Development of Cooperative Learning by Technoprenuer for Vocational Schools-Augmented Reality Model to Improve the Survival Skills

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***Abstract*—This study examines the effectiveness of the Cooperative Learning for Vocational Schools assisted by Augmented Reality (CLTSMK-AR) model in enhancing survival skills among vocational high school students. Vocational school graduates are expected to be prepared for employment, higher education, and entrepreneurship, supported by initiatives from the government, industry, and educational institutions. However, existing student skillsets often fall short in meeting industrial demands. To address this gap, this research developed a technology-driven learning model to enhance students' competencies. In collaboration with State Vocational High School 2 Depok and Toyota, the CLTSMK-AR model was implemented in classroom settings. The research followed the ADDIE framework, encompassing analysis, design, development, implementation, and evaluation. The results indicate that the CLTSMK-AR model significantly improves students' survival skills, including learning motivation, creative thinking, communication, adaptability, and managerial abilities. The implementation utilized an automotive electrical application supported by augmented reality technology. These findings highlight the potential of the CLTSMK-AR model to equip vocational school students with essential skills for future challenges.**

***Keywords*—learning model, augmented reality, light vehicles, automotive electrical, maintenance work**

I. Introduction

Critical thinking-based instruction is widely recognized as a crucial component of education across various levels of learning. The ability to think critically equips students with essential skills to navigate challenges in their personal lives, careers, and societal responsibilities [1–3]. Developing students' cognitive capacities through structured and intentional mental processes is a key approach to fostering critical thinking [4, 5].

In the context of vocational high schools (SMK), the freedom to learn is influenced by several factors, including curriculum design, learning processes, school environments, and student characteristics [6–9]. Collaboration between systemic and developmental aspects of independent learning models such as curriculum innovation, teaching methodologies, and student-centered approaches can significantly enhance students' survival skills, preparing them to face global challenges [10–14].

Despite these advancements, vocational school graduates often encounter difficulties in adapting to industry demands, resulting in high unemployment rates. Research suggests that fostering an entrepreneurial mindset among students can address this issue by equipping them not only to become skilled workers but also to create new employment opportunities [15, 16]. Entrepreneurial culture has been shown to positively impact the performance of both entrepreneurs and employees [17]. Abiddin [18] highlights that instilling entrepreneurial values through practical activities is an effective way for educators to nurture these competencies. Therefore, an engaging and interactive learning environment is critical to enhancing the quality of vocational education.

Building on these insights, this research explores the Cooperative Learning for Vocational Schools assisted by Augmented Reality (CLTSMK-AR) as an innovative approach to improve students' survival skills. The novelty of this study lies in integrating cooperative learning with technopreneurship and Augmented Reality (AR) technology. Within the vocational education context, technopreneurship emphasizes the cultivation of creativity, problem-solving, and technological skills that enable students to become innovators and job creators. This model emphasizes the application of cutting-edge technology to enable students to create products aligned with their competencies, thereby fostering technopreneurial skills. This study aims to:

1) Identify the stages of development of the CLTSMK-AR model.
2) Assess the feasibility of the model based on expert evaluations.
3) Evaluate the effectiveness of the model in improving students' survival skills, focusing on learning attitudes such as motivation, creative thinking, communication, adaptability, and managerial abilities.

By addressing these objectives, the study contributes to the body of knowledge on vocational education and proposes a scalable solution to enhance the readiness and competitiveness of vocational school graduates in the global workforce.

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II. LITERATURE REVIEW

The learning process plays a pivotal role in determining educational outcomes. It operationalizes an institution's curriculum and aims to achieve predefined learning objectives [19–21]. Key factors influencing the learning process include teacher competence, infrastructure, school policies, administration, and curriculum. Among these, teacher competence significantly impacts classroom practices, the choice of learning models, and the achievement of graduate competencies [22, 23].

One promising learning model for optimizing survival skills and fostering an entrepreneurial culture is the Cooperative Learning for Vocational Schools assisted by Augmented Reality (CLTSMK-AR) model [24, 25]. Rooted in project-based cooperative learning, CLTSMK integrates technology to cater to the unique needs of vocational high school students. It is designed to create an enjoyable learning environment (learning as an enjoyable activity), which enhances motivation, and emphasizes real-world skill application (learning in real-life settings) [26, 27]. Research indicates that the CLTSMK model effectively improves survival skills, particularly in areas such as learning motivation, creative thinking, and student management, by focusing on three core competencies: human skills, conceptual skills, and technical skills [28].

The integration of Augmented Reality (AR) into the CLTSMK model further enhances its educational potential. AR technology seamlessly overlays the virtual world onto the real world, offering innovative learning tools that make complex concepts more accessible. AR's applications in education have been extensively documented, showing that:

1) AR-based learning media enhance students' understanding of course materials [29–31].
2) AR involvement in learning can increase students' learning motivation [32–34].
3) AR can increase student attention during learning activities [35].
4) AR technology can provide a different learning experience for students, can have a unique learning experience, making their coursework more engaging and appealing [36].
5) AR has a lot to offer the actual learning process [37] they can improve their competence.

The practicality of AR is bolstered by advancements in hardware and software technologies. Modern smartphones, equipped with cameras and AR-enabled platforms (e.g., Android, iOS), make AR integration cost-effective and accessible [32, 35, 38]. This practicality underscores the viability of AR as a tool for transforming vocational education.

This study focuses on the application of the CLTSMK-AR model in improving survival skills such as learning motivation, creative thinking, adaptability, communication, and managerial skills among vocational high school students. Specifically, it targets the Light Vehicle Engineering Department at State Vocational High School 2 Depok, integrating AR-assisted automotive electrical applications. By contextualizing the potential of the CLTSMK-AR model, this research aims to provide a robust theoretical framework and empirical evidence to support its transformative role in enhancing students' survival skills.

III. MATERIALS AND METHODS

Research and Development (R&D) is an approach that seeks to create a specific product through a research-driven needs analysis and subsequently evaluate its effectiveness to ensure its viability within the broader community. This study employed a modified version of the ADDIE (Analysis, Design, Development, Implementation, Evaluation). Fig. 1 presents the ADDIE development model.

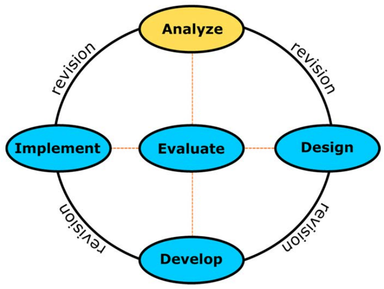

Fig. 1. ADDIE development model.

The outcome of this research includes an Augmented Reality application (accessible via mobile phones and laptops through a web-based platform), a user manual, a teaching material handbook, and a control card, all designed to meet the specific requirements of the learning process. Fig. 2 presents the approach of this research phase.

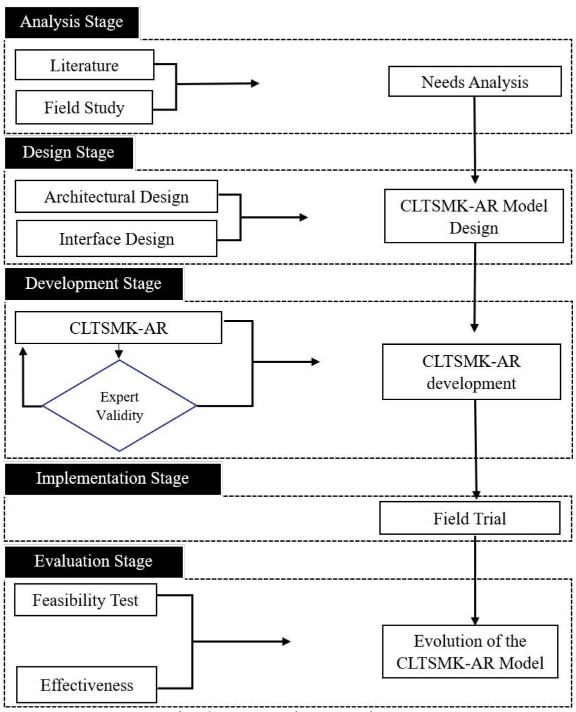

Fig. 2. Research stage chart.

Table 1. Assessment criteria

Score	Category
76–100	Very Appropriate
51–75	Appropriate
26–50	Quite Appropriate
0–25	Not Appropriate

The quantitative data regarding the appropriateness of the tutorial video were analyzed based on the total score converted from the Likert Scale. The data included four response options: "Very Appropriate," "Appropriate," "Quite Appropriate," and "Inappropriate." The conversion of these four response scales utilized assessment criteria outlined by Djatmiko [16], as detailed in Table 1 presents the assessment criteria used in the study.

This development research employed a purposive sampling technique [37], characterized by the deliberate selection of participants who align with the research objectives and possess specific attributes. The selection criteria were based on components of survival skills, including learning motivation, creative thinking, communication skills, adaptability, and managerial abilities. Consequently, data collection was conducted in a contextual, transparent, and systematic manner. The study focused on 78 students enrolled in the Light Vehicle Engineering program at State Vocational High School 2 Depok, Indonesia.

A. *Research Instruments*

1) *CLTSMK-AR validity instrument*

This study used a questionnaire as a validity instrument to assess the validity level of the augmented reality application developed. The media validation instrument grids for AR application media experts, CLTSMK-AR model instructional experts, and CLTSMK-AR model material experts, are presented in Tables 2, 3 and 4 below.

Table 2. Grid of validation instruments for AR application media experts

Aspect	No	Variable
Display/Visual	1	The fonts used are appropriate
	2	The font size used is appropriate
	3	Blend of text color with app background color
	4	The color composition of the working image with the background color is correct
	5	The layout of the image/object is correct
Instructional	6	The learning materials in the Augmented Reality Application are suitable for learning automotive electricity.
	7	This application is suitable for learning
	8	Interactivity between Augmented Reality Application and users is good
	9	Augmented Reality applications can increase student learning motivation in automotive electrical learning
Navigation	10	Button very easy to use in running this Augmented Reality Application
	11	Image target to be scanned on the AR Menu for easy access
	12	3D objects in AR Applications are easy to appear
	13	Flipbook material button on AR menu is easy to access
Audio	14	The use of sound in this Augmented Reality Application is well-timed
	15	The sound used in this AR Application is clear.

Table 3. Grid of validation instruments for models CLTSMK-AR instructional experts

Aspect	No	Variable
Content Eligibility	1	The learning phases in the CLTSMK-AR model are clearly described.
	2	Each learning step is easy to understand and follow.
	3	The sequence of learning steps is in accordance with the objectives to be achieved.
	4	Each phase of learning can be implemented well
Social System	5	Teacher tasks in the CLTSMK-AR learning model are explained in detail
	6	The teacher's responsibilities in each phase of learning are clearly outlined.
	7	Student activities in the learning process are specifically described
	8	There are sufficient opportunities for students to interact with teachers.
Reaction Principle	9	The learning model provides clear guidance on how teachers can respond to student criticism.
	10	There are clear instructions on how teachers should provide feedback
	11	The feedback provided supports an effective learning process.
	12	Learning models provide strategies to motivate students
Instructional Impact	13	The learning model is designed to achieve predetermined learning objectives
	14	There is alignment between learning activities and the goals to be achieved
	15	Learning models support improving students' conceptual understanding
	16	Learning activities facilitate the construction of knowledge by students.
Accompanying Impacts	17	Learning models encourage students' learning motivation towards the learning process
	18	Learning activities help foster student interest in the material being studied.
	19	Learning models stimulate the development of students' creative thinking abilities
	20	There are activities that encourage students to adapt to technology and communication skills between friends.

Table 4. Grid of validation instruments for models CLTSMK-AR material experts

Aspect	No	Indicator
Content	1	Learning objectives are formulated clearly and measurably
	2	The information presented is accurate and reliable
	3	Sources of information are clearly stated and can be verified.
	4	The material presented is in accordance with the latest scientific developments.
Presentation	5	The material is presented systematically and logically
	6	The order of presentation of the material makes it easier
	7	Instructions for using the manual are clearly stated.
	8	The instructions for each section are easy to understand
Language	9	Suitability of explanations and questions in the application with learning materials
Graphics	10	The layout of the guidebook is attractive and functional

2) *Practicality instrument*

Table 5. A useful tool for teacher

Aspect	No	Variable
Ease of use of AR application	1	The produced media is straightforward and user-friendly.
	2	The material employed is simple to comprehend.
	3	The ability to use AR applications anywhere and at any time is flexible.
	4, 5	The information provided is simple to comprehend.
Risk Free	6	AR software reduces study time
	7	Pupils can comprehend learning topics more easily.
	8, 9	AR applications are useful.
Usefulness of AR aplication	10	can help deliver the content efficiently. AR applications are flexible learning tools.
	11, 12	The AR application can be modified to work with different course materials.
	13	The produced media is straightforward and user-friendly.

Practicality assesses the ease of use and implementation of learning facilitated by the developed augmented reality application, focusing on three key categories: ease of use, time efficiency, and usability of the application. Practicality data were collected through a questionnaire designed to capture feedback, suggestions, and input from teachers and students in the Light Vehicle Engineering program who utilized the application. The practicality questionnaire instruments for teachers and students are detailed in Table 5 and Table 6.

Table 6. A useful tool for students

Aspect	No	Indicator
Ease of use of AR application	1	To what extent was the login page straightforward for you to locate and access?
	2	How does the app's User Interface (UI)design facilitate your use of it?
	3	Are the usage instructions simple to follow?
	4	Is it possible to use the developed application anywhere?
Risk Free	5, 6	Is it possible to use the developed application anywhere?
	7	AR apps assist you in saving time when learning the subject?
	8	Whether grades for students can be found out directly.
Usefulness of AR application	9, 10	Considering ideas when creating graphics?
	11	Does the AR app offer variation in the study of graphic design?
	12	AR apps impart abilities in computational thinking?

B. Data Analysis Technique

1) Validity analysis technique

This coefficient is based on the assessment of an item's representation of the measured construct by a panel of n experts. The steps listed below are used to get the average score:

1) A value between 1 (not very representative or relevant) and 5 (extremely representative or highly relevant) should be used to score the responses.
2) Total the scores for all indications from each validator.
3) The formula for Aiken's V statistic is:

$$V = \sum S/[n(c-1)]$$

Information:

V = validity index; $s = r - lo$; lo = lowest validity assessment number; c = highest validity assessment; r = the number given the validator; n = validator's number

The following tools were used to gather primary data for this study on learning media development:

1) Validation tools for media specialists evaluating view, usage, and media usefulness.
2) Validation tools for material specialists evaluating content, learning, and evaluation.
3) Validation achievement levels ranging from 0.6 to 1.0 (ranging from 0.6 to 1.0) were classified as valid, whereas levels below 0.6 (<0.6) were considered invalid. Table 7. presents the categories of validity values of AR applications.

C. Practical Analysis Methodology

The subjects of this study were students and teachers of automotive electrical subjects majoring in light vehicle engineering who participated in the practical analysis. To measure the effectiveness of the AR application media, a questionnaire was completed, and practicality was assessed using a Likert scale with five possible responses. answers namely very practical (5), practical (4), quite practical (3), less practical (2), and not practical (1). The practical value is determined by adding up the answers and calculating the percentage using the formula:

$$Practicality = \frac{\sum Score\ obtained}{\sum Maximum\ Score} \times 100\%$$

Table 8 presents the practicality category of the AR application

Table 7. AR application validity value category table

Average value score	Results
$0.6<n<1.0$	Valid
$n<0.6$	Invalid

Table 8. AR application practicality category

Achievement Level (%)	Category
0–20	Not practical
21–40	Less practical
41–60	Moderately practical
61–80	Practical
81–100	Very practical

IV. Result and Discussion

A. Development

According to Bacca Acosta., *et al.* [26], students' survival skills are manifested through learning motivation and creativity. These skills refer to students' abilities in the workplace, which are demonstrated through their motivation to learn, creative thinking, and managerial skills. This is achieved by identifying the survival skills necessary for success in the professional world. The development of survival skills in vocational high school students focuses on aspects that influence their learning attitudes, enabling them to either work in the industrial sector or establish their own businesses. Some definitions of survival skills outlined by Pratama and Triyono's views [15], including: curiosity and imagination as components of learning motivation; initiative, critical thinking, and problem-solving as elements of creative thinking; network collaboration, oral communication, and information analysis as components of student management. According to Gouveia *et al.* [38], survival skills encompass the ability to analyze situations, build relationships, solve problems, and communicate effectively.

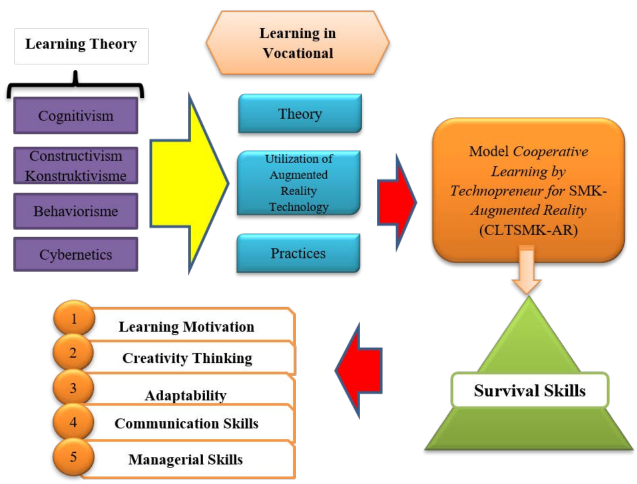

Fig. 3. CLTSMK-AR conceptual model.

Additionally, Arnab [39] describes survival skills as including communication abilities, motivation, and creative thinking. Meanwhile, Samala *et al*. [40] define survival skills as comprising self-intelligence, learning motivation, basic skills, and adaptability. Therefore, the survival skills developed in students encompass five key aspects: learning motivation, creativity, adaptability, communication skills, and managerial skills. Fig. 3 presents the CLTSMK-AR conceptual model.

The CLTSMK-AR model consists of four phases, namely: Phase 1: Delivering objectives and motivating students; Phase 2: Presenting information, observing, and asking; Phase 3: Providing opportunities to collect information, engage in discussions, demonstrate, and present findings; and Phase 4: Reinforcing the material and concluding the learning process. Each phase is designed to enhance students' survival skills in specific aspects. A detailed explanation of each phase is provided below:

1) Phase I: Orientation

In the orientation phase, students are introduced to the automotive electrical system that will be covered in the learning topic. The phase begins with the presentation of the learning objectives and the potential benefits of future learning. Students are also briefed on the learning materials, the CLTSMK-AR learning model, and the augmented reality media to be used. Additionally, students are tasked with designing products related to automotive electrical systems and are divided into six groups with equal responsibilities. The objective of this orientation phase is to enhance students' learning motivation, contributing to the development of their survival skills.

2) Phase II: Modeling

The modeling phase involves students actively studying information about automotive electrical systems with the aid of augmented reality. Students explore augmented reality applications that showcase electrical system components and their functions, fostering improvement in their creative thinking skills. In the subsequent stage, students are tasked with creating products using augmented reality, further enhancing their creativity. The collaborative nature of this phase, as students work in groups, also contributes to the development of their adaptability and managerial skills.

3) Phase III: Model application

In the application phase, students are guided in creating products using augmented reality. The formulation of product designs helps enhance students' creative thinking. Following this, students collect and analyze data related to the product design, applying the augmented reality model to produce their creations. The primary goal of this phase is to deepen students' understanding of the inspection and maintenance processes for automotive electrical systems through hands-on experience. Collaboration, communication, and group management are integral aspects of this phase, all of which contribute to the development of students' survival skills in creative thinking, communication, and managerial capabilities.

4) Phase IV: Reflection

The final phase, reflection, involves students presenting their group's modeling and application results in a class forum. During this phase, students are encouraged to share their reflections on the activities carried out, highlighting the benefits and drawbacks of the augmented reality model. The phase concludes with reinforcement from the teacher, summarizing key takeaways and providing feedback to students. This reflective phase enhances students' survival skills in terms of motivation, communication, and management.

The Augmented Reality application, designed for automotive electrical system learning, provides a platform for students to conduct experiments, develop electrical system models, and engage in modeling application projects, either individually or collaboratively. The application integrates essential learning materials, including student worksheets, supporting media, learning modules, and evaluation instruments. Fig. 4 presents KLIK.AR, the Augmented Reality application for automotive electrical learning.

Fig. 4. KLIK.AR application. (automotive electricity augmented reality).

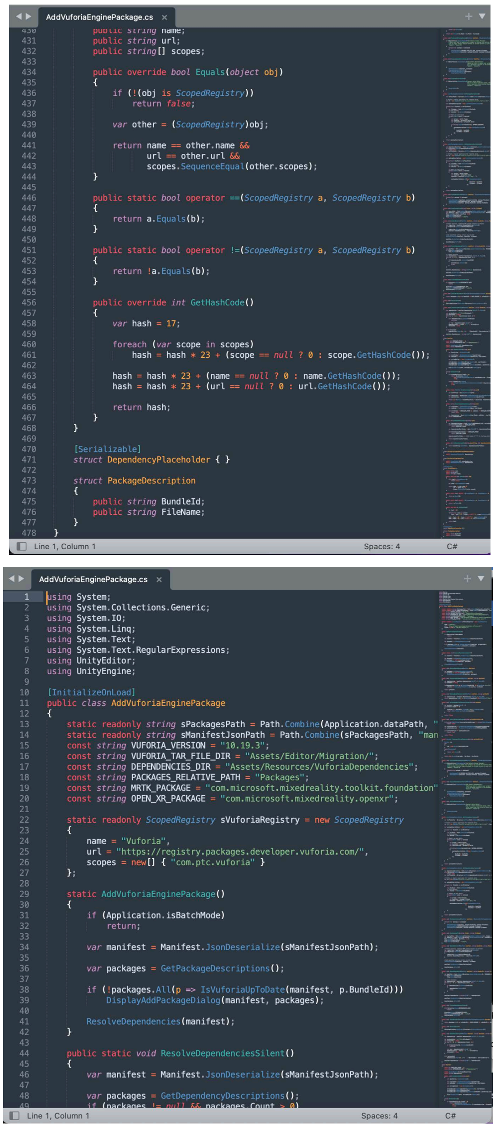

Fig. 5. Unity studio application coding view.

The Augmented Reality application, KLIK.AR, is designed to enhance the learning of automotive electrical systems by utilizing augmented reality technology. This application enables users to visualize automotive components and electrical system circuits in a 3D environment, providing an interactive and immersive learning experience. Fig. 5 illustrates the coding interface within the Unity Studio application.

The application features a user-friendly interface with the following menu options: AR Menu, Automotive Electricity Questions, Application Usage Guide, and Exit Menu. Fig. 6 illustrates the augmented reality light circuit.

Fig. 6. Augmented reality light circuit.

When the 3D model is displayed, the “Flipbook Material” and "YouTube Video" buttons become accessible. Selecting the "Flipbook Material" button opens an interactive flipbook, offering students supplementary resources for independent learning. Fig. 7 illustrates the Flipbook interface as a source of self-directed learning materials for students.

Fig. 7. Flipbook display as a source of independent learning material for students.

In addition to accessing flipbook materials, students can enhance their independent learning through the YouTube video feature. By selecting the video button, the application automatically redirects users to the corresponding instructional video on YouTube, offering supplementary learning resources. Fig. 8 illustrates the display of video material on the YouTube platform.

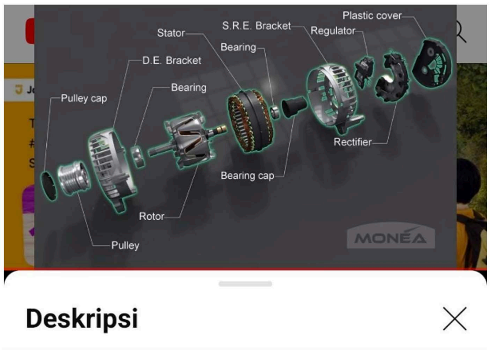

Fig. 8. Display of video material on the YouTube website.

Upon completing the AR ZONE menu process, users can click the “Back” button located at the top-right corner of the screen to return to the main menu interface.

B. Research Results

1) Validity analysis results

The validity of the AR application was thoroughly evaluated through a systematic validation process involving four material experts and three media experts. For the media validation, aspects such as appearance, usability, and functionality were assessed, while material validation focused on aspects such as design, content, educational value, and assessment. A descriptive statistical analysis approach was employed to analyse the research data, with the pilot test results of the questionnaire being processed using descriptive statistics. Consequently, the validity coefficients obtained from expert evaluations confirm the tool’s validity for this study.

Furthermore, the researchers administered questionnaires to two additional validators to verify the content and structure of the developed learning module. Both the material and media aspects of the AR application for automotive electrical subjects were evaluated. The assessment results from each validator were analysed using Aiken’s V statistical formula. The findings of the validation of the AR application for automotive electrical subjects are illustrated in Figs. 9–10 below.

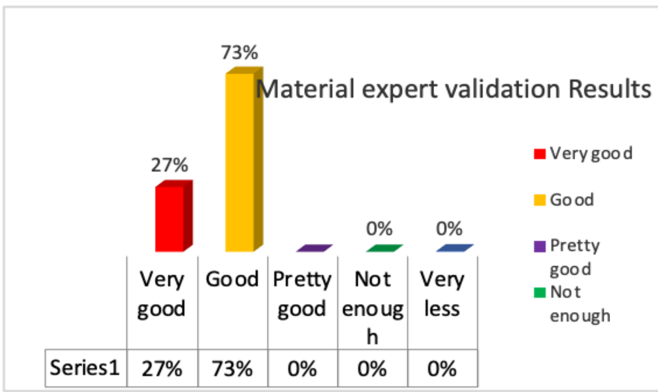

Fig. 9. Material expert validation results.

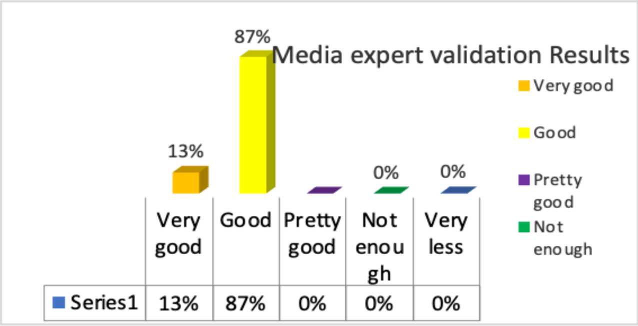

Fig. 10. Material expert validation results.

The validity analysis of the AR application developed for electrical automotive learning in the Light Vehicle Engineering program at State Vocational High School 2 Depok, Indonesia, has been conducted. The results of the validation, based on assessments from media and material experts, are summarized in Table 9.

Table 9. Analysis results of media experts and material experts

Validator	Aiken's coefficient	Classification
Media validation results	0.80	Valid
Material validation results	0.83	Valid

The AR application is categorized as "valid" based on the validity test results, with an average score of 0.80 from media experts, which exceeds the threshold of 0.667. Additionally, the content within the AR application for graphic design lessons is deemed "valid," as evidenced by an average validation score of 0.83 from material experts, surpassing the same threshold.

2) Practicality analysis results

The practicality analysis was conducted based on feedback from teachers, focusing on their evaluation of the usability and practicality of the AR application. The primary objective of this analysis was to assess the ease of use and effectiveness of the AR application as perceived by teachers of automotive electrical subjects. The results of the practicality assessment, which involved teachers specializing in automotive electrical courses, are summarized in Table 10.

Table 10. Practicality analysis results of teacher response

Aspect	Average	Category
Ease of use of AR application	86%	Very Practical
Time efficiency	88%	Very Practical
Usefulness of AR application	92%	Very Practical
Average	88.7 %	Very Practical

As presented in Table 10, the teachers' feedback indicated an average score of 88.7%, categorizing the AR application's practicality as "Very Practical." This evaluation, derived from the learning media practicality test, highlights the utility of the AR application in supporting instructors to effectively teach electrical and automotive systems.

Furthermore, a practicality analysis was conducted based on feedback from students to assess the perceived usefulness and functionality of the AR application. This analysis primarily relied on student responses, providing valuable insights into the application's practicality from the learners' perspective. The results of the student practicality assessment, as outlined in Table 11, demonstrate the effectiveness of the augmented reality application in enhancing the learning experience in the context of vocational education.

Table 11. Practicality analysis results of student response

Aspect	Average	Category
Ease of use of AR application	84%	Very Practical
Time efficiency	86%	Very Practical
Usefulness of AR application	90%	Very Practical
Average	86,7%	Very Practical

Table 11 illustrates that the AR application received an average practicality score of 86.7% based on student responses. This analysis categorizes the application as "Very Practical," highlighting its usability and relevance in supporting students' learning processes. The findings underscore the effectiveness of the AR application in facilitating the learning of automotive electrical systems among Light Vehicle Engineering students at State Vocational High School 2 Depok, Indonesia. Additionally, the implementation of the CLTSMK model assisted by augmented reality achieved an effectiveness score of 86.7%, categorizing it as effective in enhancing the overall learning experience.

C. Discussion

The findings of this study, corroborated by previous research [40–44], highlight the transformative potential of AR-based applications in enhancing survival skills among students in vocational settings. The integration of an Android-based automotive electrical mobile application proved effective in fostering a balance between creative expression and logical reasoning within the automotive electrical domain. This aligns with earlier studies [45, 46] which emphasize significant improvements in creative thinking, problem-solving, and overall survival abilities when technology-enhanced learning tools are utilized. Moreover, this research reaffirms the conclusions of [47] demonstrating that students exposed to mobile AR applications gain a deeper understanding of creative thinking and problem-solving, which are essential for tackling complex challenges. These outcomes suggest that AR technology effectively supports skill acquisition for diverse user demographics. Consistent with [48, 49] the purposive sampling technique used in this study encompassing students, educators, and professionals from varied backgrounds enhanced the external validity of the findings. The inclusion of diverse demographics allowed for evaluating the app's effectiveness across a broader range of user profiles, strengthening its applicability to real-world scenarios [50, 51]. Feedback from validation experts during the development phase significantly improved the app's content and instructional videos, ensuring its relevance to automotive electrical education. The iterative development process, involving collaboration with media and material specialists, enhanced the robustness and user-centered design of the AR application [52, 53]. These results have broader implications for the integration of mobile learning applications in education, particularly in vocational training. The AR application's alignment with the digital era's demands underscores the need for innovative and engaging teaching strategies [54–56], Future studies could explore the scalability of such applications in diverse educational contexts and assess their long-term impact on users' survival skills. To summarize, the AR application represents a promising resource at the intersection of survival skills development and electrical automotive education, offering valuable insights into technology-enhanced learning.

V. Conclusion

This study examines the effectiveness of an Android-based Augmented Reality (AR) application in enhancing survival skills within the context of automotive electrical education. By integrating survival skill principles into the learning framework, the application fosters creativity, critical thinking, and problem-solving abilities. Validation results confirm the reliability of the application, while its practicality and usability are supported by positive evaluations from both educators and learners. The findings highlight the transformative potential of AR technology in vocational education, offering an innovative and interactive approach to skill development. The application bridges the gap between technological advancements, cognitive growth, and practical learning outcomes, contributing to the improvement of educational quality and the development of essential survival skills. Future studies are encouraged to explore the adaptability of such AR applications across various disciplines and assess their long-term impact on education and skill acquisition. This research underscores the role of AR technology as a catalyst for advancing vocational education and fostering meaningful, technology-driven learning experiences.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Sigit Purnomo: Conceptualization; Data curation; Methodology; Software; Investigation; Supervision; Writing - original draft. Herminarto Sofyan: Validation, Data curation; Writing-review & editing. Ibnu Siswanto: Validation, Data curation; Writing-review & editing. Agustin Anis Ainun: Formal analysis; data curation. Muhammad Hakiki: Data curation; Methodology; Software; Investigation; Writing - original draft. Dianna Ratnawati: Validation, Data curation; Writing-review & editing. Resti Utami: Validation, Data curation; Writing-review & editing. Adhan Efendi: Validation, Data curation; Writing-review & editing. All authors had approved the final version.

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