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Utilization of Pneumatic E-Module in Basic Vocational Process Learning for Students of SMK Negeri 3 Yogyakarta

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ABSTRACT

Purpose of the study: This study aims to analyze the utilization of a pneumatic e-module as a learning medium in the Basic Vocational Mechanical Process subject for students at State Vocational School 3 Yogyakarta.

Methodology This research employed a quantitative descriptive approach. The e-module was developed using the Daryanto module development model and the Pressman waterfall model (analysis, design, coding, testing) with Lectora Inspire software. Data were collected through observation, interviews, black box testing, and questionnaires, then analyzed using descriptive statistics.

Main Findings: The e-module was validated as "good" by material experts (average score 114) and media experts (112.5). Teacher trials yielded an average score of 154.33 ("good"), and student trials resulted in 141.73 ("good"). The findings indicate the e-module is feasible and effective for use, with students finding the interactive multimedia content helpful for understanding pneumatic concepts.

Novelty/Originality of this study: This research offers a novel, specifically designed pneumatic e-module for vocational education that integrates text, animations, simulations, and videos. It advances existing knowledge by providing an interactive, standalone digital medium for the Basic Vocational Mechanical Process subject, addressing a gap in media for pneumatics learning and offering a flexible tool for both classroom and independent study.

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1. INTRODUCTION

Learning is a process of interaction between educators, students, and learning resources aimed at achieving predetermined competencies [1]. Learning success is influenced by various components, such as teachers, students, learning materials, methods, learning media, and learning evaluation. Learning media plays a crucial role in helping deliver material so that it is more easily understood by students. Current developments in information technology require educators to utilize various innovative learning media to make the learning process more engaging, effective, and interactive [2]. Therefore, the use of technology-based learning media is one strategy that can improve the quality of the learning process in schools.

In practice, the learning process in vocational schools still faces various obstacles, particularly in technical subjects such as pneumatics. Pneumatics material requires not only an understanding of theoretical concepts but also skills in understanding the workings of pneumatic components and circuits [3]. However, limited learning resources and media often result in students lacking a grasp of the basic concepts being studied. This situation results in learning focusing more on practice without a strong theoretical understanding. As a result, student learning outcomes in the theoretical aspect are often lower than in the practical aspect.

One way to address these issues is to utilize digital technology-based learning media. Computer-based learning media can help students understand abstract concepts through more interactive and engaging presentations [4]. One form of media that can be used is an electronic module, or e-module, systematically designed according to learning competencies. E-modules enable material presentations complemented by animations, simulations, videos, and practice exercises to enhance student understanding. Therefore, the use of e-modules is expected to help students grasp pneumatic concepts more effectively.

Several previous studies have shown that the use of electronic modules can improve the quality of learning in vocational schools [5]. Research conducted by several researchers in the field of educational technology indicates that e-modules can increase learning motivation, learning independence, and student conceptual understanding. Furthermore, digital-based learning media is also considered capable of providing a more interactive learning experience compared to conventional printed modules [6]. These research results indicate that the use of e-modules can be an effective alternative learning medium to support the learning process in schools.

However, most previous research has focused on the development of learning media in general or on other subject areas. Research specifically examining the use of e-modules in pneumatics learning in vocational high schools is still relatively limited [7]. Furthermore, some previous studies have focused on developing media products without a more in-depth analysis of how these media are used to support classroom learning. This situation indicates a research gap that requires further study, particularly regarding the use of e-modules in pneumatics learning in mechanical engineering programs.

Based on this gap, this study offers a novelty in the form of utilizing a pneumatic e-module as a learning medium in the Basic Mechanical Vocational Process subject in vocational high schools [8]. The e-module used not only functions as a digital teaching material, but is also designed to support conceptual understanding through systematic, interactive, and multimedia-based presentation of the material. The integration of animation, simulation, and evaluation exercises in the e-module is expected to help students understand the working principles of pneumatic systems more clearly [9]. Thus, this study contributes to the development of the use of digital learning media in vocational education.

This research is important because the use of technology-based learning media can improve the effectiveness of the teaching and learning process in vocational schools. Furthermore, the use of e-modules can help students understand pneumatic concepts more deeply through interactive presentation of materials [10]. This research is also expected to provide alternative innovative learning media for teachers in delivering learning materials. Therefore, this study aims to analyze the use of pneumatic e-modules in learning Basic Vocational Mechanical Processes for students of Vocational School Negeri 3 Yogyakarta [11]. The results of this study are expected to contribute to the development of learning media in vocational education.

2. RESEARCH METHOD

This study uses a quantitative descriptive approach to analyze the use of pneumatic e-modules as learning media in the Basic Vocational Mechanical Process subject [12]. This method is used to describe the level of feasibility and user responses to the developed learning media through the analysis of quantitative data obtained from an assessment questionnaire.

2.1. Development Model

The development of the pneumatic e-module in this study uses two development model approaches, namely the module development model and the software development model [13]. Module development refers to the model proposed by Daryanto which includes four main stages, namely module writing planning, module writing, review and testing, and product finalization. Meanwhile, the process of developing the module in electronic form is carried out using the waterfall model approach adapted from Pressman [14]. This model consists of four systematic stages: analysis, design, coding, and testing. Through this approach, the pneumatic learning module is developed in the form of a multimedia-based e-module that can be used as a learning medium in the Basic Process of Mechanical Vocational Subject.

2.2. Development Procedures

The e-module development procedure in this research consists of several interrelated stages, namely planning, development, testing, and product finalization.

2.2.1. Module Writing Planning

The planning stage is the initial step in e-module development [15]. This stage involves analyzing learning needs, including student characteristics, learning objectives, learning materials, media, and assessment strategies. Careful planning is necessary to ensure the e-module is well-readable and aligns with the competencies students must achieve.

2.2.2. E-Module Development

The development stage is carried out using a waterfall model approach which consists of four main stages as follows:

Table 1. E-Module Development Stages with the Waterfall Model

Development Stage	Main Activities	Tools / Methods Used
a. Analysis	• Identifying learning media needs • Reviewing pneumatics material • Observing and studying literature	• Field observations • Literature studies • Learning needs analysis
b. Design	• Designing the e-module structure (media architecture) • Designing the interface • Designing the program navigation flow	• Block diagram • Storyboarding • Flow chart
c. Coding	• The process of creating/developing e-modules based on design • Integrating multimedia elements	• Main software: Lectora Inspire • Supporting software: Corel Draw, Macromedia Flash
d. Testing	• Ensure media functions properly • Test technical and material suitability	• Black Box Testing • Subject Matter Expert Validation • Media Expert Validation

2.2.3. Review, Testing, and Revision

After the development process is complete, the e-module is reviewed by subject matter and media experts to assess its feasibility [16]. Next, alpha and beta testing is conducted with teachers and students to obtain user feedback on the developed learning media. The results of these trials are used as the basis for product revisions.

2.2.4. Product Finalization

The finalization stage is the product refinement stage after going through an evaluation and revision process [17]. The revised e-module is then packaged as a learning medium ready for use in the pneumatics learning process in the Basic Mechanical Vocational Processes subject.

2.3. Place and Time of Research

This research was conducted at Vocational School Negeri 3 Yogyakarta, located at Jalan W. Monginsidi No. 2, Yogyakarta, from September to December.

2.4. Subjects and Objects of Research

The subjects in this study included material experts, media experts, teachers, and students of the Mechanical Engineering expertise program at Vocational School Negeri 3 Yogyakarta [18]. Meanwhile, the object of the research was the pneumatic learning e-module used as a learning medium in the Basic Mechanical Vocational Process subject.

2.5. Data collection technique

This study employed several data collection methods, including observation, interviews, black box testing, and questionnaires. Observation and interviews were used initially to obtain information regarding learning needs [19]. Black box testing was used to verify the system functionality of the e-module, while questionnaires were used to determine the suitability of the learning media based on expert, teacher, and student assessments.

2.6. Research Instruments

The research instruments used were observation sheets and an e-module feasibility assessment questionnaire. The questionnaire was structured using a four-level assessment scale: very feasible, feasible, fairly feasible, and less feasible.

Table 2. E-Module Assessment Aspects by Material Experts

Aspect	Indicator
Self-Instructional	Clarity of learning objectives, learning materials, practice questions
Self Contained	Suitability of material with learning competencies
Stand Alone	Modules can be used without relying on other teaching materials
Adaptive	The material follows the development of science
User Friendly	Ease of use and clarity of instructions

Table 3. Aspects of E-Module Assessment by Media Experts

Aspect	Indicator
Appearance	Slide design, colors, layout, images, videos
Programming	Navigation, ease of use, interactivity

2.7. Validity and Reliability of Instruments

Instrument validity was assessed through expert judgment by two experts to ensure its suitability for the research objectives [20]. After revisions based on expert advice, the instrument was declared suitable for use in the study. Instrument reliability was tested using Cronbach's alpha coefficient. The test results showed a reliability value of 0.91, which is considered highly reliable.

Table 4. Reliability Coefficient Categories

Reliability Coefficient	Category
0,00 – 0,20	Less reliable
0,21 – 0,40	Somewhat reliable
0,41 – 0,60	Quite reliable
0,61 – 0,80	Reliable
0,81 – 1,00	Very reliable

2.8. Data Analysis Techniques

The research data was analyzed using quantitative descriptive statistics by calculating the mean, median, and standard deviation [21]. The assessment results were then categorized based on score intervals to determine the e-module's suitability as a learning medium.

Table 5. Categories of Feasibility Assessment

Score Interval	Category
$Mi + 1{,}5\ SDi < X \leq Mi + 3\ SDi$	Very Worthy
$Mi < X \leq Mi + 1{,}5\ SDi$	Worthy
$Mi - 1{,}5\ SDi < X \leq Mi$	Quite Decent
$Mi - 3\ SDi < X \leq Mi - 1{,}5\ SDi$	Less than worthy

The results of the data analysis are used to determine the level of feasibility and utilization of the pneumatic e-module as a learning medium in the Basic Vocational Mechanical Process subject at Vocational School Negeri 3 Yogyakarta [22].

3. RESULTS AND DISCUSSION

3.1. Pneumatic E-Module Development Results

This research resulted in a product in the form of a pneumatic learning e-module that is used as a learning medium in the Basic Vocational Mechanical Process subject at Vocational School Negeri 3 Yogyakarta. The e-module was developed to help students understand the basic concepts of pneumatic systems more interactively through a combination of text, images, simulations, and learning videos [23]. The development process involves several stages: planning, development, testing, and product finalization. During the planning stage, learning needs are analyzed through observations and interviews with teachers, as well as observations of student characteristics [24]. The analysis results show that 10th-grade Mechanical Engineering students are aged around 15–17 years and possess basic computer skills. Furthermore, they have never studied pneumatics before, so the e-module is structured in stages, from basic concepts to the application of pneumatic systems.

Table 6. Material Structure in the Pneumatics Learning E-Module

No.	Subject	Details of Material / Sub-Topics
1	Basic Concepts of Pneumatic Systems	• Understanding pneumatics

		• Advantages and disadvantages of pneumatic systems • Classification of pneumatic systems • Basic principles of the laws of physics (pressure, force, air flow)
2	Components and Working Principles of Pneumatic Systems	• Compressed air generating unit (compressor) • Air service unit (filter, regulator, lubricator) • Actuator components: single and double acting cylinders • Pneumatic component operating principles
3	Valve Types and Actuating Components	• Valve types: directional valves, pressure regulating valves, flow regulating valves • Valve numbering (e.g., 3/2, 5/2) • Pneumatic symbols • Actuating components (cylinders, pneumatic motors)
4	Pneumatic Control System Circuit	• Understanding pneumatic control systems • Direct and indirect control • Control with logic valves (AND, OR) • Drawing pneumatic circuit diagrams
5	Applications of Pneumatic Systems in Practice	• Simple circuit case study • Pneumatic work process simulation (animation) • Video of pneumatic applications in industry • Practical worksheets/assignments for assembling

Table 7. Main Features of the Pneumatics Learning E-Module

No.	Key Features	Description / Function
1	Home Page	The initial view of the e-module contains the main navigation menu to access all learning features (Instructions, Competencies, Materials, Evaluation, etc.).
2	Material Menu	Presents the concepts and theories of pneumatic systems in a structured manner, complete with supporting text, images and illustrations.
3	Pneumatic System Simulation	Interactive features in the form of animations that illustrate the working process of components and air flow in pneumatic circuits to facilitate understanding.
4	Learning Videos	Showing real applications of pneumatic systems in industry or practical demonstrations to provide students with an applicative overview.
5	Practice Questions and Evaluation	Contains questions to measure students' understanding of the material. Equipped with automatic assessment (feedback).

Table 8. Product Technical Specifications

Aspect	Information
Developer Software	Lectora Inspire (and supporting software such as Corel Draw, Macromedia Flash)
Output Format	Executable application (.exe)
Superiority	Can be run directly on the computer without the need to install additional software.

3.2. Validation Results by Material Experts

Validation by subject matter experts was conducted to assess the e-module's suitability in terms of learning content. The assessment was based on five aspects: self-instructional, self-contained, stand-alone, adaptive, and user-friendly [25]. The results of the subject matter expert assessment are presented in the following table.

Table 9. Results of Material Expert Assessment

No	Aspect	Subject Matter Expert 1	Subject Matter Expert 2	Average	Category
1	Self instructional	79	78	78,5	Baik
2	Self contained	12	13	12,5	Baik
3	Stand alone	5	6	5,5	Baik
4	Adaptive	7	9	8	Baik
5	User friendly	9	10	9,5	Baik

Total average score = 114 (Good Category)

Based on these results, it can be concluded that the pneumatics e-module is suitable for use as a learning medium in terms of content. The material presented is deemed to align with basic competencies and is easy for students to understand.

3.2. Validation Results by Media Experts

Validation by media experts was carried out to assess the quality of the e-module from the aspect of appearance and ease of use.

Table 10. Media Expert Assessment Results

No	Aspect	Subject Matter Expert 1	Subject Matter Expert 2	Average	Category
1	Display	84	77	80,5	Baik
2	Usage	31	33	32	Baik

Total average score = 112.5 (Good Category)

These results indicate that the e-module's appearance and navigation are considered good and easy to use in the learning process [26]. The developed learning media are considered quite engaging and capable of supporting visual material delivery.

3.2. Teacher Trial Results (Alpha Test)

Alpha testing was conducted on three pneumatics subject teachers at Vocational School Negeri 3 Yogyakarta to determine the feasibility of the e-module before it was used by students.

Table 11. Teacher Assessment Results

Respondents	Material Aspect	Media Aspects	Learning Aspects	Total Score	Category
Teacher 1	34	74	33	141	Good
Teacher 2	43	77	38	158	Very good
Teacher 3	40	86	38	164	Very good

Average score = 154.33 (Good Category)

Based on these results, it can be concluded that the e-module is considered suitable for use as a learning medium by teachers. Teachers believe the e-module can help deliver pneumatics material in a more systematic and engaging manner.

3.2. Student Trial Results (Beta Test)

Beta testing was conducted on 30 students of class X Mechanical Engineering at Vocational School Negeri 3 Yogyakarta to determine user responses to the developed e-module.

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Table 12. Student Assessment Results

Assessment Aspects	Average Score	Category
Material	35,63	Baik
Media	78,03	Baik
Module Learning	28,07	Baik

Total average score = 141.73 (Good Category)

These results indicate that students responded positively to the use of e-modules in pneumatics learning. This medium is considered capable of helping students understand the material more easily through visual and interactive presentations.

3.2. E-Module Final Product

Table 13. Specifications and Characteristics of the Final E-Module Product

Aspect	Information
Product name	Pneumatics Learning E-Module
Product Form	Executable application (.exe)
Learning Content	• Pneumatic system teaching materials • Pneumatic work process simulations • Pneumatic application learning videos • Practice questions and self-evaluation
Minimum Device Specifications	• Processor: Intel Pentium III • RAM: 128 MB

Screen Resolution	1024 × 600 pixels (optimal)
Distribution Media	Digital storage media (CD/flash disk)
Target Users	Teachers and students of class X Mechanical Engineering
Purpose of Use	• Classroom learning activities • Resources for students' independent learning at home

The research results show that the use of the pneumatics e-module in the Basic Vocational Mechanical Process learning at Vocational School Negeri 3 Yogyakarta yielded positive results. The developed e-module was deemed suitable for use based on validation results from material experts and media experts, with a good rating. This indicates that the material, display, and navigation system in the e-module align with the learning needs of vocational schools [27]. Furthermore, teachers also gave positive feedback on the use of the e-module as a learning medium. These results indicate that the e-module can be an alternative digital teaching material to support the vocational learning process.

Student responses to the use of the pneumatics e-module also showed positive results. Students assessed the material presented as easy to understand and helped them grasp the basic concepts of pneumatic systems [28]. The use of images, animations, and videos in the e-module made learning more engaging and interactive. Furthermore, the practice questions feature available in the e-module helped students gauge their level of understanding of the material. Thus, the use of e-modules can increase student engagement in the learning process.

These research findings align with several previous studies that suggest that the use of digital-based learning media can improve learning effectiveness. Interactive learning media can help students understand technical and procedural concepts more visually [29]. In vocational learning, the use of technology-based media is crucial because the material studied is closely related to work processes and practices. However, some schools still find limitations in the use of digital media in learning. Therefore, the development of pneumatic e-modules is one solution to support more effective and modern learning.

The novelty of this research lies in the development and utilization of pneumatic e-modules specifically designed for the Basic Mechanical Vocational Process subject [30]. The e-modules not only present material in text form but also include images, animations, videos, and interactive exercises. The combination of these various media provides a more engaging learning experience for students. Furthermore, the e-modules are designed for independent use by students as supplementary learning resources. This demonstrates that e-modules have the potential to support more flexible, technology-based learning.

The implications of this research indicate that the use of e-modules can be an effective alternative learning medium in vocational high schools. Teachers can utilize e-modules as supporting teaching materials in explaining technical material. Furthermore, students can use e-modules for independent learning outside of class. The use of digital media such as e-modules can also increase student motivation to learn. Therefore, the use of e-modules is expected to improve the quality of the learning process in vocational fields.

However, this study still has several limitations. The study was conducted only at one school, SMK Negeri 3 Yogyakarta, so the results cannot necessarily be generalized to other schools. Furthermore, this study focused more on media feasibility and user response. This study did not directly measure the effect of e-module use on improving student learning outcomes. Another limitation is that e-modules still require a computer to run. Therefore, further research can develop e-modules for wider use and test their effectiveness on student learning outcomes.

4. CONCLUSION

Based on the results of the research and discussion, it can be concluded that the development and utilization of the pneumatic e-module in the Basic Vocational Mechanical Process learning at Vocational School Negeri 3 Yogyakarta is feasible and beneficial for the learning process. The validation results from material experts and media experts indicate that the developed e-module is categorized as good and suitable for use as a learning medium. In addition, the results of the teacher assessment also show that the e-module can assist teachers in delivering pneumatically related material in a more systematic and interesting manner.

The results of the student responses also demonstrate that the use of the pneumatic e-module provides a positive learning experience. Students consider that the material presented in the e-module is easier to understand because it is supported by visual elements such as images, animations, and videos. Furthermore, the interactive features and evaluation questions available in the e-module help students measure their level of understanding of the material being studied. This shows that the use of e-modules can increase student engagement in the learning process.

Overall, the pneumatic e-module developed in this study can be used as an alternative digital learning medium to support vocational education, particularly in mechanical engineering programs. The integration of multimedia elements makes the learning process more interactive and flexible, allowing students to learn both in

the classroom and independently. For future studies, further research can focus on testing the effectiveness of e-modules in improving student learning outcomes and developing e-modules that can be accessed through mobile devices or online learning platforms.

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REFERENCES

[1] A. Liljaniemi and H. Paavilainen, "Enhancing engineering education through immersive environments a study of the holodeck vr system in hydraulics and pneumatics," *Cogent Educ.*, vol. 12, no. 1, pp. 1–29, 2025, doi: 10.1080/2331186X.2025.2530900.

[2] K. R. Winatha and M. M. Abubakar, "The usage effectivity of project based interactive e-module in improving students' achievement," *J. Pendidik. Teknol. dan Kejuru.*, vol. 24, no. 2, pp. 198–202, 2018, doi: 10.21831/jptk.v24i2.20001.

[3] I. B. P. Puja, "The mediating role of online learning motivation in the influence of service quality, social media usage, and pedagogical teaching competence of teachers on student learning satisfaction," *Cogent Soc. Sci.*, vol. 10, no. 1, pp. 1–29, 2024, doi: 10.1080/23311886.2024.2396934.

[4] L. M. Smith, G. Kumar, P. Chaudhary, and B. Gordon, "Ethics in clinical research, e-module versus traditional online lecture, a randomized study," *J. Stat. Data Sci. Educ.*, vol. 33, no. 3, pp. 1–7, 2025, doi: 10.1080/26939169.2024.2418114.

[5] I. Saleh, "Longitudinal study of the vocational and high school graduation rate from 2011 to 2016 in erie county, New York," *J. Pendidik. Teknol. dan Kejuru.*, vol. 24, no. 2, pp. 229–237, 2018, doi: 10.21831/jptk.v24i2.20019.

[6] M. Rifai *et al.*, "Trends in the learning style of aviation polytechnic cadets during distance learning," *J. Pendidik. Teknol. dan Kejuru.*, vol. 28, no. 2, pp. 226–237, 2022, doi: 10.21831/jptk.v28i2.53682.

[7] W. Sanderse, "Vocational education and bildung: A marriage or divorce?," *J. Vocat. Educ. Train.*, vol. 76, no. 1, pp. 146–163, 2024, doi: 10.1080/13636820.2021.2015714.

[8] R. N. Syamsudin, S. Sukardi, and H. Shiyu, "Vocational high school teachers' efforts in equipping graduates with soft skills based on Work Demands," *J. Pendidik. Teknol. dan Kejuru.*, vol. 24, no. 2, pp. 303–309, 2018, doi: 10.21831/jptk.v24i2.19956.

[9] J. J. Eckert, Í. Pavani Teodoro, M. Valente Lopes, Q. Wu, and A. A. Santos, "Multi-objective optimization of electro-pneumatic braking process with fuzzy logic control for heavy haul railway applications," *Int. J. Rail Transp.*, vol. 13, no. 2, pp. 332–351, 2025, doi: 10.1080/23248378.2024.2338837.

[10] A. Forsler, P. Nilsson, and S. Walan, "Teaching for sustainable development in vocational education," *J. Biol. Educ.*, vol. 59, no. 2, pp. 268–281, 2025, doi: 10.1080/00219266.2024.2320110.

[11] I. Suwono, A. E. Rahmaningrum, and M. Sholikah, "E-agenda simulation: Is it effective for improving students' learning competences and motivation in vocational high school?," *J. Pendidik. Teknol. dan Kejuru.*, vol. 28, no. 1, pp. 47–62, 2022, doi: 10.21831/jptk.v28i1.33736.

[12] W. D. Kurniawan, A. P. Budijono, and N. A. Susanti, "Developing computer assisted media of pneumatic system learning oriented to industrial Demands," *J. Pendidik. Teknol. dan Kejuru.*, vol. 23, no. 3, pp. 1–6, 2017, doi: 10.21831/jptk.v23i3.13417.

[13] A. Rose, "Tim winton's pneumatic materialism," *Interventions*, vol. 22, no. 5, pp. 641–656, 2020, doi: 10.1080/1369801X.2020.1715819.

[14] E. Flores-García, D. Hoon Kwak, Y. Jeong, and M. Wiktorsson, "Machine learning in smart production logistics: A review of technological capabilities," *Int. J. Prod. Res.*, vol. 63, no. 5, pp. 1898–1932, 2025, doi: 10.1080/00207543.2024.2381145.

[15] A. Richterich, "Hackerspaces as technofeminist sites for experiential learning," *Learn. Media Technol.*, vol. 47, no. 1, pp. 11–25, 2022, doi: 10.1080/17439884.2021.2018604.

[16] G. S. Santyadiputra, Purnomo, W. Kamdi, S. Patmanthara, and D. Nurhadi, "Vilanets: An advanced virtual learning environments to improve higher education students' learning achievement in computer network course," *Cogent Educ.*, vol. 11, no. 1, pp. 1–18, 2024, doi: 10.1080/2331186X.2024.2393530.

[17] Yoana, I. Auwalin, and Rumayya, "The role of vocational education on unemployment in Indonesia,"

Cogent Educ., vol. 11, no. 1, pp. 1–11, 2024, doi: 10.1080/2331186X.2024.2340858.
[18] A. Q. Noori, S. N. Orfan, S. A. Akramy, and A. Hashemi, "The use of social media in EFL learning and teaching in higher education of Afghanistan," *Cogent Soc. Sci.*, vol. 8, no. 1, pp. 1–12, 2022, doi: 10.1080/23311886.2022.2027613.
[19] X. Zhu *et al.*, "Modeling of h pneumatic drying machine for moisture control," *Dry. Technol.*, vol. 43, no. 6, pp. 1038–1055, 2025, doi: 10.1080/07373937.2025.2481614.
[20] A. Al-Mahasneh, M. Abu Mallouh, M. A. Al-Khawaldeh, B. Jouda, O. Shehata, and M. Baniyounis, "Online reinforcement learning control of robotic arm in presence of high variation in friction forces," *Syst. Sci. Control Eng.*, vol. 11, no. 1, pp. 1–16, 2023, doi: 10.1080/21642583.2023.2251521.
[21] H. H. Nour *et al.*, "Pneumatic vs laser lithotripsy for mid-ureteric stones: Clinical and cost effectiveness results of a prospective trial in a developing country," *Arab J. Urol.*, vol. 18, no. 3, pp. 181–186, 2020, doi: 10.1080/2090598X.2020.1749800.
[22] B. Liu *et al.*, "Sleep quality of students from elementary school to university: A cross-sectional study," *Nat. Sci. Sleep*, vol. 12, pp. 855–864, 2020, doi: 10.2147/NSS.S266493.
[23] R. S. Adinata, W. Srisayekti, and R. Jatnika, "The role of perceived teacher, peer, and parental support in school belonging among vocational high school students," *Int. J. Adolesc. Youth*, vol. 30, no. 1, pp. 1–15, 2025, doi: 10.1080/02673843.2025.2526459.
[24] K. A. Y. Puspaningtyas, F. Mutia, and A. M. Ghazali, "Civic literacy in the information age: A survey of vocational high school student in sidoarjo, indonesia," *Cogent Soc. Sci.*, vol. 10, no. 1, pp. 1–12, 2024, doi: 10.1080/23311886.2024.2350109.
[25] N. Hidayat, S. Hadi, A. Basith, and S. Suwandi, "Developing e-Learning Media with the contiguity principle for the subject of autocad," *J. Pendidik. Teknol. dan Kejuru.*, vol. 24, no. 1, pp. 72–82, 2018, doi: 10.21831/jptk.v24i1.17796.
[26] P. Lewis and P. Lewis, "Innovation , technician skills , and vocational education and training : Connecting innovation systems and vocational education and training vocational education and training," *J. Vocat. Educ. Train.*, vol. 77, no. 2, pp. 364–391, 2025, doi: 10.1080/13636820.2023.2215749.
[27] U. Hanifah, Z. Binti Adam, M. Faizin, I. Miftakhul Jannah, and Y. Hanafi, "Accelerating the digitalisation of learning post covid 19 era to improve the pedagogical competence of pre service arabic teachers," *Cogent Educ.*, vol. 11, no. 1, pp. 1–16, 2024, doi: 10.1080/2331186X.2024.2413241.
[28] J. Maknun, U. P. Indonesia, and C. Author, "The technological pedagogical content knowledge (tpack) competence of vocational high school teacher," *J. Pendidik. Teknol. dan Kejuru.*, vol. 28, no. 1, pp. 63–74, 2022, doi: 10.21831/jptk.v28i1.42624.
[29] N. Fajaryati and P. W. Pranoto, "E-module development for the subject of measuring instruments and measurement in electronics engineering education," *J. Pendidik. Teknol. Dan Kejuru.*, vol. 23, no. 2, pp. 1–9, 2016, doi: 10.21831/jptk.v23i2.13187.
[30] U. M. Isa, U. Lawal, Y. I. Salihu, H. Shuaibu, and A. M. Cledumas, "Embedding components of entrepreneurship and creativity skills into construction technology education curriculum in Nigeria," *J. Pendidik. Teknol. dan Kejuru.*, vol. 29, no. 1, pp. 109–124, 2023, doi: 10.21831/jptk.v29i1.59867.