

Development of a Job Sheet for Mechanical Measuring Instruments Using Virtual Learning and Project-Based Learning in the Motorcycle Engineering Department at SMK Negeri 2 Palembang

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Abstract: This study aims to develop a mechanical measurement practical worksheet integrated with Project-Based Learning (PjBL) and delivered through a Learning Management System (Google Classroom), as well as to examine its validity, practicality, and effectiveness. The study employed the ADDIE development model, consisting of analysis, design, development, implementation, and evaluation stages, with PjBL principles embedded in the product design and learning activities. The participants were 35 tenth-grade vocational students (N=35). The results showed that the developed worksheet achieved a very high level of validity based on expert evaluations of media, content, and language, with an average score of 94.6%. In terms of practicality, teacher and student responses reached 92.72% and 93.18%, respectively, both categorized as “very good,” indicating that the worksheet is easy to use and supports flexible practical learning. Regarding effectiveness, students’ learning outcomes improved significantly, with mean scores increasing from 30.92 (pretest) to 86.00 (posttest) and an N-gain of 0.80 (high category). Hypothesis testing confirmed a significant difference ($p < 0.05$) before and after implementation. In conclusion, the PjBL-integrated mechanical measurement practical worksheet distributed through Google Classroom as an LMS is valid, practical, and effective in improving students’ learning outcomes.

Keywords: ADDIE; Google classroom; Learning outcomes; Project-based learning; Virtual learning worksheets

Introduction

Learning is a communication process between Learning is fundamentally a process of communication between educators and learners aimed at achieving specific competencies through structured interactions and meaningful exchanges of information. In this context, vocational education plays a strategic and indispensable role within the national education system, as it is specifically designed to produce graduates who are not only knowledgeable but also technically

competent, skilled, and ready to meet the dynamic demands of industry and the workforce. Unlike general education, vocational education emphasizes the integration of theoretical understanding with hands-on practice, ensuring that learners acquire competencies aligned with real workplace standards. Therefore, the effectiveness of vocational education is highly dependent on how well the learning process can bridge the gap between classroom instruction and industrial practice (Elida et al., 2025).

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The increasing complexity and competitiveness of the industrial sector require vocational education to continuously evolve in order to remain relevant and responsive to workforce demands. Graduates are expected not only to master technical skills but also to demonstrate higher-order thinking skills such as critical thinking, collaboration, creativity, and problem-solving. Consequently, learning in vocational high schools must be designed in a contextual and application-oriented manner, allowing students to experience authentic learning situations that reflect real-world challenges. This highlights the importance of designing instructional strategies and learning environments that can effectively support the development of both technical competencies and 21st-century skills in an integrated manner (Gustina et al., 2024; Krisdiantoro et al., 2024).

The rapid advancement of information and communication technology has brought about transformative changes in the educational landscape, including in vocational education. Learning is no longer limited to face-to-face interactions or traditional classroom settings but has expanded into more flexible, interactive, and technology-enhanced environments. The integration of digital technology in education serves not only as a substitute for conventional tools but also as a means to innovate and improve the quality of teaching and learning processes. Through the use of digital platforms and multimedia resources, learning can be made more engaging, accessible, and adaptable to the diverse needs of learners (Ermiyawati et al., 2025).

In the digital era, virtual learning has emerged as a highly relevant approach to support flexible and student-centered learning. Virtual learning refers to a digital learning environment that allows students to access instructional materials, participate in learning activities, and engage with content anytime and anywhere, provided that internet access is available (Munandar et al., 2024). This approach typically incorporates various forms of interactive media, including videos, simulations, animations, and digital exercises, which can significantly enhance students' understanding of complex concepts (Muliyadi et al., 2026). Particularly in vocational education, virtual learning offers opportunities to simulate real-world practices and procedures that may otherwise be difficult to demonstrate using conventional methods (Meirawati et al., 2025).

In this study, virtual learning is implemented through a Learning Management System (LMS), namely Google Classroom, which functions as a platform for organizing, delivering, and managing learning activities in a structured manner. It is important to emphasize that Google Classroom does not constitute virtual learning itself but serves as a medium through which virtual

learning content is delivered (Putri et al., 2022). The LMS facilitates various instructional processes, including the distribution of learning materials, assignment submission, feedback provision, and communication between teachers and students. By leveraging Google Classroom, educators can create a more organized and accessible learning environment that supports both synchronous and asynchronous learning activities (Irawan et al., 2025).

Instructional media play a crucial role in enhancing the effectiveness and quality of the learning process, particularly in vocational education where practical skills are emphasized (Putritama et al., 2026). The use of appropriate media can help clarify complex information, improve students' attention and motivation, and foster active participation in learning activities. Moreover, instructional media can facilitate better interaction between students and learning content, enabling them to construct knowledge more effectively. Therefore, the selection and development of suitable instructional media are essential to ensure that learning objectives can be achieved optimally (Atika et al., 2025).

In vocational practice-based learning, one of the most widely used instructional media is the practical worksheet or jobsheet. A practical worksheet serves as a structured guide that outlines learning objectives, required tools and materials, and step-by-step procedures that students must follow during practical activities. It functions as a bridge between theoretical knowledge and practical application, enabling students to perform tasks systematically and accurately (Husnulwati et al., 2019). The effectiveness of practical worksheets largely depends on how well they can guide students in understanding procedures and applying concepts in real practice situations (Desky, Ganefri, et al., 2025).

However, in many vocational high schools, practical worksheets are still predominantly presented in conventional printed formats, which pose several limitations. Printed worksheets are often unable to effectively visualize complex procedures or provide dynamic representations of practical tasks, especially in technical subjects that require high levels of precision and clarity (Dini et al., 2024). As a result, students may encounter difficulties in understanding procedural steps, which can negatively affect their performance during practical activities. This limitation highlights the need for more innovative and interactive forms of instructional media (Faridah et al., 2023; Indarta et al., 2021).

To address these limitations, the development of digital-based practical worksheets, commonly referred to as e-jobsheets, has become increasingly important. E-jobsheets are designed to be accessed through digital devices and allow the integration of various multimedia

elements such as instructional videos, animations, images, and simulations. These features enable students to visualize procedures more clearly and engage in self-directed learning (Agraini et al., 2026). Furthermore, e-jobsheets provide flexibility for students to access learning materials anytime, thereby supporting independent and continuous learning beyond the classroom setting (Sumardi et al., 2024).

Mechanical measuring instruments constitute a fundamental competency in vocational education, particularly in the field of motorcycle engineering. These instruments are essential tools used in measuring dimensions, inspecting components, and ensuring the accuracy and quality of mechanical systems. Mastery of mechanical measuring instruments requires not only conceptual understanding but also a high level of precision, attention to detail, and the ability to interpret measurement results accurately (Algiffary et al., 2023). Therefore, effective learning strategies and media are required to support students in mastering these competencies (Miranda et al., 2026).

Despite the importance of this competency, many students still experience difficulties in understanding measurement concepts, reading scales accurately, and applying measurement procedures correctly. These challenges indicate that existing instructional approaches and materials may not be sufficiently effective in facilitating students' learning (Anis et al., 2021). In particular, the lack of interactive and visually rich learning resources can hinder students' ability to fully grasp complex measurement procedures, which ultimately affects their learning outcomes (Sudianti et al., 2025).

Based on preliminary observations and interviews with teachers, as well as an analysis of student characteristics at SMK Negeri 2 Palembang, it was found that 89% of the practical learning facilities and implementation were categorized as "very good." However, this positive condition in terms of facilities does not necessarily translate into optimal student learning outcomes. In reality, a number of students still have not achieved the minimum competency criteria and show limited engagement in active and collaborative learning during practical sessions. This indicates a discrepancy between the availability of adequate facilities and the effectiveness of the learning process (Siregar et al., 2021).

Furthermore, the use of digital learning resources in practical instruction remains limited, which restricts students' opportunities to engage in independent and flexible learning outside the classroom (Ningsih et al., 2025). As a result, students may lack sufficient practice and reinforcement in mastering the use of mechanical measuring instruments. This limitation underscores the need for innovative instructional solutions that can

support continuous learning and improve students' understanding and skills (Desky, Taali, et al., 2025).

To address these challenges, an instructional model that promotes active, collaborative, and authentic learning is required. Project-Based Learning (PjBL) is considered highly appropriate in this context, as it emphasizes learning through real-world projects that require students to apply knowledge and skills in solving practical problems (Susilawati et al., 2023). PjBL has been widely recognized for its effectiveness in enhancing problem-solving abilities, collaboration, and practical competencies. In the context of mechanical measuring instruments, PjBL enables students to engage in measurement and inspection projects that closely simulate industrial practices, thereby improving their readiness for the workforce (Sudira et al., 2022).

The novelty of this study lies in the integration of digital practical worksheets (e-jobsheets), Project-Based Learning (PjBL), and a Learning Management System (Google Classroom) within a comprehensive virtual learning framework (Widyastuti et al., 2023). Unlike previous studies that tend to focus on a single instructional component, this research combines interactive digital media, project-based pedagogy, and structured online learning management into a unified system specifically designed for precision-based technical learning. This integrated approach is expected to provide a more effective solution in improving students' engagement, practical skills, and learning outcomes, particularly in mastering mechanical measuring instruments (Hakim et al., 2025).

Therefore, this study aims to develop and evaluate a virtual learning-based practical worksheet integrated with Project-Based Learning for mechanical measuring instruments. The findings of this study are expected to contribute to the advancement of instructional design in vocational education by providing an innovative and effective learning model that enhances students' competencies, independence, and readiness to meet the evolving demands of the industrial sector (Handoyo et al., 2025).

Method

This study adopts a Research and Development (R&D) approach utilizing the ADDIE model, which consists of five systematic stages: Analysis, Design, Development, Implementation, and Evaluation. The selection of the ADDIE model is based on its structured and iterative framework, which enables the development of instructional products in a logical, measurable, and evaluative manner (Yulirismayenti et al., 2025). Through this model, each stage is designed to ensure that the developed product meets the required standards of validity, practicality, and effectiveness. In

particular, the integration of Project-Based Learning (PjBL) principles is embedded within the design and development phases to ensure that the resulting product not only delivers content but also facilitates active, contextual, and skill-oriented learning experiences (Desky, Taali, et al., 2025).

The product developed in this study is a virtual learning-based practical worksheet (e-jobsheet) on mechanical measuring instruments, delivered through Google Classroom as a Learning Management System (LMS) (Ermawalis et al., 2025). The use of Google Classroom serves as a structured platform for distributing interactive learning content, managing assignments, and facilitating communication, while the PjBL approach enables students to engage in authentic measurement and inspection tasks that simulate real-world practices. The implementation of this product involved tenth-grade students (N=35) in the Motorcycle Engineering Department at SMK Negeri 2 Palembang. The overall stages of the ADDIE model applied in this study are illustrated in Figure 1.

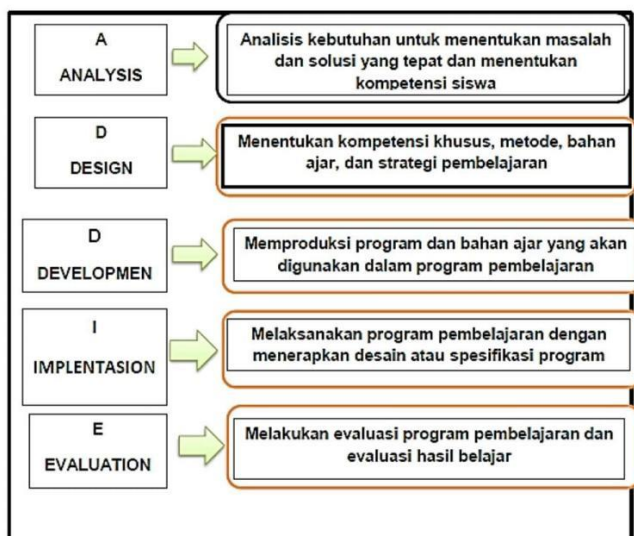


Figure 1. Model ADDIE

The Analysis phase was conducted through a review of the Learning Outcomes (LO) documents of the Merdeka Curriculum, participant observations of the practical learning process, and limited interviews with subject teachers to identify the need for jobsheet development. Additionally, an analysis of student characteristics was conducted, covering learning readiness, prior learning experiences, and digital media literacy. In the Design phase, the researcher designed the worksheet structure, digital interface, and PjBL-based learning flow. Subsequently, the Development phase produced a digital worksheet integrated into Google Classroom, which was then validated by subject matter experts, media experts, language experts, and learning

evaluation experts using a five-point rating scale ranging from “highly valid” to “highly invalid” based on Yulirismayenti et al. (2025) score conversion. In the Implementation phase, the worksheets were pilot-tested over approximately 3 sessions (12 × 45 minutes per session) with all students in Class X TSM 2, with teachers and students completing a practicality questionnaire using a five-point Likert scale. The Evaluation phase was conducted formatively at each stage and summatively through analysis of pretest–posttest results (Desky, Taali, et al., 2025).

The research instruments included an observation sheet, an interview guide, an expert validation questionnaire, a practicality questionnaire, and a 30-item multiple-choice test covering cognitive domains C1–C5 according to Bloom’s taxonomy. Validity data analysis used the mean formula and a five-point scale score conversion (Deviana et al., 2025), while practicality was calculated using a percentage formula with categories ranging from excellent (80%–100%) to very poor (0%–19.99%) (Sugiyono, 2020). Product effectiveness was analyzed through the calculation of Normalized Gain (N-Gain) to measure the increase in learning outcomes between the pretest and posttest, followed by a normality test using SPSS version 23, as well as a paired-sample t-test hypothesis test with a significance level of $\alpha = 0.05$ to determine whether there was a significant difference in learning outcomes before and after the implementation of the virtual learning-based worksheet (Deviana et al., 2025).

Result and Discussion

Result

Define Stage

This study employs a Research and Development (R&D) approach to produce a product in the form of a virtual learning-based mechanical measurement tool worksheet (e-jobsheet), developed using the ADDIE model (Analysis, Design, Development, Implementation, Evaluation). Virtual learning in this study refers to interactive digital learning content delivered through Google Classroom as a Learning Management System (LMS), rather than the platform itself. The developed product integrates Project-Based Learning (PjBL) principles to facilitate authentic, task-based learning experiences relevant to industrial practices. A pilot study was conducted with 40 tenth-grade students (N=40) in the Motorcycle Technology program at SMK Negeri 2 Palembang. The validation process involved four experts—a media expert, a content expert, a language expert, and a learning evaluation expert—to ensure the product’s validity. The entire research procedure systematically followed the ADDIE model’s stages.

The needs analysis phase was conducted through observations and structured interviews with teachers in the Motorcycle Technology program to identify learning conditions and challenges faced. The observation instrument consisted of 16 items covering three aspects: lesson preparation (4 items), implementation of Project-Based Learning (9 items), and follow-up activities (3 items). Additionally, the interview guide consisted of 15 questions focused on the use of practice worksheets, the integration of PjBL, the utilization of Google Classroom as an LMS, and expectations regarding the development of digital learning media. Analysis results indicate that the practice worksheets used are systematically organized as guides for practical activities; however, they remain predominantly in printed form, thereby limiting flexibility, interactivity, and opportunities for independent learning among students. Furthermore, regarding mechanical measuring instruments, some students still struggle to read measurement scales and accurately determine precision levels. These findings indicate a gap between the availability of instructional materials and students' competency achievements, thereby reinforcing the urgency of developing interactive, easily accessible e-worksheets based on virtual learning that support self-directed and repeated learning through digital platforms (Taali et al., 2024).

Define Stage

The design phase in this study generated two core outputs, namely the development of the practical worksheet (e-jobsheet) design and the assessment instrument design, both of which were constructed in a coherent, systematic, and pedagogically grounded manner. The e-jobsheet was specifically designed to facilitate procedural learning and the acquisition of technical skills through a comprehensive and structured format. It consists of essential components, including a cover page, jobsheet identity, concise theoretical framework, student identity, clearly defined learning objectives, usage instructions, occupational health and safety (OHS) aspects, a list of tools and materials, step-by-step work procedures, a measurement results table, reflective questions, and an assessment rubric. This structured design not only guides students in performing practical tasks systematically but also supports conceptual understanding, critical reflection, and self-evaluation. Simultaneously, Google Classroom was utilized as a Learning Management System (LMS) to organize and deliver virtual learning content in a structured and integrated manner. The platform was designed with a clear architecture, consisting of a main learning interface, activity guidelines, and session-based material sections that incorporate key components such as attendance tracking, access to e-jobsheets, tutorial videos, assignment submission features, assessment

rubrics, and documentation uploads of practical activities. This integrated system ensures that the learning process is not only well-organized and interactive but also aligned with the principles of Project-Based Learning (PjBL), thereby enabling students to engage in authentic, task-oriented, and contextually relevant learning experiences (Hazar et al., 2025).

The cover page serves as the initial point of interaction between students and the learning material, functioning as the primary visual and informational identity of the developed e-jobsheet. As illustrated in Figure 2, the cover page contains comprehensive product identification elements, including the Motorcycle Engineering competency area, subject name, grade level, jobsheet title aligned with the mechanical measuring instruments topic, a representative visual illustration of measurement practice activities, the author's name, and the year of development. The visual design is carefully crafted using a balanced composition of color schemes, typography, and layout to achieve both aesthetic appeal and professional presentation. This deliberate design strategy is intended to create a strong first impression, enhance students' engagement, and stimulate learning motivation from the outset before they engage with the instructional content. This finding is consistent with instructional media design principles, which emphasize that the initial visual appearance of learning materials plays a critical role in shaping learners' attention, perception, and readiness to participate in the learning process.



Figure 2. Jobsheet cover page view

Figure 3 displays the jobsheet's identification page and brief theory section, which serve as a bridge between the administrative context of learning and students' conceptual readiness prior to conducting the

practical exercise. The jobsheet's identification section contains important technical information, namely skill competencies, subject name, school location, grade/semester, and time allocation. This information clarifies the context of the learning implementation so that students understand the jobsheet's position within the overall curriculum framework. The brief theory section reinforces foundational concepts relevant to the mechanical measuring instruments to be practiced, covering definitions, functions, operating principles, and techniques for reading measurement results of the instruments discussed. The inclusion of a brief theoretical section in the worksheet is intended to ensure students have adequate knowledge before engaging in practical activities, thereby reducing procedural errors that often occur due to a lack of conceptual understanding. This approach aligns with Prastowo's (2015) view that effective instructional materials must provide conceptual orientation before students perform procedural skills.

materials is provided, complete with quantities and descriptions for each, to serve as a guide for practical preparation. This structured layout reflects the principles of vocational worksheet development outlined by the Ministry of Education and Culture (2008), namely that worksheets must be able to guide students in carrying out activities independently, safely, and in accordance with standard industry procedures.



Figure 3. Jobsheet identity page and brief overview

Figure 4 shows the core structure of the worksheet, which is organized systematically and sequentially to help students follow the flow of practical activities from start to finish. This structure includes the student's identifying information—such as name, class, subject, and date—to personalize the worksheet and track participation, followed by learning objectives that outline the competencies to be achieved, ensuring students have a clear direction in their learning. Instructions for using the worksheet are included to guide students in understanding how to use the worksheet independently, while occupational health and safety (OHS) aspects are explicitly highlighted to foster safety awareness and a safety culture—a crucial competency in vocational learning. A list of tools and

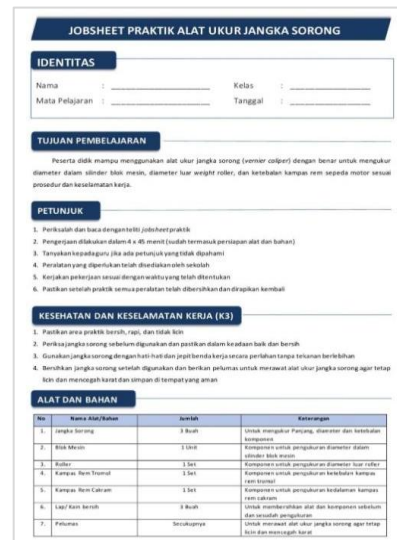


Figure 4. Jobsheet structure view

Figure 5 displays the work steps that form the operational core of the jobsheet as a technical guide for conducting measurement practices. The work steps are arranged in a sequential, systematic, and progressive manner, starting from the preparation stage, through the measurement process, to the completion of the activity, thereby forming a logical and easy-to-follow workflow. Each step is accompanied by a concise explanation and relevant supporting illustrations to clarify the procedures to be followed, particularly in stages requiring high precision, such as reading scales on vernier calipers, micrometers, or other precision measuring instruments. The inclusion of images in each step serves not merely as decoration but substantially helps students visualize the correct procedure, thereby minimizing the risk of measurement errors. This approach to presenting work steps using both text and images is consistent with Paivio's (1990) dual-coding theory, which states that information presented verbally and visually simultaneously is absorbed and remembered more effectively by students than when presented in a single modality.

Figure 6 shows the evaluation and reflection sections, which are key components of the project-based learning cycle. The evaluation section takes the form of a measurement results table designed to record the actual data obtained by students during the practical

activity, including columns for standards, measured values, and conclusions. Through this table, students are encouraged to compare their measurement results with the established standard values so they can objectively assess the level of precision and accuracy of their work. The reflection section contains open-ended questions designed to encourage students to think metacognitively about the learning process they have undergone, identify the difficulties encountered, and formulate solutions for improvement in subsequent activities. The inclusion of a reflection component in the worksheet aligns with the characteristics of the Project-Based Learning model, which emphasizes the importance of self-evaluation as an integral part of the learning process (Krajcik & Shin, 2014). Pedagogically, the combination of product evaluation and process reflection within a single worksheet component fosters the development of students' higher-order thinking skills—a primary requirement of the Merdeka Curriculum.

Figure 7 shows the assessment rubric, which serves as a transparent and objective evaluation guide for both teachers and students. The assessment rubric covers five equally weighted aspects, namely: reparation and implementation of occupational safety and health (OSH), the process and accuracy of measurements, the accuracy of measurement results according to standards, the ability to work collaboratively in a team, and the ability to answer reflective questions. These five aspects were carefully selected to reflect comprehensive competencies, covering the dimensions of attitude, process skills, product skills, social competencies, and cognitive competencies in a balanced manner. A key feature of this rubric is its open accessibility to students via Google Classroom before and during the practical activities. Early access to the rubric allows students to understand the expected performance standards, enabling them to prepare more effectively and with greater motivation to meet the established criteria. This approach reflects the principle of authentic assessment proposed by Mueller (2005), which states that rubrics communicated to students from the outset contribute to improved performance quality and a sense of responsibility toward the learning process.

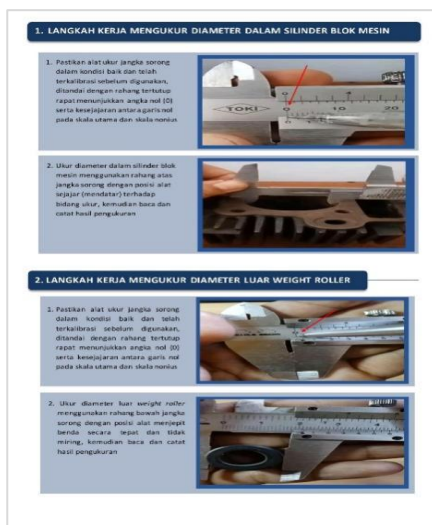


Figure 5. Workflow view

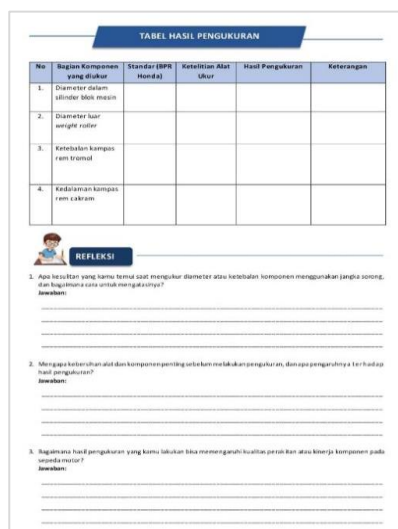


Figure 6. Evaluation and reflection section

RUBIK PENILAIAN			
No	Aspek Penilaian	Indikator Penilaian	Bobot
1.	Penyagaan dan K3	Mempersiapkan alat dan bahan dengan benar dan melaksanakan keselamatan kerja	20
2.	Proses dan pengukuran	Melakukan pengukuran diameter dalam silinder blok mesin, diameter luar weight roller, dan ketelitian ketepatan cara membaca meter standar prosedur	20
3.	Hasil pengukuran	Hasil pengukuran tepat dan sesuai standar	20
4.	Kerja sama tim	Bekerja sama dengan baik, saling membantu dan bertanggung jawab	20
5.	Refleksi	Mengapa pertanyaaan refleksi dengan benar dan jelas	20

Figure 7. Rubik's cube assessment display

Figure 8 shows the bibliography page listing all the references used as the basis for the brief theoretical framework in the job sheet. The inclusion of a bibliography in the job sheet is not merely an academic formality; rather, it serves an important substantive function in the context of instructional material development. First, the bibliography provides a scientifically accountable foundation for the content presented, thereby enhancing the accuracy and credibility of the jobsheet as instructional material. Second, the inclusion of references opens opportunities

for learners who wish to deepen their understanding to independently trace the original sources, which is part of fostering self-directed learning. Third, the presence of a bibliography reflects the researcher’s commitment to academic integrity in the development of learning materials. This aligns with the standards for instructional materials established by the National Education Standards Agency (BSNP), which require that high-quality instructional materials must include valid, reliable, and relevant references aligned with the competencies being taught.



Figure 8. Bibliography format

Figures 9 and 10 the class stream homepage is the first page students see when they access the virtual classroom via Google Classroom. The class cover is designed to present the class’s identity in a comprehensive and informative manner, including the course title “Fundamentals of Motorcycle Technology,” the academic year, the grade level, and the mechanical measurement tools to be covered, with an attractive visual design and images relevant to the vocational motorcycle mechanics learning context so that students can easily identify the class they are enrolled in while gaining an initial overview of the learning topics. Additionally, the announcements feature on the class homepage is utilized by teachers as a regular learning communication tool, through which teachers convey learning activity guidelines covering technical instructions for practical exercises, task workflows, job sheet submission requirements, and other important information organized in a structured manner with clear language so that all students can understand the instructions without having to rely entirely on the teacher’s verbal explanations in class. The combination of an informative class cover page and these structured

announcements creates a well-organized virtual learning environment while providing students with clear initial orientation before engaging in learning activities, which aligns with the perspective of Basilaia et al. (2020) that the effectiveness of digital platform-based learning is significantly influenced by the quality of organization and the clarity of instructional communication within that virtual environment.

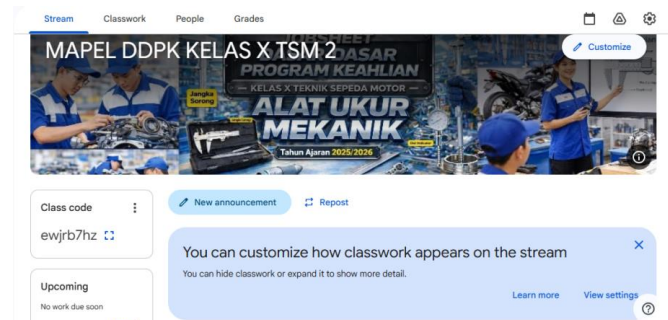


Figure 9. Cover image on the class home page

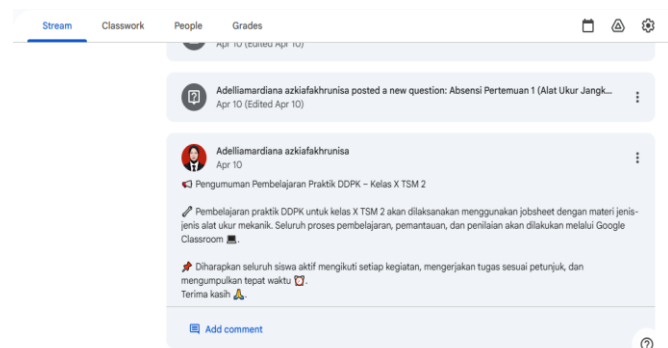


Figure 10. Class home page

Table 1. Assessment Results for the Virtual Learning-Based Mechanical Measuring Instruments Worksheet

Assessment Aspects	Average Validator Value	Categories
Media Suitability	0.908	Valid
Content Suitability	0.900	Valid
Language Eligibility	0.867	Valid

Based on the table above, all assessment scores from the three validators fall within the range of 4.22–5.00, which falls into the “highly valid” category. The media expert’s assessment score of 96% indicates that the visual presentation of the job sheet meets the standards for effective instructional media. The content expert’s evaluation of 95% indicates that the jobsheet’s content aligns with the targeted competencies, is conceptually accurate, and is presented in a logical sequence consistent with vocational learning procedures. The 93% rating from the language expert indicates that the language used in the worksheet is structurally correct, effective in conveying the message, and appropriate for

the students' developmental level. Thus, the product is deemed suitable for use in learning without revision.

Table 2. Validity Level Categories (Irsyadunas et al., 2021)

Achievement Level	Categories
0-0.666	Invalid
≥ 0.666	Valid

The average teacher response rate of 92.72% and the average student response rate of 93.18% both fall into the

“very good” category. The high practicality scores from both groups indicate that the Google Classroom-based worksheets are easy to use, the content is presented clearly, and the practical activities were carried out effectively. The insignificant difference in percentage between teacher and student responses also demonstrates consistency in the assessment of the product’s practicality from both the facilitator’s and the direct user’s perspectives.

Table 3. Practical Data Results from Teacher and Student Response Questionnaires.

Indicator	Percentage		Practicality Criteria	Percentage Student Assessment	Practicality Criteria
	Teacher Assessment				
Technical	92.33		Very Practical	93.33	Very Practical
Effective	93.50		Very Practical	93.50	Very Practical
Design	92.72		Very Practical	93.18	Very Practical
Presentation and Delivery of Material	92.72		Very Practical	94.18	Very Practical
Presentation and Delivery of Material	92.00		Very Practical	93.20	Very Practical
Average Percentage (%)	92.94		Very Practical	93.94	Very Practical

The practicality test of the instructional media aimed to measure the level of practicality of the developed instructional media (Purnomo & Nuryanto, 2021). Based on this practicality test, the media received an average practicality score of 93.94% in the “very practical” category on the teacher feedback questionnaire. In the student feedback questionnaire, an average practicality score of 93.18% was obtained, which also falls into the “very practical” category. Therefore, based on feedback from teachers and students regarding the use of Google Classroom-based worksheets, it can be concluded that this learning medium is very practical to use.

Effectiveness of Virtual Learning-Based Job Sheets

Jobsheet Berbasis Virtual Learning worksheet that has been developed has undergone a validation process

and practical testing. In addition, the effectiveness of this tool was assessed using gain score tests and independent samples t-tests to measure its success.

Gain Score

When pretest and posttest results are compared using the N-Gain or gain score, the effectiveness of the learning media can be observed through improvements in student learning outcomes, as these scores indicate the extent to which students have progressed after using the media. If the gain score achieved by students reaches a minimum threshold of ≥ 0.3 , which falls into the moderate category, the learning media is then considered effective in enhancing student understanding and performance.

Table 4. Conclusions from the N-Gain Analysis

Aspects Analyzed	Value	Description
Number of Students	40	All students participated
Pre-test Average	30.92	Relatively low initial proficiency
Post-test Average	86.00	Significant improvement in learning outcomes
Average Difference	55.08	Significant improvement
N-Gain (g)	0.80	High Category
N-Gain (%)	80%	High learning effectiveness
Category	Tall	Based on the N-gain criteria

Table 5. Distribution of Students' N-Gain Categories

Aspects Analyzed	Value	Description
Tall ($g \geq 0.70$)	36	90%
Moderate ($0.30 \leq g < 0.70$)	4	10%
Low ($g < 0.30$)	0	0%
Total	40	100%

The average N-gain score of 0.80 falls into the high category. The distribution of N-gain categories shows that 36 students (90%) were in the high category, 4 students (10%) in the moderate category, and no students were in the low category. The dominance of the high category among 90% of the students indicates that

virtual learning-based worksheets are capable of having a consistent and significant impact on improving the understanding of all students.

A homogeneity test was conducted as a prerequisite for parametric statistical tests. Based on Table 4.14, the significance value for the Based on Mean is $0.779 > 0.05$; therefore, it can be concluded that the variances of the pretest and posttest data are homogeneous and suitable for proceeding to the next stage of analysis.

A normality test was conducted using the Shapiro-Wilk test because the sample size was 40 students ($n < 50$). The hypotheses used were H_0 : the data are normally distributed and H_1 : the data are not normally distributed, with the following decision criterion: if $Sig. > 0.05$, then H_0 is accepted.

Table 6. Results of Normality Tests

Class	Data	Shapiro-Wilk		
		Statistic	df	Sig
Value	PreTest	.946	40	.120
	PostTest	.935	40	.095
	PreTest	.952	40	.119
	PostTest	.964	40	.090

The Shapiro-Wilk p-values for the pretest (0.120) and posttest (0.095) were both greater than 0.05, so H_0 was accepted. The pretest and posttest data were found to be normally distributed and met the requirements for the use of the paired-sample t-test.

Table 7. Homogeneity Test of Experimental Class and Control Class Pre-test and Post- test

Independent Samples Test				
Levene's Test for Equality of Variances	t- Test for Equality of Means			
	F	Sig.(2-tailed)	T	Df
Equal Variances Assumed	.126	0.00	-72.320	39
Equal Variances Assumed		0.00	4.086	59.859

Based on Table 4, there was an increase in the mean score from 30.92 on the pretest to 86.00 on the posttest. Table 6 shows a correlation coefficient of 0.519 with a significance level of 0.001, indicating a fairly strong and consistent relationship between the pretest and posttest scores. Table 7 shows a calculated t-value of -72.320 with a mean difference of -55.125 (the posttest score is higher than the pretest) and a Sig. (2-tailed) value of $0.000 < 0.05$. Thus, H_0 is rejected and H_a is accepted, meaning there is a significant difference between students' learning outcomes before and after the implementation of the virtual learning-based mechanical measurement worksheet using Google Classroom.

Discussion

The validation results of the virtual learning-based mechanical measuring instrument jobsheet indicate a very high level of validity with an average of 94.6%, including assessments from media experts (96%), material experts (95%), and language experts (93%), all of which fall within the interval of 4.22–5.00 on a five-point scale. This indicates that the product has comprehensively met feasibility standards in terms of appearance, content, and language. The high validation score from media experts reflects that the visual design of the developed jobsheet covering proportional layout, readable typography, harmonious color combinations, and completeness of illustrative images – is aligned with the principles of effective instructional media design, as stated by Arsyad (2014) that the quality of instructional media appearance directly affects readability and learners' comprehension. The material expert validation score of 95% confirms that the content reflects conceptual accuracy, appropriate scope, relevance to targeted competencies, and systematic work procedures in accordance with vocational learning standards. Meanwhile, the language expert validation score of 93% indicates that the language used is structurally appropriate, effective in conveying information, and suitable for the intellectual development level of vocational high school students, consistent with Daryanto and Dwicahyono (2014). This level of validity also reflects the success of an iterative validation process involving experts with relevant academic and professional backgrounds, in line with Nieveen (1999), which emphasizes that valid learning products must reflect state-of-the-art knowledge and internal consistency among components.

The practicality analysis results show an average teacher response of 92.72% and an average student response of 93.18%, both categorized as very good, indicating that the developed product successfully meets practical needs from both the facilitator and user perspectives. From the teacher's perspective, the high practicality score demonstrates that the Google Classroom-based jobsheet effectively supports the organization of practical activities, monitoring of student participation, systematic distribution of materials and assignments, and implementation of transparent and objective assessments. The integration of Google Classroom as a platform for administration and material distribution has been shown to reduce administrative workload while improving the efficiency of learning management. From the students' perspective, the high score indicates that the jobsheet is easy to understand, tutorial videos help clarify complex procedures, and digital accessibility provides learning flexibility not available in conventional printed jobsheets. This finding supports Rogers (1983), who

states that technologies with relative advantages and ease of use are more readily adopted. Moreover, the high practicality is aligned with the characteristics of digital-native students, reinforcing the relevance of Google Classroom-based virtual learning in supporting 21st-century vocational education, as also highlighted by Hamid et al. (2020).

The effectiveness analysis reveals a significant improvement in learning outcomes, as indicated by the increase in average scores from 30.92 (pretest) to 86.00 (posttest), with an N-gain value of 0.80 in the high category, confirming both absolute and relative improvement. The distribution showing that 90% of students fall into the high N-gain category demonstrates that the positive impact is experienced broadly, not limited to certain groups. The paired sample t-test result (Sig. $0.000 < 0.05$) confirms a statistically significant difference between pretest and posttest results, while the correlation value of 0.519 ($p = 0.001$) indicates consistent and structured improvement attributable to the applied learning intervention. This effectiveness is driven by the integration of structured jobsheets, the Project Based Learning (PjBL) model, and the Google Classroom platform. The jobsheet provides clear guidance, PjBL promotes active engagement through authentic learning processes, and Google Classroom facilitates access to materials, assignment management, and transparent feedback. This synergy creates an active and structured learning environment aligned with Vygotsky's constructivist theory and is consistent with prior studies such as Pratiwi et al. (2021) and Rahayu and Suryani (2022), ultimately confirming that the developed product is both feasible and effective for broader implementation in vocational high school learning.

Conclusion

This study concludes that the developed virtual learning-based e-jobsheet on mechanical measuring instruments is valid, practical, and effective for use in vocational education. The validity results indicate a very high level (94.6%) across media, content, and language aspects, confirming that the product is conceptually sound, well-structured, and pedagogically appropriate. In terms of practicality, both teachers (92.72%) and students (93.18%) provided highly positive responses, demonstrating that the e-jobsheet is easy to use and effectively supports structured and flexible learning activities. Furthermore, the product has been proven effective in improving students' learning outcomes, as evidenced by the significant increase in posttest scores compared to pretest results and a high N-gain value (0.80). Statistical testing confirms that this improvement is significant and consistent. This effectiveness is strongly influenced by the integration of structured

practical worksheets, the Project-Based Learning (PjBL) model, and the use of Google Classroom as a Learning Management System (LMS), which together create an active, organized, and interactive learning environment aligned with the demands of 21st-century vocational education.

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Authors Contribution

Conceptualization and methodology, H. L. B.; software, validation, formal analysis, and investigation, H. L. B. and A.; data curation, H. L. B. and A.; writing—original draft preparation, H. L. B., A. and R.; writing—review and editing, R.

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Conflicts of Interest

There is no conflict of interest.

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