Vol. 9, No.1, 2026, pp. 198-204
DOI: https://doi.org/10.32698/02236

Contents lists available at Journal Global Econedu

Journal of Educational and Learning Studies

ISSN: 2655-2760 (Print) ISSN: 2655-2779 (Electronic)

Journal homepage: http://jurnal.globaleconedu.org/index.php/jels

Development of an adobe animate-based virtual laboratory for electronic fuel injection practicum

Ghaus Dhiyaurrahman Baunan, Zelhendri Zen, Darmansyah Darmansyah, Rayendra Rayendra[*)]
Universitas Negeri Padang, Padang, Indonesia

Article Info

Article history:

Received Apr 16th, 2026
Revised May 04th, 2026
Accepted Jun 30th, 2026

Keyword:

Virtual laboratory,
Adobe Animate,
Electronic fuel injection,
Vocational education

ABSTRACT

This study developed an Adobe Animate–based virtual laboratory for motorcycle electronic fuel injection practicum in vocational high schools. The study applied the Four-D development model involving define, design, develop, and limited disseminate stages. Data were collected through expert validation sheets, practicality questionnaires, pre-test and post-test, and a motivation questionnaire. Data were analyzed using descriptive percentages, N-gain, and paired-samples t-test. The product was highly valid (89.00%) and highly practical (88.06%). Learning outcomes increased from 61.89 to 89.29, with high N-gain (0.72), improved mastery from 21.4% to 92.9%, and significant test results ($t = 8.840$; $p < .001$). Student motivation reached a high category (79.11%). The virtual laboratory is feasible and effective for supporting EFI practicum.

Corresponding Author:

Rayendra Rayendra,
Universitas Negeri Padang
Email: rayendra@fip.unp.ac.id

Introduction

Vocational education in vocational high schools is designed to equip students with practical competencies that are directly aligned with workforce demands. In the automotive sector, the implementation of the Merdeka Curriculum in Phase F requires students to master motorcycle electronic fuel injection (EFI) maintenance competencies because EFI technology has become the dominant system in modern motorcycles and represents an essential competency for automotive technicians. Nevertheless, the readiness of SMK to implement these competencies remains uneven due to limitations in practical facilities, learning resources, and teacher preparedness in implementing the curriculum (Fatah, 2022; Sriyanto et al., 2023). These conditions indicate that improving practical-learning support is crucial to ensure that vocational graduates achieve the competencies required by industry.

Preliminary observations and interviews conducted at SMK Negeri 6 Batam revealed several challenges in implementing EFI practicum. The number of practical tools was insufficient to accommodate all students, several components were damaged, and the risk of equipment damage and work accidents constrained the frequency of practical activities. Similar conditions have also been reported in motorcycle engineering and business programs, where the procurement and maintenance costs of practical equipment limit learning opportunities (Putra & Solikin, 2022). These limitations reduce students' opportunities to repeatedly practice procedural skills and may negatively affect their engagement and motivation in learning, despite the fact that vocational competencies require intensive and continuous practical experiences (Cholik et al., 2023).

One promising alternative for addressing these limitations is the use of virtual laboratories, which provide interactive digital environments that allow students to conduct simulations without the risks associated with real equipment. Systematic and bibliometric reviews have shown a rapid increase in the use of virtual laboratories, particularly after the pandemic, and have demonstrated their potential to support science and engineering learning objectives (Raman et al., 2022; Reeves & Crippen, 2021). Furthermore, a meta-analysis in engineering education reported that virtual laboratories positively influence learning outcomes, student engagement, and motivation (Li & Liang, 2024). However, previous studies have also noted that the effectiveness of virtual laboratories depends on the suitability of instructional design and contextual adaptation to specific learning competencies.

In vocational education, virtual laboratories and simulation technologies have been developed for various competencies, including electro-pneumatics (Sukardjo et al., 2023), CNC machining (Prasetya et al., 2023), direct-current electric motors (Badarudin et al., 2023), and virtual-reality-based vocational training (Long et al., 2025). These studies consistently reported improved engagement, technology acceptance, and learning effectiveness (Rafiq et al., 2022; Yanto et al., 2022, 2023). In the automotive field, simulation media for vehicle electrical systems have also demonstrated promising feasibility and learning benefits (Dede et al., 2020; Suyitno et al., 2020). Nevertheless, studies specifically focusing on motorcycle EFI practicum remain scarce, and little evidence is available regarding the development of simulation media tailored to EFI competencies in vocational high schools.

The development of interactive simulation media can be facilitated by Adobe Animate, which enables the integration of text, images, animations, and script-based interactivity within a single learning environment. Previous studies have demonstrated that Adobe Animate–based media possess high validity and practicality and contribute to improved learning outcomes (Aini & Mufit, 2022; Akmal et al., 2022; Pratama et al., 2023; Rosemarry & Isdaryanti, 2024). These capabilities are theoretically supported by the Cognitive Theory of Multimedia Learning, which argues that appropriately integrated verbal and visual information facilitates information processing in working memory (Mayer, 2024). In addition, active learning principles suggest that simulation environments allowing learners to observe, manipulate, and repeatedly perform procedures can promote meaningful learning experiences (Makransky et al., 2021; Parong & Mayer, 2021). Therefore, an Adobe Animate–based virtual laboratory may provide an appropriate pedagogical solution for supporting EFI practical learning in resource-constrained vocational settings.

Despite the growing body of research on virtual laboratories and Adobe Animate–based learning media, studies that specifically develop a virtual laboratory for motorcycle EFI practicum at the SMK level are still very limited. Existing studies have predominantly focused on science learning, general engineering contexts, or other automotive competencies, and only a few have examined the application of interactive simulation media to motorcycle EFI learning. Moreover, previous studies have rarely integrated product quality evaluation with an examination of students' motivational responses within the same development framework. Accordingly, this study aimed to develop an Adobe Animate–based virtual laboratory for motorcycle EFI practicum in Phase F of SMK and evaluate its validity, practicality, effectiveness in improving learning outcomes, and students' learning motivation.

Method

Research Type and Model

This study employed research and development using the four-D model proposed by Thiagarajan (1974), consisting of four stages: define, design, develop, and disseminate. Product quality was evaluated based on three quality criteria for educational products according to Nieveen (1999), namely validity, practicality, and effectiveness.

Development Procedure

The define stage was conducted through needs analysis, learner analysis, task analysis, and concept analysis, including interviews with teachers to identify the constraints of EFI practicum. The design stage produced flowcharts, storyboards, and the product interface. The develop stage included building the product with Adobe Animate, expert validation, revision, and a field trial. The disseminate stage was carried out on a limited scale by distributing the product to teachers and students at the trial school.

Subjects and Setting

The trial was conducted at SMK Negeri 6 Batam with Grade XI Light Vehicle Engineering students. The practicality and motivation assessments involved 34 students and two subject teachers, while the analysis of learning outcomes used data from 28 students who had complete pre-test and post-test scores.

Instruments and Data Collection

The research instruments comprised media-expert and instrument-expert validation sheets, teacher and student practicality questionnaires, learning-outcome tests (pre-test and post-test), and a learning-motivation questionnaire. The motivation indicators referred to the learning-motivation theories of Sardiman (2011) and Uno (2023), covering perseverance, resilience, interest, independence, confidence, desire to succeed, need-driven motivation, hopes and aspirations, appreciation, the attractiveness of activities, and a conducive learning environment. The validity and practicality questionnaires used a five-point scale, whereas the motivation questionnaire used a four-point Likert scale with reverse scoring for negative items.

Data Analysis

Validity and practicality data were analyzed using descriptive percentages with the criteria of 81–100% highly valid/highly practical, 61–80% valid/practical, and so on. Effectiveness on learning outcomes was analyzed using the normalized gain (N-gain) according to Hake (1998), with categories of high ($g \geq 0.70$), medium ($0.30 \leq g < 0.70$), and low ($g < 0.30$), as well as a paired-samples t-test after the normality assumption was met. The effect size was computed using Cohen's d. The use of N-gain as an indicator of improvement is supported by recent methodological studies (Coletta & Steinert, 2020; Evans & Yuan, 2022). Motivation data were analyzed using descriptive percentages with categories of very high, high, low, and very low.

Results and Discussion

The Developed Product

The product is a motorcycle EFI virtual laboratory developed with Adobe Animate and published in an application format. It consists of a cover page, a main menu, materials (components, working principles, and EFI system diagnosis), an interactive engine-operation simulation, reflection in the form of a pre-test and post-test, and a confirmation page. Inter-page interactivity is controlled by scripting so that students can explore the materials and run simulations independently.

Product Validity

The validation results placed the product in the highly valid category. Media-expert validation obtained 96.00% and instrument-expert validation 82.00%, with a combined average of 89.00%. The aspects of visual appearance, navigation, interactivity, technical quality, and instructional feasibility were all in the high category, as detailed in Table 1. During validation, suggestions for improvement were given, namely correcting navigation-button links and adding backgrounds and a narrator, which were then addressed in the revision stage.

Table 1. Product validation results

Assessment aspect	Score/Max	Percentage	Category
Visual appearance	24/25	96.0%	Highly valid
Navigation	23/25	92.0%	Highly valid
Interactivity	23/25	92.0%	Highly valid
Technical	25/25	100.0%	Highly valid
Instructional feasibility	25/25	100.0%	Highly valid
Media expert (total)	120/125	96.0%	Highly valid
Instrument expert (total)	82/100	82.0%	Highly valid
Combined average		89.0%	Highly valid

Product Practicality

The practicality assessment by two teachers obtained 95.00% and by 34 students 81.13%, with a combined average of 88.06%, which falls in the highly practical category. The usefulness aspect obtained the highest percentage in the students' assessment, whereas the appearance aspect was highest in the teachers' assessment. The detailed practicality results are presented in Table 2.

Table 2. Product practicality assessment results

Respondent / Aspect	Score/Max	Percentage	Category
Teachers (total, 2)	133/140	95.00%	Highly practical
Students — Appearance	662/850	77.9%	Practical
Students — Material	412/510	80.8%	Practical
Students — Usefulness	719/850	84.6%	Highly practical
Students (total, 34)	1793/2210	81.13%	Highly practical
Combined average	—	88.06%	Highly practical

Effectiveness on Learning Outcomes

The product's effectiveness is shown by the increase in the mean score from 61.89 (pre-test) to 89.29 (post-test) with an N-gain of 0.72 (high category), and by the increase in classical mastery from 21.4% to 92.9% (Table 3). The Kolmogorov–Smirnov normality test indicated that the data were normally distributed (pre-test sig. 0.832; post-test sig. 0.457), as was the gain data (sig. 0.213). The paired-samples t-test produced t = 8.840, greater than the t-table value of 2.052, with a significance of 0.000, so the improvement in learning outcomes was statistically significant; this result was reinforced by the Wilcoxon test (sig. 0.000) and a very large effect size (Cohen's d = 1.67). The assumption and supporting tests are summarized in Table 4.

Table 3. Learning-outcome statistics and improvement (n = 28)

Statistic	Pre-test	Post-test
Mean	61.89	89.29
Minimum score	25	70
Maximum score	100	100
Standard deviation	18.06	9.50
Classical mastery	21.4%	92.9%
N-gain	0.72 (high)	
Paired-samples t-test	t = 8.840; df = 27; sig. = 0.000	
Effect size	Cohen's d = 1.67	

Table 4. Normality assumption and supporting test results

Data / Test	Test type	Sig. (p)	Result
Pre-test	Kolmogorov–Smirnov	0.832	Normal
Post-test	Kolmogorov–Smirnov	0.457	Normal
Gain score	Shapiro–Wilk	0.213	Normal
Pre-test – Post-test	Wilcoxon	0.000	Significant

Students' Learning Motivation

Students' learning motivation after using the virtual laboratory was in the high category (79.11%), with all indicators in the high to very high category. The conducive-learning-environment indicator obtained the highest percentage (83.09%), followed by the attractiveness of activities (80.15%) and perseverance and resilience (81.25% each). The percentage of each motivation indicator is presented in Table 5.

Table 5. Students' learning-motivation percentage by indicator (n = 34)

No.	Motivation indicator	Percentage	Category
1	Perseverance in tasks	81.25%	Very high
2	Resilience to difficulties	81.25%	Very high
3	Showing interest	79.78%	High
4	Preference for independent work	72.06%	High
5	Ability to defend opinions	75.74%	High
6	Desire and will to succeed	80.88%	High
7	Drive and need in learning	77.57%	High
8	Hopes and future aspirations	79.41%	High
9	Appreciation in learning	79.04%	High
10	Engaging learning activities	80.15%	High
11	Conducive learning environment	83.09%	Very high
Average		79.11%	High

The development of the Adobe Animate–based virtual laboratory directly addressed the problems identified during the needs analysis, particularly the limited number and condition of EFI practical equipment and the risks associated with real practicum activities. The product was designed to provide interactive simulations of EFI components, system operation, and diagnostic procedures that could be accessed repeatedly and independently by students. The use of Adobe Animate to integrate text, images, animation, and script-based interactivity is consistent with previous studies reporting its capability to visualize abstract processes that are difficult to observe directly (Aini & Mufit, 2022; Akmal et al., 2022). Compared with conventional instructional media, the virtual laboratory provides opportunities for repetitive procedural practice without concerns regarding equipment damage or work accidents.

The product achieved a high validity score (89.00%), indicating that the visual design, navigation, interactivity, technical quality, and instructional feasibility were appropriately integrated. The highest scores were obtained in technical quality and instructional feasibility, demonstrating that the simulation environment and learning content were well aligned with the objectives of EFI practicum. This finding supports the Cognitive Theory of Multimedia Learning, which emphasizes that appropriately designed verbal and visual information can optimize information processing (Mayer, 2024). The results are also in line with previous studies that reported high validity of Adobe Animate–based media and vocational virtual laboratories (Pratama et al., 2023; Rosemarry & Isdaryanti, 2024; Badarudin et al., 2023; Sukardjo et al., 2023). Moreover, revisions to navigation links and the addition of backgrounds and narration demonstrate the importance of iterative improvement processes in educational product development (Nieveen, 1999).

The virtual laboratory was also perceived as highly practical, with a combined practicality score of 88.06%. Teachers provided a higher practicality assessment than students, indicating that educators particularly recognized the usefulness of the product in complementing limited teaching aids and facilitating practicum instruction. Meanwhile, students rated the usefulness aspect highest, suggesting that the product effectively supported independent learning and understanding of EFI procedures. These findings are consistent with previous studies showing that vocational students positively accept virtual laboratories and perceive them as engaging learning alternatives when practical facilities are limited (Rafiq et al., 2022; Yanto et al., 2023; Cholik et al., 2023). Nevertheless, the relatively lower score for the appearance aspect indicates that further improvements in visual design and user experience are still necessary.

The product effectively improved students' learning outcomes, as indicated by the increase in mean scores from 61.89 to 89.29, a high N-gain value of 0.72, and a very large effect size (Cohen's d = 1.67). These findings suggest that the virtual laboratory substantially contributed to students' conceptual understanding and procedural knowledge of motorcycle EFI systems. This result is consistent with meta-analytic evidence demonstrating the effectiveness of virtual laboratories in engineering education and with studies reporting learning improvements through animation-based instructional media (Li & Liang, 2024; Bulkani et al., 2022; Pratama et al., 2023). From a theoretical perspective, the simulation environment allowed students to repeatedly observe and practice EFI procedures actively, which aligns with active learning principles in immersive environments (Makransky et al., 2021; Parong & Mayer, 2021). However, because the study employed a single-group design without a control group, the improvement in learning outcomes should be interpreted cautiously.

Students' learning motivation reached a high category (79.11%), particularly on indicators related to a conducive learning environment, engaging activities, perseverance, and resilience. These findings may be interpreted through the ARCS motivational model, in which attractive simulations potentially stimulate attention, contextual EFI content strengthens relevance, opportunities for independent practice build confidence, and feedback promotes satisfaction (Keller, 2010). Previous meta-analyses and vocational studies similarly reported positive associations between ARCS-based instructional designs and students' motivation and achievement (Goksu & Islam Bolat, 2021; Jatmoko et al., 2021; Hung et al., 2023; Qawaqneh et al., 2023). Nevertheless, the present study measured motivation only after product implementation; therefore, the findings reflect the level of motivation attained rather than empirical evidence of motivational improvement attributable to the intervention.

Conclusions

This study produced an Adobe Animate–based virtual laboratory for motorcycle EFI practicum in Phase F of SMK that was declared highly valid (89.00%) and highly practical (88.06%). The product effectively improved learning outcomes with an N-gain of 0.72 (high category), an increase in classical mastery from 21.4% to 92.9%, and a statistically significant improvement (t = 8.840; sig. 0.000), while fostering students' learning motivation in the high category (79.11%). Therefore, this virtual laboratory is feasible and effective as an alternative or complementary medium for EFI practicum, particularly when the availability of practical tools is limited. Further research is recommended to test the product's effectiveness using an experimental design with a control group and before–after motivation measurement on a larger sample.

References

Aini, S., & Mufit, F. (2022). Using Adobe Animate CC Software in Designing Interactive Multimedia Based on Cognitive Conflict in Straight Motion. Jurnal Penelitian Pendidikan IPA, 8(5), 2350–2361. https://doi.org/10.29303/jppipa.v8i5.2048

Akmal, N., Putri, Y. E., & Anugerah, A. I. (2022). Developing adobe animate-based interactive learning media of table manner for university students. International Journal for Educational and Vocational Studies, 4(3). https://doi.org/10.29103/ijevs.v4i3.9336

Badarudin, R., Hariyanto, D., Supriyadi, E., Djatmiko, I. W., Triyono, M. B., Kassymova, G. K., & Urazaliyeva, U. (2023). Virtual Laboratory Application of Direct Current Electric Motor: An Expert-Based Evaluation. International Journal of Online and Biomedical Engineering (iJOE), 19(04), 4–21. https://doi.org/10.3991/ijoe.v19i04.36749

Bulkani, B., Fatchurahman, M., Adella, H., & Setiawan, M. A. (2022). Development of Animation Learning Media Based on Local Wisdom to Improve Student Learning Outcomes in Elementary Schools. International Journal of Instruction, 15(1), 55–72. https://doi.org/10.29333/iji.2022.1514a

Cholik, M., Umaroh, S. T., Rijanto, T., & Soeryanto, S. (2023). Youtube as an alternative to learning media: A case study. Jurnal Pendidikan Teknologi Dan Kejuruan, 29(1), 86–97. https://doi.org/10.21831/jptk.v29i1.49115

Coletta, V. P., & Steinert, J. J. (2020). Why normalized gain should continue to be used in analyzing preinstruction and postinstruction scores on concept inventories. Physical Review Physics Education Research, 16(1), 010108. https://doi.org/10.1103/PhysRevPhysEducRes.16.010108

Dede, Abdullah, A. G., Mulyanti, B., Rohendi, D., & Sulaeman. (2020). TVET Learning Innovation on Automotive Virtual Laboratory Based on Cloud Openstack. Journal of Technical Education and Training, 12(3), 51–60. https://publisher.uthm.edu.my/ojs/index.php/JTET/article/view/5541

Evans, D. K., & Yuan, F. (2022). How Big Are Effect Sizes in International Education Studies? Educational Evaluation and Policy Analysis, 44(3), 532–540. https://doi.org/10.3102/01623737221079646

Fatah, A. (2022). Kesiapan SMK Negeri dalam Implementasi Kurikulum Merdeka. Jurnal Pendidikan Vokasi Otomotif, 5(1), 95–109. https://doi.org/10.21831/jpvo.v5i1.55862

Goksu, I., & Islam Bolat, Y. (2021). Does the ARCS motivational model affect students' achievement and motivation? A meta-analysis. Review of Education, 9(1), 27–52. https://doi.org/10.1002/rev3.3231

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. American Journal of Physics, 66(1), 64–74. https://doi.org/10.1119/1.18809

Hung, C.-Y., Lin, Y.-T., Yu, S.-J., & Sun, J. C.-Y. (2023). Effects of AR- and VR-based wearables in teaching English: The application of an ARCS model-based learning design to improve elementary school students' learning motivation and performance. Journal of Computer Assisted Learning, 39(5), 1510–1527. https://doi.org/10.1111/jcal.12814

Jatmoko, D., Susanto, A., Purwoko, R. Y., Arifin, Z., & Purnawan, P. (2021). The Implementation of ARCS Learning Model to Improve Students Learning Activities and Outcomes in Vocational High School. Tarbawi : Jurnal Ilmu Pendidikan, 17(2), 137–144. https://doi.org/10.32939/tarbawi.v17i2.1008

Keller, J. M. (2010). Motivational Design for Learning and Performance: The ARCS Model Approach. Springer US. https://doi.org/10.1007/978-1-4419-1250-3

Li, J., & Liang, W. (2024). Effectiveness of virtual laboratory in engineering education: A meta-analysis. PLOS ONE, 19(12), e0316269. https://doi.org/10.1371/journal.pone.0316269

Long, Y., Zhang, X., & Zeng, X. (2025). Application and effect analysis of virtual reality technology in vocational education practical training. Education and Information Technologies, 30(7), 9755–9786. https://doi.org/10.1007/s10639-024-13197-7

Makransky, G., Andreasen, N. K., Baceviciute, S., & Mayer, R. E. (2021). Immersive virtual reality increases liking but not learning with a science simulation and generative learning strategies promote learning in immersive virtual reality. Journal of Educational Psychology, 113(4), 719–735. https://doi.org/10.1037/edu0000473

Mayer, R. E. (2024). The Past, Present, and Future of the Cognitive Theory of Multimedia Learning. Educational Psychology Review, 36(1), 8. https://doi.org/10.1007/s10648-023-09842-1

Nieveen, N. (1999). Prototyping to Reach Product Quality. In J. van den Akker, R. M. Branch, K. Gustafson, N. Nieveen, & T. Plomp (Eds), Design Approaches and Tools in Education and Training (pp. 125–135). Springer Netherlands. https://doi.org/10.1007/978-94-011-4255-7_10

Parong, J., & Mayer, R. E. (2021). Cognitive and affective processes for learning science in immersive virtual reality. Journal of Computer Assisted Learning, 37(1), 226–241. https://doi.org/10.1111/jcal.12482

Prasetya, F., Syahri, B., Fajri, B. R., Wulansari, R. E., & Fortuna, A. (2023). Utilizing Virtual Laboratory to Improve CNC Distance Learning of Vocational Students at Higher Education. TEM Journal, 1506–1518. https://doi.org/10.18421/TEM123-31

Pratama, I. A., Subiki, S., & Harijanto, A. (2023). Pengembangan Media Pembelajaran Interaktif Fisika SMA Berbasis Adobe Animate CC Pada Materi Hukum Gravitasi Newton. Jurnal Pendidikan Fisika, 11(1), 17–27. https://doi.org/10.24127/jpf.v11i1.5818

Putra, A. E. T., & Solikin, M. (2022). Implementasi Program Tsm Honda Pada Kompetensi Keahlian Teknik Bisnis Sepeda Motor SMK PGRI 1 Nganjuk. Jurnal Pendidikan Vokasi Otomotif, 5(1), 43–54. https://doi.org/10.21831/jpvo.v5i1.51849

Qawaqneh, H., Ahmad, F. B., & Alawamreh, A. R. (2023). The Impact of Artificial Intelligence-Based Virtual

Laboratories on Developing Students' Motivation Towards Learning Mathematics. International Journal of Emerging Technologies in Learning (iJET), 18(14), 105–121. https://doi.org/10.3991/ijet.v18i14.39873

Rafiq, A. A., Triyono, M. B., & Djatmiko, I. W. (2022). Enhancing student engagement in vocational education by using virtual reality. Waikato Journal of Education, 27(3), 175–188. https://doi.org/10.15663/wje.v27i3.964

Raman, R., Achuthan, K., Nair, V. K., & Nedungadi, P. (2022). Virtual Laboratories- A historical review and bibliometric analysis of the past three decades. Education and Information Technologies, 27(8), 11055–11087. https://doi.org/10.1007/s10639-022-11058-9

Reeves, S. M., & Crippen, K. J. (2021). Virtual Laboratories in Undergraduate Science and Engineering Courses: A Systematic Review, 2009–2019. Journal of Science Education and Technology, 30(1), 16–30. https://doi.org/10.1007/s10956-020-09866-0

Rosemarry, L. A., & Isdaryanti, B. (2024). Adobe Animate-based Learning Media for IPAS Class V Elementary School Tlogosari Kulon 05 Effective and Improve Learning Outcomes. Jurnal Penelitian Pendidikan IPA, 10(8), 5953–5960. https://doi.org/10.29303/jppipa.v10i8.8268

Sardiman, A. M. (2011). Interaksi dan motivasi belajar mengajar.

Sriyanto, J., Budiman, A., Suyanto, W., Sulistyo, B., Priti, P., Pangestu, S., Utama, O. S. T., Pawoko, L. T., & Pratama, F. D. (2023). Problematika Guru Teknik Kendaraan Ringan Otomotif (TKRO) di SMK Pelaksana Implementasi Kurikulum Merdeka Kategori Mandiri Berubah. Jurnal Pendidikan Vokasi Otomotif, 6(1), 99–108. https://doi.org/10.21831/jpvo.v6i1.67853

Sukardjo, M., Khasanah, U., Rahmat, S. T., Khaerudin, & Setiawan, B. (2023). Virtual Laboratory Design for Learning Electro-Pneumatic Practices in Vocational High Schools. European Journal of Educational Research, 12(2), 719–737. https://doi.org/10.12973/eu-jer.12.2.719

Suyitno, S., Purwoko, R. Y., Widiyono, Y., Jatmoko, D., Nurtanto, M., & Hassan, Z. (2020). Development of Learning Media for Automotive Charging System Based on Macromedia Flash Vocational School. Universal Journal of Educational Research, 8(11C), 64–71. https://doi.org/10.13189/ujer.2020.082308

Thiagarajan, S. (1974). Instructional development for training teachers of exceptional children: A sourcebook. http://files.eric.ed.gov/fulltext/ED090725.pdf

Uno, H. B. (2023). Teori motivasi dan pengukurannya: Analisis di bidang pendidikan. Bumi Aksara. https://books.google.co.id/books?hl=id&lr=&id=lOqoEAAAQBAJ&oi=fnd&pg=PP1&dq=Uno,+H.+B.+(2017).+Teori+motivasi+dan+pengukurannya:+Analisis+di+bidang+pendidikan.+Bumi+Aksara.&ots=JQmYhcjcDP&sig=8pTvifOLRLFlw98aBePPQdUR6iI&redir_esc=y#v=onepage&q&f=false

Yanto, D. T. P., Kabatiah, M., Zaswita, H., Jalinus, N., & Refdinal, R. (2022). Virtual Laboratory as A New Educational Trend Post Covid-19: An Effectiveness Study. Mimbar Ilmu, 27(3), 501–510. https://doi.org/10.23887/mi.v27i3.53996

Yanto, D. T. P., Sukardi, Kabatiah, M., Zaswita, H., & Candra, O. (2023). Analysis of Factors Affecting Vocational Students' Intentions to Use a Virtual Laboratory Based on the Technology Acceptance Model. International Journal of Interactive Mobile Technologies (iJIM), 17(12), 94–111. https://doi.org/10.3991/ijim.v17i12.38627