JIPI (Jurnal Ilmiah Penelitian dan Pembelajaran Informatika)
Journal homepage: https://jurnal.stkippgritulungagung.ac.id/index.php/jipi
ISSN: 2540-8984
Vol. 10, No. 3, September 2025, Pp. 2838-2846

DIGITALIZATION OF AUTOMOTIVE AC PRACTICUM THROUGH AN INTERACTIVE EPUB-BASED E-JOBSHEET INTEGRATED WITH QR CODE

Dianna Ratnawati*[1)], Erwin Khomara Mindarta[2)], Robby Wijaya[3)], Mahfudi Sahly Subandi[4)]
1. Automotive Engineering Education, Faculty of Engineering, Universitas Negeri Malang, Indonesia
2. Automotive Engineering Education, Faculty of Engineering, Universitas Negeri Malang, Indonesia
3. Automotive Engineering Education, Faculty of Engineering, Universitas Negeri Malang, Indonesia
4. Automotive Engineering Education, Faculty of Engineering, Universitas Negeri Malang, Indonesia

Article Info
Keywords: Digital, e-jobsheet, practicum; interactive

Article history:
Received 11 September 2025
Revised 27 September 2025
Accepted 28 September 2025
Available online 28 September 2025

DOI :
https://doi.org/10.29100/jipi.v10i3.9161

* Corresponding author.
Corresponding Author
E-mail address:
dianna.ratnawati.ft@um.ac.id

ABSTRACT
Practical learning in vocational education serves as a key driving factor in supporting the achievement of core competencies for prospective graduates of automotive education programs to meet the competency demands of the automotive industry labor market. Particularly in the era of artificial intelligence, industrial demands have shifted towards high-level digital technology literacy. Therefore, practical learning tools such as jobsheets need to be developed in digital formats. This study aims to develop an interactive e-jobsheet based on ePub integrated with QR codes, designed for effective use in automotive air conditioning (AC) practicum learning for students. The research is categorized as Research and Development (R&D), employing the ADDIE model stages of Analysis, Design, Development, Implementation, and Evaluation. The results of expert validation tests showed that the average media expert assessment of the e-jobsheet was 96%, indicating it is highly feasible, while the average assessment from subject matter experts was 98%, also highly feasible. Furthermore, evaluation results revealed positive student responses, with an average assessment of the e-jobsheet content at 97% (highly feasible) and an average perception rating of the e-jobsheet media at 98% (highly feasible). Thus, it can be concluded that the ePub-based e-jobsheet integrated with QR codes is highly recommended as a teaching material to support practicum learning in automotive workshops and is relevant to the needs of the automotive industry, especially in fulfilling graduate competencies in the era of Industry 4.0. This e-jobsheet also demonstrates superiority in supporting self-directed digital learning compared to conventional jobsheets.

I. INTRODUCTION

THE rapid development of information and communication technology in the era of the Fourth Industrial Revolution has influenced almost every sector of life, including education. Digital transformation not only changes patterns of communication and lifestyle but also requires a fundamental shift in the delivery of learning. Digitalization in education has become a strategic necessity that can no longer be avoided, as schools are expected to produce graduates with skills aligned with modern industrial demands [1], [2]. In this context, vocational education holds a strategic position because it is directly oriented towards preparing a skilled workforce. The distinctive characteristic of vocational education, particularly in vocational high schools (SMK), is its strong emphasis on practice-based learning, which requires systematic, interactive, and applicable teaching media. This aligns with the mandate of vocational education, which is not only to prepare students for higher education but also to equip them with work-ready skills that meet industry standards [3], [4].

One of the most essential learning media in vocational education is the jobsheet. As a learning tool, a jobsheet contains work instructions, technical diagrams, and safety procedures that serve as practical guidance for students [5], [6]. Jobsheets enable students to work independently, reduce dependency on instructors, and ensure that practical procedures are carried out according to standards. From the teacher's perspective, jobsheets also streamline the learning process by saving explanation time and maintaining procedural consistency [7], [8]. Nevertheless, conventional printed jobsheets face significant limitations. The materials are often monotonous, lack

visualization, and can only be used in the classroom or workshop, which makes it difficult for students to review procedures outside of school. Such conditions may reduce learning motivation and hinder students' ability to recall complex technical processes [3], [9].

With technological advancement, numerous studies have attempted to digitize jobsheets, and this innovation has proven to enhance practical learning outcomes. Badruttamam & Hadromi [10] developed an Android-based interactive jobsheet that improved both motivation and learning achievement. Aisyah et al [7] designed a QR Code-based e-jobsheet that functions not only as a guide but also as a digital assessment tool. Similarly, in the fashion sector, e-jobsheets increased student pass rates by up to 95% [3]. In mechanical engineering, jobsheets integrated with project-based learning were reported as highly valid and practical [1]. In the welding field, Amanulloh et al. [11] found that integrated welding jobsheets significantly improved students' hands-on skills. Collectively, these findings highlight the positive impact of digital jobsheets on vocational learning [12], [13].

However, the transformation of jobsheets should not be limited to digitalization of format. The integration of interactive media is becoming increasingly necessary. The ePuB format, for example, allows richer learning content since it can accommodate text, images, audio, and video in a structured format. With this format, work instructions can be presented more clearly and engagingly [14], [15] . Meanwhile, QR Codes provide quick access to supplementary learning resources such as video tutorials, animations, or online assessments through a simple scan using smart devices [16], [17]. The combination of these technologies offers great potential to create flexible, adaptive, and learner-centered practical learning media, particularly for digital-native students.

In the automotive sector, the need for digital jobsheets is becoming increasingly urgent. Modern automotive service industries demand efficiency, precision, and strict adherence to standards. Graduates of vocational high schools in the automotive field must therefore acquire specific competencies aligned with both workshop practices and global automotive industry standards [1], [18]. Among the key competencies, the ability to maintain and repair automotive air conditioning (AC) systems is particularly crucial. Unlike other automotive topics such as braking systems or basic electrical circuits that are often easier to simulate, AC system practice requires detailed procedural understanding, precise technical skills, and high caution due to its involvement with pressurized systems and refrigerants, which may pose hazards [7].

Furthermore, almost every modern vehicle is equipped with an air conditioning system, making this skill a fundamental competency that automotive students must master. Yet in practice, teaching and learning AC systems still face several challenges. Conventional jobsheets used in this area are often limited to brief textual descriptions with minimal diagrams, which makes it difficult for students to fully grasp the process. The complexity of the task also leads to strong reliance on instructors, thereby reducing opportunities for independent learning [11], [14]. These realities emphasize the urgency of developing digital jobsheets that are interactive and easily accessible, enabling students to review and practice procedures independently, anytime and anywhere.

Based on observations on 4 November 2024 in the 5th semester automotive engineering education programme's car air conditioning practical class at Malang State University, practical activities still used conventional jobsheets in groups, with some students not bringing their jobsheets. It was also observed that some groups faced challenges in understanding the compressor diagrams and overhaul procedures, as their prior education was at the secondary school level. Consequently, the practical activities could not be fully carried out independently by the students in accordance with the procedures. Meanwhile, the challenges for lecturers are limited time and energy in comprehensively explaining the practical steps, as well as limitations in handling/controlling the overall practical activities of each individual so that they run in accordance with Standard Operating Procedures (SOP). Furthermore, Occupational Health and Safety is very important to be implemented in car air conditioning practical activities. Students must possess the competency to fill freon correctly, skilfully, and in accordance with SOPs. A lack of in-depth understanding among students regarding freon filling can lead to toxic gas leaks and even explosions. Therefore, it is important for students to master a deep understanding of practical SOPs and independence in practice.

Car air conditioning maintenance and repair skills are among the skills required for workers in the automotive industry, given that data shows automotive after-sales services in Indonesia increased by IDR 85 trillion in 2023 and are expected to continue growing by 8.9% between 2025 and 2031 [19]. In line with the high vehicle sales figures, the demand for workers in the automotive sector has also increased from 38,390 people in 2021 to 57,918 people in 2025 [20]. Research conducted in automotive workshops in the Makassar area found that the most common damage was to the compressor and evaporator components. Therefore, skilled mechanics are needed to diagnose and repair car air conditioning systems [21]. Thus, the role of the education sector in developing digital learning media such as interactive and adaptive e-jobsheets according to industry needs is urgently needed to

support the strengthening of car air conditioning system maintenance and repair skills for prospective graduates in order to meet the skill requirements of the automotive industry.

While previous research has shown that digital jobsheets improve learning effectiveness, most of the studies are still concentrated on disciplines such as fashion, chemistry, and CAD/CAM. Research in the automotive field particularly in automotive AC system practice remains limited [1], [3]. Additionally, many existing studies focus primarily on the validity and practicality of media, leaving the potential for integrating cross-format features such as ePuB with QR Code underexplored [9], [18]. This gap becomes even more pronounced when compared to the actual demands of the automotive industry, which requires learning media that are not only efficient and accurate but also aligned with specific workplace competencies. Unfortunately, the connection between digital jobsheet development and these industrial requirements has not yet been deeply examined [2], [5]. Based on these considerations, the main purpose of this study is to develop an interactive e-jobsheet in ePuB format integrated with QR Code technology for automotive AC system practice in vocational high schools. It is expected that the developed media will not only be valid and practical but also enhance students' independent learning, technical skills, and overall relevance to the current needs of the automotive industry

II. METHOD

This research employs a Research and Development (R&D) approach using the ADDIE model, in which the research stages consist of Analysis, Design, Development, Implementation, and Evaluation. Furthermore, the detailed research stages are illustrated in Figure 1 below.

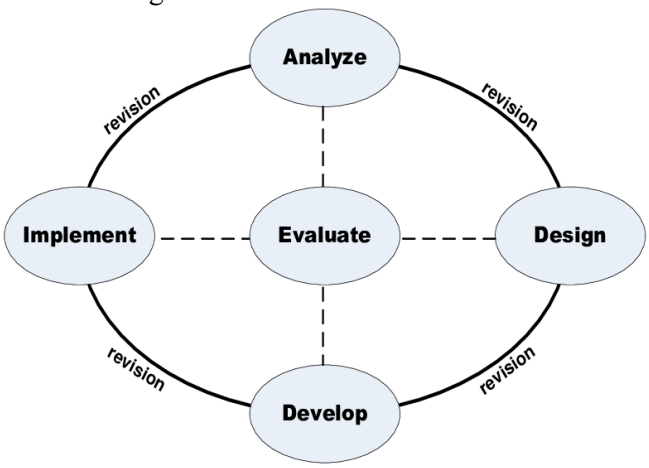

Fig 1. ADDIE Model

Referring to Fig 1, each stage of the research activities can be explained more specifically as follows. (1) at the **Analysis** stage, the activities carried out included identifying the alignment of the Course Learning Outcomes (CLOs) of the Automotive AC Practicum with the curriculum of the Bachelor Program in Automotive Engineering Education, conducting a survey of lecturers regarding the challenges faced in teaching automotive AC practicum materials, and surveying students regarding the difficulties they encountered in learning the content and work procedures of the automotive AC practicum. In addition, a literature review on automotive AC service procedures was conducted, and the SOPs of the automotive AC practicum were mapped to be developed using Sigil software and the ePub application, ensuring relevance to the curriculum and technological advancements in the automotive industry. (2) at the **Design** stage, the activities included creating the design of the interface, storage system, content of practicum work procedures, videos, images, animations, and assessment instruments for the automotive AC practicum, all of which would be integrated into Sigil, ePub, and the e-jobsheet. (3) at the **Development** stage, the activities involved conducting feasibility tests of the e-jobsheet with automotive education lecturers who are experts in digital content development, validating the material and work procedures in the e-jobsheet, revising the product content based on suggestions from subject matter and media experts, and finalizing the e-jobsheet until it was ready for implementation. (4) at the **Implementation** stage, the e-jobsheet product was tested in the automotive AC practicum class, and verbal feedback and testimonials about the product were obtained from students. During the implementation stage, the e-jobsheet product was tested on respondents who were students majoring in automotive engineering taking the car air conditioning practicum course using purposive sampling. Students in semester 5 offering B1-02ME were selected, with a total of 20 students in the class who still used manual jobsheets as a practicum guideline. (5) Finally, at the **Evaluation** stage, the activities included evaluating the results of the product feasibility tests, gathering feedback from lecturers and students regarding the depth of the material and practicum

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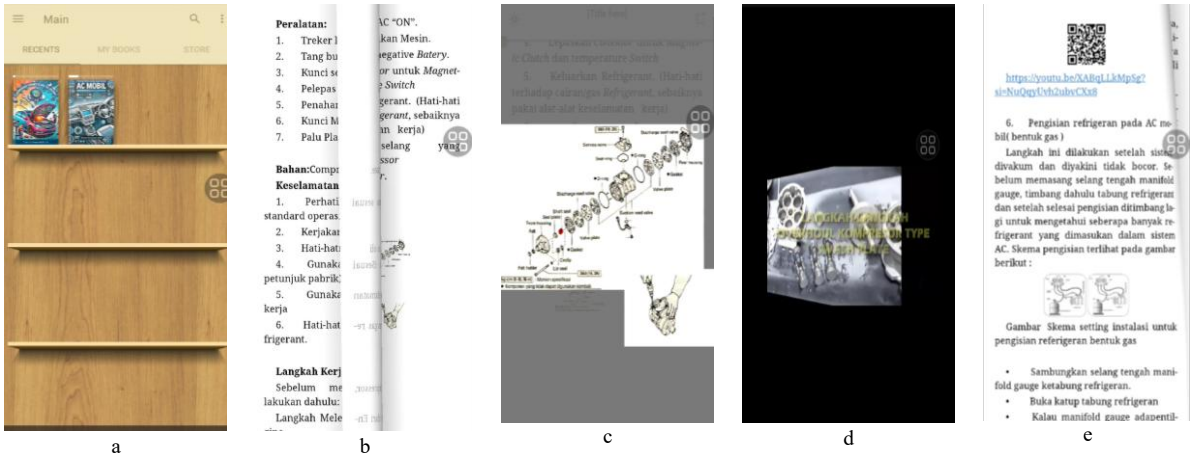
procedures, visuals, and accessibility, analyzing student learning outcomes, conducting student satisfaction surveys, and identifying as well as updating elements of the e-jobsheet content for sustainable product development

III. RESULT AND DISCUSSION

The E-jobsheet product has been successfully developed, tested, and evaluated. The display of the e-jobsheet can be seen in Figures 2a, 2b, 2c, 2d, and 2e.

A. E-Jobsheet Development Results



a b c d e

Fig 2. e-Jobsheet Display

Overall, the developed e-jobsheet product can be accessed at the link: https://drive.google.com/file/d/14VjWJTKnxiZzvdJ7oeLmOqB48HMwAYh7/view?usp=sharing . To access it, Android users can install the application through https://play.google.com/store/apps/details?id=com.prestigio.ereader , while Windows users can install the application through https://chromewebstore.google.com/detail/epubreader/jhhclmfgfllimlhabjkgkeebkbiadflb

This ePub-based e-jobsheet integrated with QR codes has the advantage of presenting automotive AC practicum work procedures that are equipped with practicum evaluations and supported by engaging and interactive visualizations. The font display can be adjusted according to the user's device, whether a smartphone or a laptop. The work procedures are accompanied by 2D images of automotive AC components that can be zoomed in and out, as well as structured 3D video demonstrations of the practicum accessible directly through YouTube links and QR codes provided. Users can also navigate the e-jobsheet pages with a flip/slide by slide model, making it easier to guide them in applying and mastering practicum procedures independently anytime and anywhere. The e-jobsheet is also easy to access, requiring only 8,478 kb of storage space. In addition to these advantages, there are also weaknesses, namely that it cannot be accessed on iPhone smartphones and requires the installation of an e-reader application and an ePubReader application to access the e-jobsheet. This increases the storage space required for both the application and the product on the user's device. Furthermore, to access the e-jobsheet online, a stable internet connection is required. Therefore, this e-jobsheet product has limited access and lacks support if it is implemented as a medium to support practical learning activities in remote areas or places with weak internet connections.

B. Expert Assessment Result

The developed e-jobsheet was validated by subject matter experts and media experts from among the lecturers. The assessment used a Likert scale of 1–5, with the following criteria: 1 = not feasible, 2 = less feasible, 3 = moderately feasible, 4 = feasible, and 5 = highly feasible. The results of the subject matter expert assessment indicated a product feasibility level of 98% (highly feasible). This data is illustrated in the diagram shown in Figure 3.

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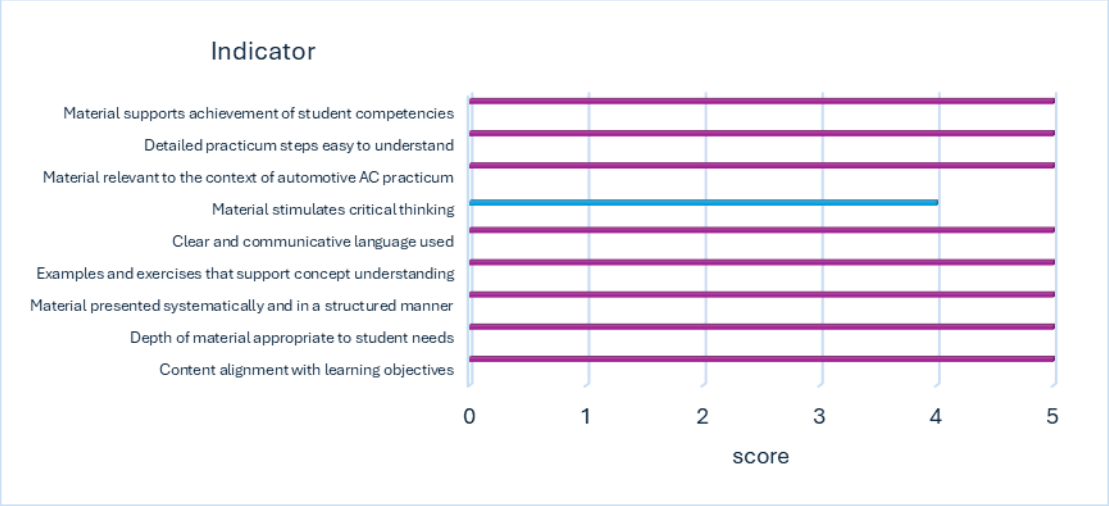

Fig 3. Expert Assessment Results

Based on Fig 3, the indicators of the material aspect were rated as highly feasible by the subject matter experts, with the exception of the indicator concerning examples and exercises supporting conceptual understanding, which was rated as feasible. Overall, the average rating was highly feasible. The experts also provided suggestions, namely to add a practicum video on refrigerant filling using an automatic tool available in the automotive engineering education workshop. This suggestion was implemented in the e-jobsheet, starting from the procedure of emptying to filling refrigerant with an automatic tool, and was complemented by a student practicum video validated by the course lecturer, complete with a barcode and YouTube link for access.

Furthermore, the results of the media expert assessment showed a product feasibility level of 96% (highly feasible). Based on Fig 4, the indicators of the media aspect were rated as highly feasible by the media experts, with the exception of the indicators on the suitability of the design with user needs and the attractiveness and proportionality of the layout, which were rated as feasible. Overall, the average rating by the media experts was highly feasible. The experts also provided suggestions, namely that some layouts, particularly the spacing, were not yet consistent and needed to be refined to be more proportional. This suggestion was subsequently addressed by improving the spacing in the layout of each page in the e-jobsheet.

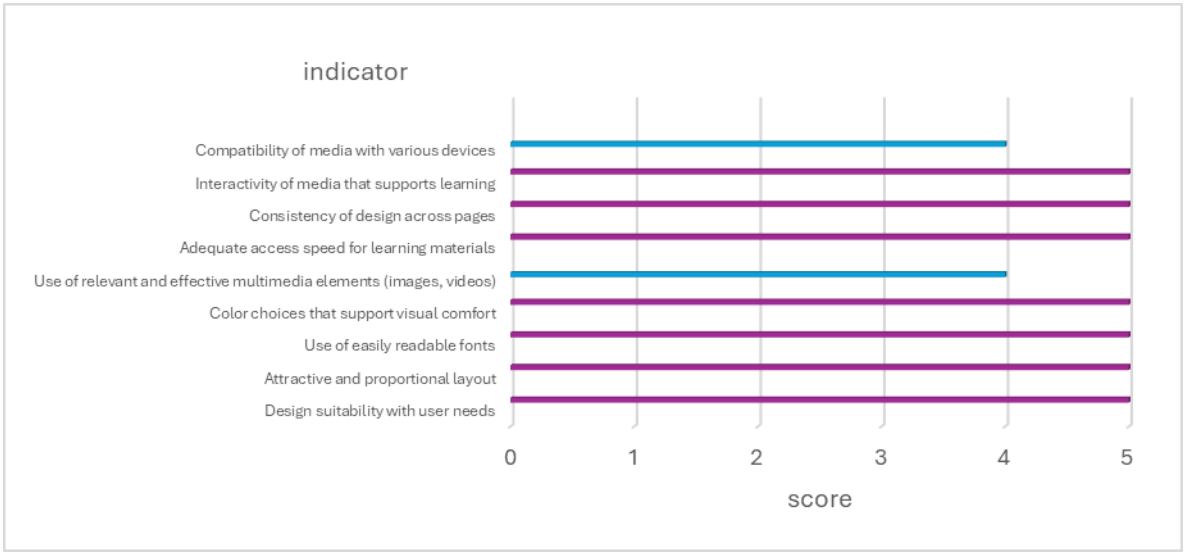

Fig 4. Media Expert Assessment

C. *Implementation*

The results of the e-jobsheet development were implemented in one automotive AC practicum class with a total of 20 students. The sample was selected using a purposive sampling technique. Based on the implementation results, students' perceptions regarding the feasibility of the e-jobsheet content reached 97%. This percentage was derived from students' assessments of 10 indicators of e-jobsheet content using a Likert scale of 1–5, as illustrated in Fig 5.

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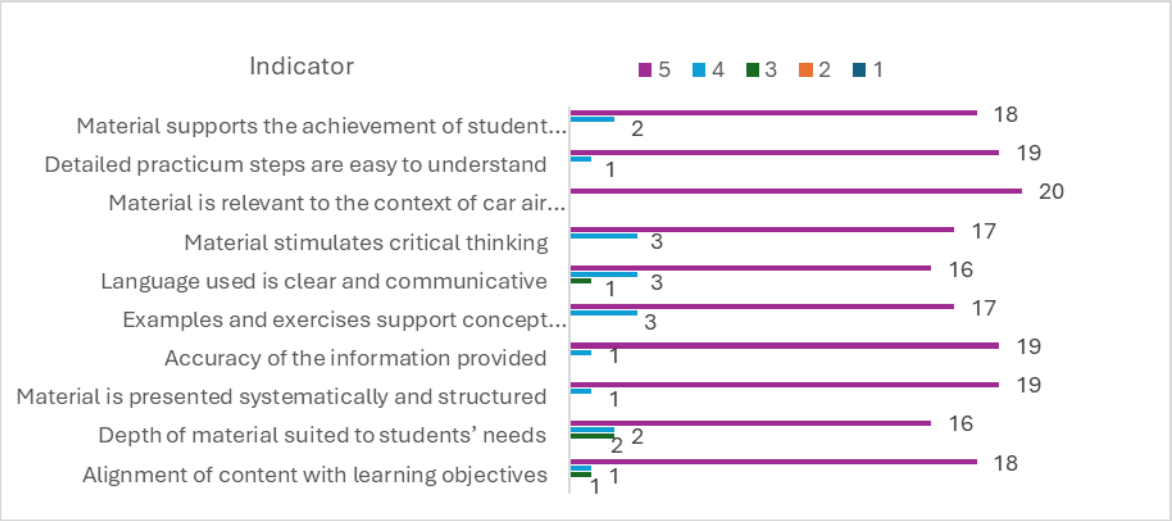

Fig 5. Diagram of Students' Perceptions of the Feasibility of E-jobsheet Content

Furthermore, the implementation results showed that students' perceptions regarding the feasibility of the e-jobsheet media reached 98%. This percentage was obtained from students' assessments of nine indicators of e-jobsheet media using a Likert scale of 1–5, as illustrated in Fig 6.

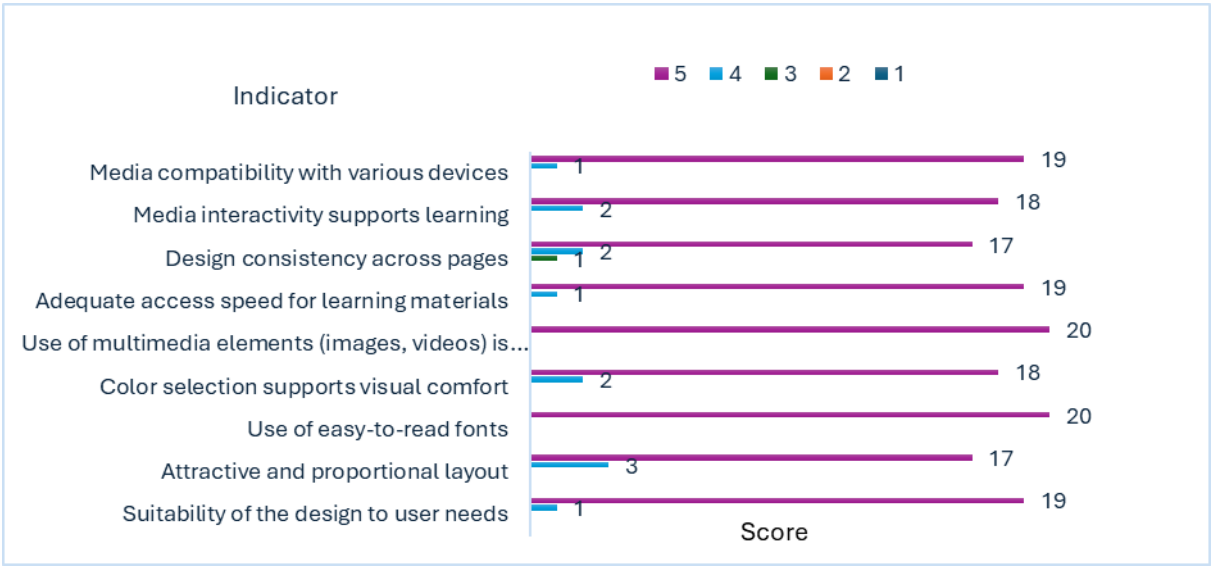

Fig 6. Diagram of Students' Perceptions of the Feasibility of E-jobsheet Media

D. Evaluation

Based on the results of product implementation, the use of the e-jobsheet had an impact on the automotive AC practicum, achieving a 100% pass rate with an average practicum score of 90. Through the use of the e-jobsheet, students were able to engage in self-directed practicum learning in a digital format. Thus, the e-jobsheet proved effective for implementation in practicum learning. Furthermore, this e-jobsheet is highly feasible to be recommended as supplementary teaching material for the automotive AC practicum, as supported by student perceptions and expert assessments.

E. Dicussion

The results of this study indicate that the QR Code based e-jobsheet for automotive air conditioning practice obtained very high validation scores from media experts (96%) and material experts (98%), and received positive responses from students. This achievement shows that the developed product has met the criteria of validity, practicality, and effectiveness in the context of vocational education. The high level of validity indicates that the content and media design are in accordance with students' needs, while the students' responses confirm the product's acceptability in actual practice. This finding is in line with the argument that digitalization of jobsheets can overcome the limitations of conventional paper based jobsheets that are often incomplete or easily lost. Therefore, these

results reinforce the importance of instructional media innovation in improving the quality of vocational learning, particularly in the automotive field.

These findings are consistent with previous research that emphasized the effectiveness of digital jobsheets in enhancing students' competencies. [22] reported that the use of Simurelay assisted jobsheets in project based learning significantly improved students' cognitive, affective, and psychomotor competencies. Similarly, [11] found that an integrated welding jobsheet, which combined industrial work orders with practice, effectively improved vocational students' competence. Both studies affirm that innovative jobsheet development has a direct impact on students' mastery of vocational skills. Thus, the results of this study strengthen the position of digital jobsheets as an essential instrument for supporting vocational education.

The consistency of these findings is also demonstrated by other studies in technical education that developed jobsheets using digital and multimedia approaches. [23] developed an animation video based jobsheet for lathe machining practice and reported very high validation scores from both experts and students, proving its effectiveness in improving comprehension of procedural steps. Meanwhile, [24] found that jobsheets for electrical motor installation practice were rated as highly valid, highly practical, and effective in enhancing learning outcomes. Both studies emphasize that jobsheet based digital media play a vital role in helping students understand complex technical processes. Therefore, the findings of this research are relevant to and consistent with ongoing trends in jobsheet development in vocational education.

Furthermore, the results of this study align with jobsheet development in non-automotive fields such as fashion and arts. [14] developed jobsheet based e-modules for fashion business management courses and obtained feasibility scores exceeding 90%, while [16] demonstrated that a Canva based e-jobsheet for women's pants pattern making achieved a 100 percent pass rate among students. Likewise, [7], [8] designed an interactive e-jobsheet using Adobe Flash for loom material and reported a material validation score of 95%. These cross disciplinary studies highlight that e-jobsheets can be applied widely across diverse fields. Accordingly, the findings of this study confirm that QR Code based e-jobsheets are consistent with best practices in digital learning media for vocational contexts.

The main advantage of this research lies in the integration of QR Codes with ePub format, enabling students to access learning materials via mobile devices. This aspect differentiates the present study from earlier works that were limited to local or offline applications. [25] highlighted that students' readiness to use QR Code based e-jobsheets was still constrained by infrastructure and connectivity issues, although the potential was significant. This study contributes by successfully integrating QR Codes so that students can directly access practice instructions using their smartphones. Consequently, the developed product addresses both technological readiness challenges and the need for flexible vocational practice learning in the digital era.

Beyond accessibility, the QR Code based e-jobsheet in this study also aligns with innovations that employ active learning models. [26] showed that a Project Based Learning oriented jobsheet for electric motor control significantly improved vocational students' skills through project engagement. Similarly, [10] developed a Project Based Learning jobsheet for gear design using Autodesk Inventor and found it to be highly valid and practical, effectively enhancing students' CAD/CAM skills. These studies affirm that digital jobsheet innovation not only supports technical learning but also fosters student centered active learning through project based methods.

The relevance of this study also resonates with the digitalization trend in science education. [17] developed a STEM integrated e-jobsheet for physics learning and found it valid and practical for improving 21st century skills. Integrating STEM elements into jobsheets proved effective in fostering critical thinking, collaboration, communication, and creativity. Based on this evidence, the QR Code based e-jobsheet for automotive AC practice may serve a similar function, training students to exercise problem solving, accuracy, and digital literacy within practical learning. Thus, this study supports the broader direction of vocational education policies emphasizing digital literacy and readiness for Industry 4.0.

This study is also in agreement with earlier research specifically in automotive contexts. [18] demonstrated that a diagnostic problem based e-jobsheet for automotive brake systems significantly increased student competence from 42 percent to 84 percent after implementation. Likewise, [10] developed an Android based interactive jobsheet for electrical measuring equipment and reported its effectiveness in improving student motivation and learning outcomes. These findings underline the essential role of digital jobsheets in helping vocational students understand

complex automotive procedures. Therefore, the QR Code based e-jobsheet developed in this study further validates the success of digital media implementation in the automotive field.

Referring to the results of research by Apriana and Hamid [27], the use of job sheets can improve student learning outcomes in technical drawing practical subjects, with student evaluation scores of 85%. Furthermore, job sheets also serve as a learning resource that connects theory with practice in a single learning medium that supports independent learning. Similarly, the results of research by Fadli et al. concluded that the use of e-jobsheets can improve student learning outcomes, which are more effectively used in remote sensing practicum subjects. Student evaluation results were 89.47% with an effectiveness level of 84.33% compared to conventional methods, which had an effectiveness of 74.83%. E-jobsheets are considered feasible and practical for use on various devices and capable of supporting independent practical learning. [28]. Overall, both jobsheets and e-jobsheets are effective in improving practical learning outcomes. However, e-jobsheets are superior in terms of flexibility, interactivity, and independent learning, although their success is influenced by network access and the devices used by users. [27][28][29][30]

By drawing on multiple previous studies, it can be concluded that this research occupies a significant position within the landscape of e-jobsheet development. Its uniqueness lies in its application to automotive AC practice, a relatively underexplored area, and in its integration of QR Codes with ePub format, which increases accessibility. In addition, this study carries implications for expanding students' digital literacy, promoting independent learning, and aligning vocational graduates with industry needs. Accordingly, the findings of this study are not only consistent with previous works but also contribute novel insights into extending the scope of e-jobsheet innovation to support vocational education in the digital transformation era.

IV. CONCLUSION

The Automotive AC Practicum E-jobsheet has been successfully developed through the stages of analysis, design, development, implementation, and evaluation. The developed product received a "highly feasible" rating from both subject matter experts and media experts, as well as positive responses from student assessments and perceptions. It was shown to improve practicum learning achievement and support self-directed digital practicum learning with proper SOPs. Therefore, this QR code–integrated Automotive AC Practicum E-jobsheet is highly recommended as a supplementary learning resource for automotive engineering education students.

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