , Goyal and Patel, 2018) (Qazi and Akhtar, 2019) (Firdaus, Jalinus and Effendi, 2019) .

In practice, quite a few students are then neglectful of occupational safety and health procedures. The form of negligence is that there are students who rarely use welding glasses. This negligence, if left unchecked, will become a habit and is often found in welding workshops (Ramdan, Mursyidah and Jubaedah, 2017) (Rybczyński et al. , 2018) (Mgonja, 2017) . If students are not active in using welding glasses when welding, this can result in exposure to ultraviolet rays entering the eyes, causing disease. The type of disease that can be caused is Photokeratoconjunctivitis (Ramdan, Mursyidah and Jubaedah, 2017) .

The COVID-19 pandemic and the implementation of learning that is not optimal will have a very bad impact on the competency of Vocational High School students with welding engineering skills competencies. Some efforts have been made by (Firdausia, 2021) to develop learning in the basic joint welding course Oxy Acetylene Welding (OAW) based on augmented reality. There are also (Lavrentieva et al. , 2020) (Doshi et al., 2017) which states that augmented reality has been developed to provide welding training in automotive manufacturing. Apart from that, (Papakostas et al. , 2021b) have analyzed that the existence of augmented reality in the welding field is accepted by workers who are currently in training.

Augmented reality-based learning media is defined as learning media that can provide an ideal interface by utilizing the Internet of Things (IoT) (Papakostas et al. , 2021a) . This application functions to present information about connected smart objects and services with real user views (Amin and Govilkar, 2015) (Bocevska, 2016) .

The research study on the development of learning media based on the Virtual Laboratory of Welding (VirLab of Welding) integrated with game-based learning addresses a significant research gap in the field of vocational education. This study is essential due to the following reasons: (1) *Integration of Technology in Vocational Education*(Richard *et al.*, 2023)*:* The use of virtual laboratories and game-based learning in vocational education is a relatively new and innovative approach. Traditional vocational education often lacks interactive and engaging learning experiences that can effectively prepare students for practical skills. By integrating technology and gamification, this study bridges the gap between theoretical knowledge and practical application in welding education, (2) *Enhancing Learning Experiences*(Katz, 2021): The study aims to improve learning experiences for vocational high school students by providing a virtual platform for practicing welding techniques. This approach offers a more immersive and interactive learning environment that can enhance students' understanding and competency in welding skills. By offering a blend of theoretical knowledge and hands-on practice in a virtual setting, students can gain valuable experience before entering actual practical activities in the welding laboratory, (3) *Addressing Graduation Requirements*(O'Neill and Short, 2023): The Virtual Laboratory of Welding serves as a graduation requirement for students before they engage in real-world practical activities. This ensures that students have the necessary skills and knowledge to succeed in welding practices. The study focuses on validating the effectiveness of the learning media through expert validation and student trials, highlighting the importance of preparing students adequately for future careers in welding and related fields. By addressing these research gaps and focusing on the development of innovative learning media for vocational education, this study contributes to the advancement of teaching methodologies in welding education and prepares students for the demands of the industry.

Based on the statement above the novelty of this research is the existence of welding technique learning media based on augmented reality with integrated game-based learning. This integration of game-based learning was developed to provide and implement Occupational Health and Safety (OHS) in welding workshops or laboratories. The current study aims to answer the following questions; how is the development and use of virtual laboratory-based welding technique learning media integrated with game-based learning, and what are the results of testing virtual laboratory-based welding technique learning media integrated with game-based learning?

RESEARCH METHOD

Virtual laboratory-based welding technique learning media integrated with game-based learning is included in development research. The development model used is the waterfall software development model. However, as Figure 1 by using a waterfall, requires careful planning and design to ensure that it is effective and meets the needs of both students and educators.

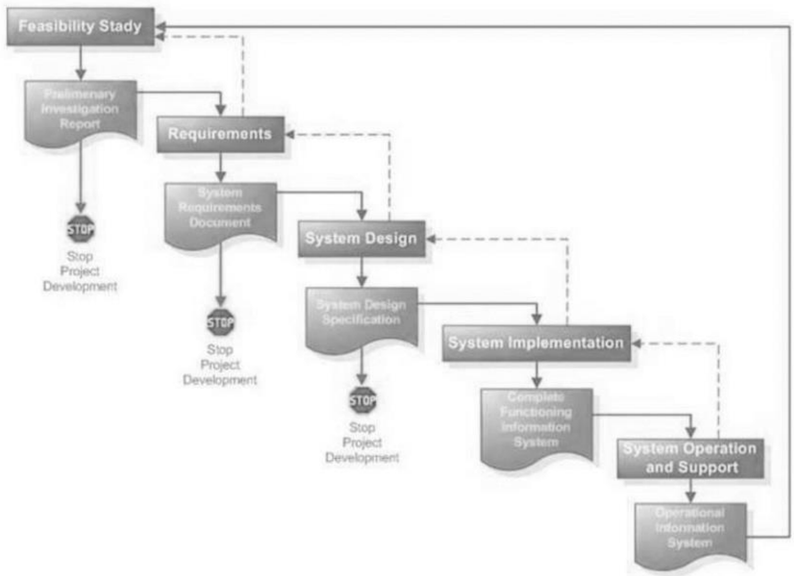


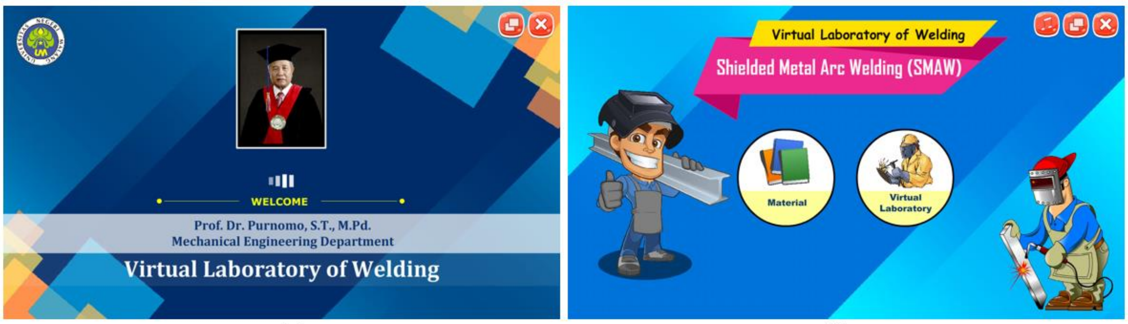
Figure 1 Waterfall development method(Wibawa *et al.*, 2020)

The steps involved in developing this model consist of (1) analysis of material needs, practical equipment, occupational safety, and health equipment and users; (2) product design by the results of previous analyses; (3) Coding the learning media developed. This coding requires software Adobe Flash. The last is (4) testing. Virtual laboratory-based learning media for welding techniques integrated with game-based learning will be tested in vocational schools that have machining and welding engineering skills programs.

RESULTS AND DISCUSSION

Results of Development and Use of VirLab of Welding

A virtual laboratory integrated with game-based learning has been successfully developed. This learning media which focuses on welding techniques in the form of software is given the name Virtual Laboratory of Welding (VirLab of Welding). In general, this learning media has two main features which contain material on welding techniques and virtual laboratories. The material offered in this learning media is basic to contemporary case studies regarding weld results. Meanwhile, the Virtual Laboratory feature presents simple welding practicums in virtual form which are packaged like games. Apart from that, in terms of appearance, this learning media is supported by therapeutic music which is good for the learning process and also provides animated images of welders carrying material and carrying out the welding process. The following are the results of the development.



(a) (b)

Figure 2. Display of the Virtual Laboratory of Welding (a) First; and (b) Second

Based on Figure 2, it can be seen that the first display (a) shows a photo as well as a brief profile of the application developer. Apart from that, the first display is also equipped with the State University of Malang logo, application name, minimize feature (to reduce the Virtual Laboratory of Welding window), maximize (Virtual Laboratory of Welding), and the X (Close) feature to close the Virtual Laboratory of Welding application. Next, the second display (b) presents a selection of learning materials. The material shown in Figure 1(b) is material about Shielded Metal Arc Welding (SMAW). This learning offers two options consisting of material (material about SMAW welding) and Virtual Laboratory (basic practical practice for SMAW welding carried out virtually).

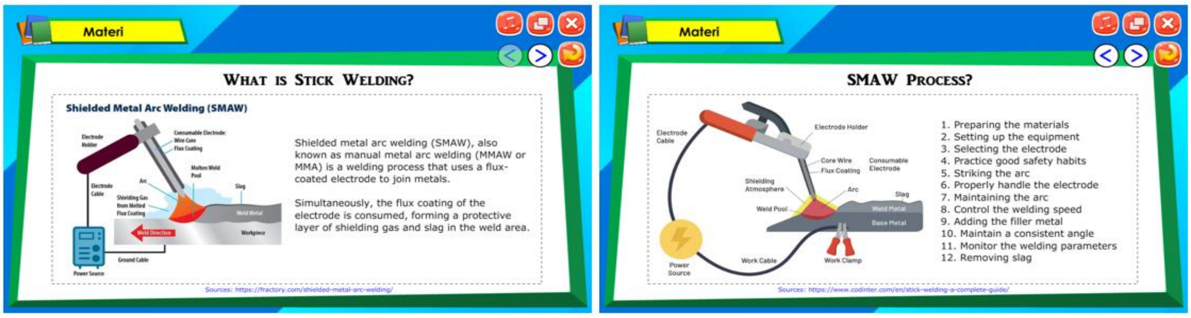


Figure 3. Display of SMAW Material in the Virtual Laboratory of Welding (a) Stick Welding; and (b) SMAW Process

Figure 3 shows the basic materials regarding Shielded Metal Arc Welding (SMAW). In Figure 3(a) it is known that the first material given focuses on the basics of stick welding. Apart from being equipped with explanatory descriptions, the Virtual Laboratory of Welding display is also equipped with good images. In this way, Vocational High School students will understand more easily. The explanations accompanied by pictures can increase students' understanding of the learning process. Figure 3(b) explains the SMAW welding process. From this figure, it can be seen that the SMAW welding process has at least 12 processes which include preparing the materials, setting up the equipment, selecting the electrode, practicing good safety habits, striking the arc, properly handling the electrode, maintaining the arc, controlling the welding speed, adding the filler metal, maintaining a consistent angle, monitoring the welding parameters, and removing slag. Apart from that, Figure 3(b) also shows the definition through a direct image which consists of a power source, electrode cable, electrode holder, core wire, flux coating, shielding atmosphere, weld pool, work clamp, arc, slag, weld metal and base. metal. By providing this simple explanation, it will be easier for students to understand the basics of SMAW welding techniques.

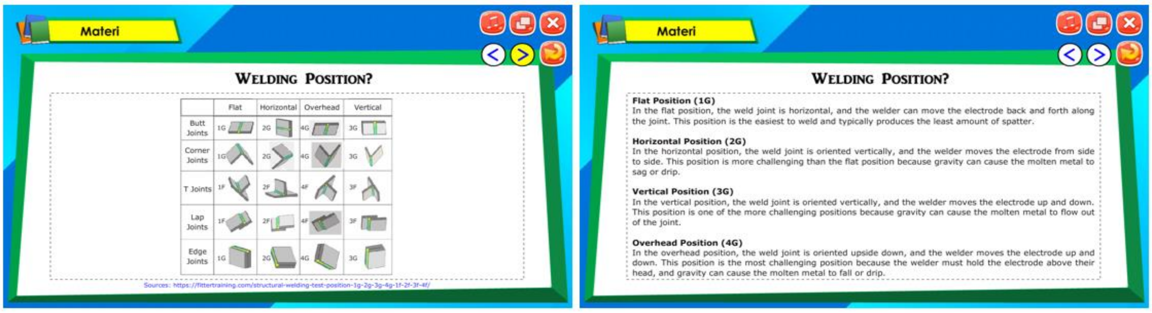


Figure 4. Welding Position Classification Display in the Virtual Laboratory of Welding (a) Figure; and (b) Description

Based on Figure 4, it can be seen that welding positions are generally divided into four, including Flat Position (1G), Horizontal Position (2G), Vertical Position (3G), and overhead position (4G). More clearly, the welding position in question can be seen in Figure 3(a) which describes in detail the differences between flat, horizontal, overhead, and vertical positions. Apart from that, the types of welding between two different plates are also presented which are detailed with the names butt joints, corner joints, T joints, lap joints, and edge joints.

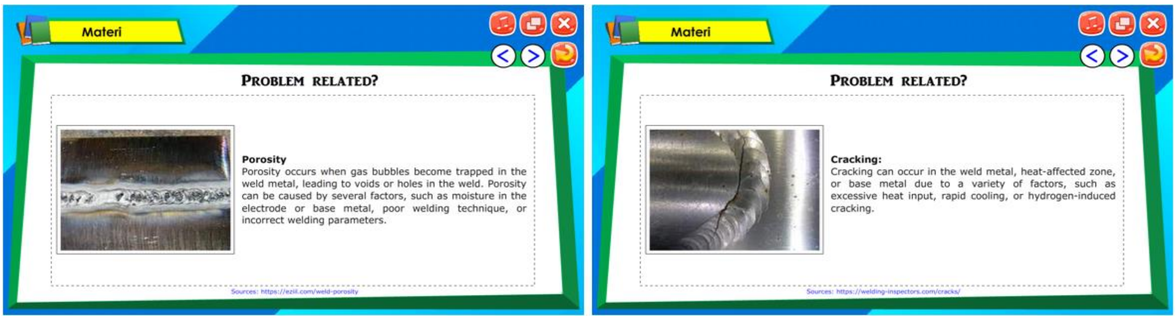


Figure 5. Display of Problem-Related Material in the Virtual Laboratory of Welding

Based on Figure 5, it can be seen that the material contained in the Virtual Laboratory of Welding, apart from presenting the basics of SMAW welding, also presents the problems found in the weld results. In the problem-related material display, six types of bad weld results are presented, including porosity, cracking, undercutting, incomplete fusion, slag inclusion, and electrode sticking. Apart from being shown detailed pictures of each type of bad weld result, knowledge was also provided about the causes of their occurrence. In this way, students will understand better and can avoid bad weld results. These causes must be recognized by students at the beginning of learning. (Simbolon, 2023) states that introducing science before carrying out the practicum will have an impact on the results of students' practicum activities. However, what needs to be paid attention to is how this knowledge is conveyed, namely that it must be interesting and detailed. If the method of conveying knowledge does not pay attention to these two aspects, then the knowledge cannot be received or only a small part is received by students.

Figure 6. Display of Application of SMAW material in the Virtual Laboratory of Welding

Based on Figure 6, it can be seen that the material contained in the Virtual Laboratory of Welding is also equipped with the application of SMAW. This is provided so that students know the benefits of learning welding techniques, especially the SMAW welding type. (Vieluf and Klieme, 2023) expressed their view that to increase students' understanding, it is highly recommended to provide theory that is integrated with practical conditions. In the application of SMAW material, it is stated that there are six applications of SMAW consisting of construction, pipeline welding, maintenance and repair, shipbuilding, fabrications, and welding thick materials.

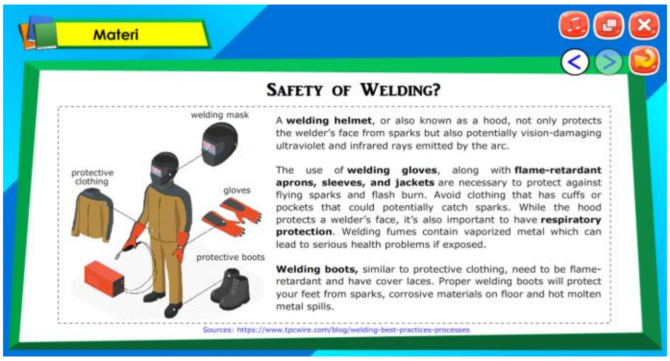


Figure 7. Display of Safety of Welding Material in the Virtual Laboratory of Welding

One part that is included in an important category in welding engineering is material about the safety of welding. (Parsaoran Tamba and Sumual, 2023) explains that the successful implementation of welding safety behavior can be trained from three parameters which include soft and hard skills of Occupational Health Safety, and work environment. Apart from that, (Kyew, 2023) also emphasizes how important work safety skills are. Even when welders enter the world of work, they are also given Occupational Health Safety (OHS). This is aimed at increasing work safety skills and awareness in the community. Based on Figure 7, it can be seen that the minimum equipment that must be present in the practicum is protective boots, gloves, welding masks, and protective clothing.

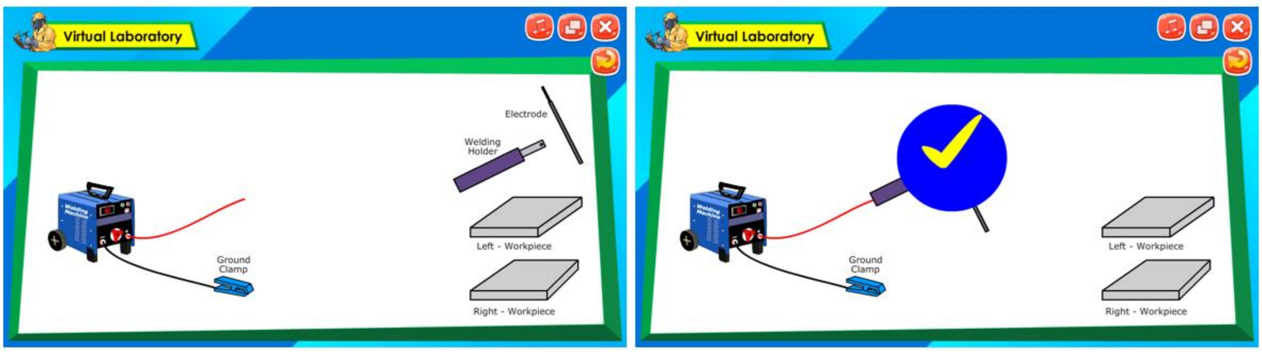


Figure 8. Virtual Laboratory Display Integrated with Game-Based Learning

(Utomo et al. , 2023) said that Game-Based Learning is becoming a learning trend, especially in the Vocational and Educational Training (VET) sector. One of the advantages of implementing game-based learning is that it can significantly increase student focus and learning experience. The Virtual Laboratory of Welding that was developed is integrated with game-based learning. Based on Figure 8, it can be seen that there are several components presented, including the power supply, welding machine, ground clamp, electrode, welding holder, left workpiece, and right workpiece. Technically, the use of game-based learning is to determine the components presented in Figure 8 to be installed systematically. If these components are not installed systematically then the welding process will not work or will fall into the failed practical category.

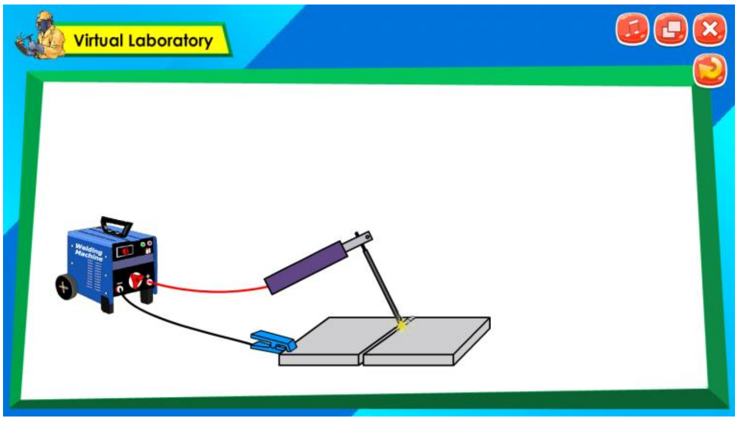


Figure 9. Virtual Laboratory Display that Can Run the Welding Process

Figure 8 shows the appearance of the virtual laboratory of welding which has successfully carried out the welding process. The systematic installation of the installed components begins with taking the welding holder and then directing it to the red cable. Next in sequence is to install the electrode on the welding holder, take and direct the left – workpiece and right – workpiece to the Ground Clamp. At the end of each correct component installation, a checkmark will appear. Lastly, when all components are installed systematically and correctly, the welding process will run automatically.

Results of Development and Use of VirLab of Welding

Virtual Laboratory of Welding is a learning medium aimed at providing virtual practical experience for Vocational High School students with machining and welding skills programs. Learning via Virtual This Laboratory of Welding is used as a graduation requirement before students enter actual practical activities in the Welding Laboratory/workshop. Therefore, testing is needed to see the quality of the learning media being developed. Testing is divided into two, namely expert validation and trial. Expert validation was carried out by two academics whose fields correspond to the learning media being developed. Meanwhile, the trial was carried out on 60 Vocational High School students with a machining and welding engineering skills program.

Expert validation is divided into two, namely media expert validation and material expert validation. In terms of media validation, there are three aspects tested, namely appearance, content, and writing. In the appearance aspect, the indicators tested include layout suitability and attractiveness. In the content aspect, the indicators tested include suitability of appearance, suitability of images, image quality, and suitability of illustrations. The writing aspect that is tested is the suitability of the letters. The results of the media expert validation test can be seen in Table 1.

Table 1. Results Media Expert Validation

Aspect	Indicator	Score Item	Score
Appearance	Layout suitability	2	7
	Attractiveness	2	8
Contents.	Suitability appearance	3	12
	Suitability picture	2	8
	Quality picture	1	4
	Suitability illustration	2	8
Writing	Suitability letter	3	12
Total		**15**	**59**

Based on Table 1, it can be seen that the total score from the media expert validation test results obtained is 59. From the validation of the results carried out by media experts, then can calculated with the formula as follows:

$$P = \frac{\sum X}{\sum Xi} \text{ x } 100\% \text{ ....(1)}$$

$$P = \frac{59}{60} \times 100\%$$

$$P = 98.3\ \%$$

Thus, it can be concluded that the results of the validation data media expert were obtained in the very good category.
Table 1 in the provided document presents the results of the media expert validation based on three key aspects: Appearance, Contents, and Writing. Here is an explanation of the indicators within each aspect: (1) *Appearance*: (a) *Layout Suitability*: This indicator assesses the appropriateness and effectiveness of the layout design of the material. It evaluates how well the visual elements, text placement, and overall structure contribute to the readability and user experience of the media, (b) *Attractiveness*: This indicator focuses on the visual appeal and aesthetic quality of the material. It evaluates the overall attractiveness of the design, graphics, and presentation style to engage and captivate the audience; (2) *Contents*: (a) *Suitability Appearance*: This indicator assesses the alignment of the visual content with the overall appearance and design of the material. It evaluates whether the visual elements complement the layout and enhance the overall presentation, (b) *Suitability Picture*: This indicator examines the appropriateness and relevance of the images or graphics used in the material. It assesses whether the pictures effectively support the content, convey information, and enhance understanding, (c) *Quality Picture*: This indicator focuses on the clarity, resolution, and visual quality of the images included in the material. It evaluates the overall quality of the pictures in terms of sharpness, detail, and visual impact, (d) *Suitability Illustration*: This indicator assesses the effectiveness of illustrations, diagrams, or visual aids in conveying information. It evaluates whether the illustrations enhance comprehension, clarify concepts, and improve the overall learning experience; (3) *Writing*: (a) *Suitability Letter*: This indicator examines the appropriateness and effectiveness of the written text in the material. It evaluates the clarity, readability, and suitability of the language used to convey information to the target audience. Overall, Table 1 provides a detailed evaluation of the media expert validation results based on these specific aspects, highlighting the strengths and areas for improvement in the appearance, content, and writing elements of the welding education material.

In terms of material validation, there are three aspects tested, namely content, presentation, and context. In the content aspect, the indicators tested include the suitability of the material and the accuracy of the material. In the presentation aspect, the indicators tested include presentation techniques, interactiveness, and conformity with language rules. The contextual aspects tested are contextual essence and contextual components. The results of the material expert validation test can be seen in Table 2.

Table 2. Results Material Expert Validation

Aspect	**Indicator**	**Score Item**	**Score**
Content	Suitability material	2	7
	Accuracy material	2	7
Presentation	Technique presentation	3	11
	Interactive	2	6
	Suitability with rule Language	2	6
Contextual	Essence contextual	2	7
	Component contextual	2	7
Total		**15**	**5 1**

Based on Table 2, it can be seen that the total score from the results of material expert validation testing is 51. From the validation of the results carried out by expert material, then can calculated with formula as follows:

$$P = \frac{\sum X}{\sum Xi} \times 100\%$$

$$P = \frac{51}{60} \times 100\%$$

$$P = 85\%$$

Thus, it can be concluded that the results of the validation data media material were obtained in the very good category.
Table 2 in the provided document presents the results of the material expert validation based on three key aspects: content, presentation, and contextual aspects. Here is an explanation of the indicators within each aspect: (1) *Content*: (a) *Suitability of Material*: This indicator assesses the appropriateness and relevance of the material in the context of welding education. It evaluates whether the content aligns with the learning objectives, curriculum standards, and industry requirements, (b) Accuracy of Material: This indicator

examines the correctness and precision of the information presented in the material. It ensures that the content is factually accurate, up-to-date, and free from errors or misconceptions related to welding techniques and practices; (2) *Presentation*: (a) *Technique Presentation*: This indicator evaluates the effectiveness of the presentation techniques used in delivering the material. It assesses the clarity, organization, and coherence of the content to facilitate understanding and engagement among students, (b) *Interactive*: This indicator focuses on the level of interactivity and engagement provided by the material. It assesses whether the material encourages active participation, hands-on learning experiences, and practical application of welding concepts, (c) *Suitability with Rule Language*: This indicator examines the adherence to language rules and standards in the presentation of the material. It ensures that the language used is appropriate, clear, and accessible to the target audience of vocational high school students in the welding field; (3) *Contextual*: (a) *Essence Contextual*: This indicator assesses the core essence and relevance of the material within the broader context of welding education. It evaluates whether the material covers essential concepts, principles, and skills required for students to succeed in real-world welding practices, (b) *Component Contextual*: This indicator examines how well the material integrates contextual components such as real-world applications, industry relevance, and practical implications. It ensures that the material prepares students for the challenges and demands of the welding profession by providing hands-on experiences and industry-specific knowledge. Overall, Table 2 provides a detailed assessment of the material expert validation results based on these specific aspects, highlighting the strengths and areas for improvement in the content, presentation, and contextual elements of the welding education material.

The Virtual Laboratory of Welding trial. This learning media trial was carried out on 60 Vocational High School students with the Machining Engineering and Welding Engineering Skills Program. Testing was carried out on the appearance, presentation of material, and contextual aspects. In the appearance aspect, the indicator tested is attractiveness. In the aspect of presenting material, the indicators tested include ease of understanding the material, accuracy of presenting the material, and understanding sentences. In the contextual aspect, the indicators tested include ease of learning and the attractiveness of learning media. The results of the Virtual Laboratory of Welding trial can be seen in Table 3.

Table 3. Results Learning Media Trial

Aspect	**Indicator**	**Score Item**	**Score**
Appearance	Attractiveness module	3	609
Presentation material	Convenience understand material	2	397
	Accuracy of systematic presentation of material	3	580
	Clarity sentence	2	396
Contextual	Convenience Study	2	409
	Interest-shaped teaching materials module	3	572
Total		**15**	**2963**

Based on Table 3, it can be seen that the total score from the test results obtained was 2963. The results of the trial, then can calculated with the formula as follows:

$$P = \frac{\sum X}{\sum Xi} \times 100\%$$

$$P = \frac{2963}{3600} \times 100\%$$

$$P = 82.3\ \%$$

Thus, it can be concluded that the results of The learning media trial were obtained in the good category.

Table 3 in the provided document presents the results of the learning media trial based on five key aspects: Appearance, Presentation Material, and Contextual aspects. Here is an explanation of the indicators within each aspect: (1) *Appearance*: (a) *Attractiveness Module*: This indicator assesses the visual appeal and aesthetic quality of the learning module. It evaluates the design elements, layout, and overall presentation of the module to engage and retain the interest of the users; (2) *Presentation Material*: (a) *Convenience Understand Material*: This indicator focuses on the ease of understanding the material presented in the learning module. It evaluates how well the content is structured, organized, and explained to facilitate comprehension and learning, (b) Accuracy of Systematic Presentation of Material: This indicator examines the systematic arrangement and presentation of the material in the module. It assesses the logical flow, coherence, and consistency of information to ensure that the content is presented in a clear and structured manner, (c) *Clarity Sentence*: This indicator evaluates the clarity and effectiveness of the sentences used in the learning module. It assesses the readability, coherence, and conciseness of the language to convey information accurately and comprehensively; (3) *Contextual*: (a) *Convenience Study*: This indicator assesses the overall convenience and user-friendliness of the study material. It evaluates how well the material accommodates the needs and preferences of the users, making the learning experience accessible and engaging, (b) *Interest-Shaped Teaching Materials Module*: This indicator focuses on the level of interest and engagement generated by the teaching materials in the module. It assesses whether the content is designed to capture and maintain the interest of the users, enhancing motivation and participation in the learning process. Overall, Table 3 provides a comprehensive evaluation of the learning media trial results based on these specific aspects, highlighting the strengths and areas for improvement in the appearance, presentation material, and contextual elements of the welding education module.

The development of the Virtual Laboratory of Welding (VirLab of Welding) integrated with game-based learning has yielded promising results and implications for vocational education. The results indicate that VirLab of Welding provides a comprehensive and interactive platform for students to learn welding techniques in a virtual environment. The successful integration of welding materials and virtual laboratory simulations in this learning medium has been well-received by both experts and students, as evidenced by high validation scores in media and material expert tests.

The engaging features of VirLab of Welding, such as therapeutic music, animated images, and gamified welding practicums, contribute to a more immersive and effective learning experience for students. By offering a blend of theoretical knowledge and practical application in a virtual setting, VirLab of Welding bridges the gap between classroom learning and real-world welding practices. This innovative approach not only enhances students' understanding of welding concepts but also improves their competency and experience in welding techniques.

The positive outcomes of the expert validation tests and student trials suggest that VirLab of Welding has the potential to revolutionize welding education by providing a hands-on, interactive, and engaging learning experience for vocational high school students. The results of this study highlight the effectiveness of integrating technology and gamification in vocational education to enhance students' skills and prepare them for future careers in welding and related fields.

CONCLUSIONS

Based on the development and successful implementation of the Virtual Laboratory of Welding (VirLab of Welding), it can be concluded that this innovative learning medium offers a valuable pre-practicum experience for Vocational High School students specializing in machining and welding engineering programs. The well-categorized materials and engaging virtual laboratory simulations provided by VirLab of Welding have proven to be effective in enhancing students' understanding of welding techniques and safety practices. By focusing on enhancing the learning experience through attractive visuals, structured content delivery, and user convenience, the module demonstrates its potential to revolutionize welding education and provide students with a more engaging and effective learning platform.

Implications of this study suggest that teachers can utilize the VirLab of Welding as an initial introduction to welding practices for students, thereby improving their welding competency and practical skills. By incorporating game-based learning and virtual simulations, this application offers a unique and interactive approach to learning welding techniques, making the educational experience more engaging and effective for students. Furthermore, the positive results obtained from expert validation tests and student trials indicate the potential of VirLab of Welding to be a valuable tool in vocational education settings, preparing students for real-world welding challenges and enhancing their overall learning experiences.

REFERENCES

1. Amin, D. and Govilkar, S. (2015) 'Comparative study of augmented reality SDKs', *International Journal on Computational Science & Applications*, 5(1), pp. 11-26.
2. Ardin, M. B. and Mujiyono, M. (2016) 'Model pembelajaran praktik pengelasan shieled metal arc welding (SMAW) posisi 1G jurusan teknik pengelasan.', *Jurnal Pendidikan Vokasi*, 6(2), pp. 198–206.
3. Bocevska, A. (2016) 'Implementation of Augmented reality in CAD design', *Journal of Emerging Research and Solutions in ICT*, 1(1), pp. 26-31.
4. Dadi, A., Goyal, P. B. and Patel, M. H. (2018) 'A Review Paper on Optimization of Shielded Metal Arc Welding Parameters for Welding of (Ms) Sa-516 Gr. 70 Plate by Using Taguchi Approach', *International Journal of Scientific Research in Science and Technology*, 4(5), pp. 1536–43.
5. Daryanto (2012) *Teknik Las*. Bandung: Alfabeta.
6. Doshi, A. *et al.* (2017) 'Use of projector based augmented reality to improve manual spot-welding precision and accuracy for automotive manufacturing', *The International Journal of Advanced Manufacturing Technology*, 89(5), pp. 1279–1293.
7. Farrasasih, Y. A. (2022) *Kebijakan Pembelajaran Daring 100 Persen Kota Malang Dimulai Senin, 14 Februari 2022, Malang Terkini.com.*
8. Firdaus, H., Jalinus, N. and Effendi, H. (2019) 'Development of Learning Modules Manual Shield Metal Arc Welding (SMAW) with Service Learning Approach', *International Research Journal of Advanced Engineering and Science,* 2(2), pp. 247–251.
9. Firdausia, F. F. (2021) *Pengembangan media pembelajaran berbasis augmented reality dalam mata kuliah pengelasan dan penyambungan dasar oxy acetylene welding (oaw)*. Universitas Negeri

Malang.
10. Hargiyarto, P., Marwanto, A. and Djatmiko, R. D. (2015) 'Analisis Kesalahan Esensial Hasil Pengelasan Peserta Lomba Kompetensi Siswa SMK Tingkat Daerah Istimewa Yogyakarta', *Jurnal Pendidikan Teknologi dan Kejuruan*, 22(3), pp. 350–364.
11. Katz, A. (2021) 'ENHANCE LEARNING EXPERIENCE USING TECHNOLOGY IN CLASS', *Journal of Technology and science Education*, 11(1), pp. 184–193. doi: https://doi.org/10.3926/jotse.1050.
12. Kyew, A. Y. (2023) 'OHS-Based Welding Training as an Effort to Increase Work Safety Skills and Awareness in the Community', *Collaborate Engineering Daily Book Series*, 1(June), pp. 73–77.
13. Lavrentieva, O. *et al.* (2020) 'Use of simulators together with virtual and augmented reality in the system of welders' vocational training: past, present, and future.'
14. Mgonja, C. T. (2017) 'The effects of arc welding hazards to welders and people surrounding the welding area', *International Journal of Mechanical Engineering and Technology*, 8(3), pp. 433-441.
15. O'Neill, G. and Short, A. (2023) 'Relevant, practical and connected to the real world: what higher education students say engages them in the curriculum', *Irish Educational Studies*, pp. 1–18. doi: 10.1080/03323315.2023.2221663.
16. Papakostas, C. *et al.* (2021a) 'Exploration of augmented reality in spatial abilities training: a systematic literature review for the last decade', *Informatics in Education*, 20(1), pp. 107-130.
17. Papakostas, C. *et al.* (2021b) 'User acceptance of augmented reality welding simulator in engineering training', *Education and Information Technologies*, pp. 1–27.
18. Parsaoran Tamba, I. and Sumual, H. M. (2023) 'The Influence of Hard Skills K3, Soft Skills and Work Environment on the Behavior of Implementing K3 in Welding Practices of Mechanical Engineering Study Program Students in Vocational High Schools in North Sulawesi', *Technium*, 16.
19. Pereira, A. B. and de Melo, F. J. (2020) 'Quality assessment and process management of welded joints in metal construction—A review', *Metals*, 10(1), p. 115.
20. Qazi, M. I. and Akhtar, R. (2019) 'Application of Taguchi Method for Optimization of Tensile Strength of Shielded Metal Arc Welding (SMAW) Process for Steel SA 516 Grade 70', *International Journal of Progressive Sciences and Technologies*, 17(2), pp. 97–103.
21. Ramdan, I. M., Mursyidah, S. B. and Jubaedah, S. (2017) 'Photokeratoconjunctivitis symptoms among informal welding operators in North Samarinda, Indonesia', *Glob Med Heal Commun*, 5(2), pp. 144–51.
22. Richard, G. S. *et al.* (2023) 'Technology Integration in Technical and Vocational Education and Training (TVET): The Role of the Art Teacher', *Journal of Technical Education and Training*, 15(4), pp. 73–88. doi: 10.30880/jtet.2023.15.04.007.
23. Rose, M. *et al.* (2015) 'Assessing the Impact of Sequencing Practicums for Welding in Agricultural Mechanics', *Journal of Agricultural Education*, 56(1), pp. 92–102.
24. Rybczyński, A. *et al.* (2018) 'Welding arc ignition and photobiological hazard evaluation', in *In 2018 IEEE International Conference on Environment and Electrical Engineering and 2018 IEEE Industrial and Commercial Power Systems Europe (EEEIC/I&CPS Europe)*, pp. 1–6.
25. Simbolon, O. (2023) 'Manfaat Metode Inquiry Terhadap Pengamatan Hasil Praktikum Las Listrik di Laboratorium Manufaktur Politeknik Bhakti Asih Purwakarta', *Journal of Industrial Management and Entrepreneurship*, 1(1), pp. 127–131.
26. Thakur, P. P. and Chapgaon, A. N. (2017) 'Effect of GTAW-SMAW hybrid welding process parameters on hardness of weld', *Gas*, 100(110), p. 120.
27. Utomo, D. P. *et al.* (2023) 'Students' Intuitive Thinking Process in Solving Geometry Tasks from the Van Hiele Level', *JTAM (Jurnal Teori dan Aplikasi Matematika)*, 7(1), pp. 139–149.
28. Vieluf, S. and Klieme, E. (2023) 'Teaching effectiveness revisited through the lens of practice theories', in *In Theorizing teaching: Current status and open issues*. Cham: Springer International Publishing., pp. 57–95.
29. Wibawa, S. C. *et al.* (2020) 'Moodle mobile development in enjoyable learning in computer system subjects', *IOP Conference Series: Materials Science and Engineering*, 830(3). doi: 10.1088/1757-899X/830/3/032017.