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Developing Augmented Reality Based Worksheets (LKPD) to Improve Learning Outcomes of Culinary Industry Kitchen Equipment Materials

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Abstract: This research was conducted to evaluate the development process, feasibility, practicality, and effectiveness of implementing an Augmented Reality (AR) based Student Worksheet (LKPD) focused on Culinary Industry Kitchen Equipment for 10th grade culinary students at SMK Widya Praja Ungaran. The study was initiated due to the limited visual representation of expensive laboratory equipment and a reliance on conventional, static worksheets that do not fully align with modern industry standards. Utilizing a Research and Development (R&D) approach with the 4D model (Define, Design, Develop, Disseminate), data were gathered via expert evaluation sheets, student feedback questionnaires, and learning achievement assessments measured through pre-tests and post-tests from 69 participants divided into experimental and control classes. The findings revealed that the development successfully combined printed worksheet with an Android-compatible AR app created via Unity and Vuforia SDK. Content and media experts rated the learning media as highly feasible, scoring 94.58% and 90.00% respectively. Moreover, a student questionnaire score of 88.89% confirmed its high practicality. The effectiveness analysis through an Independent Samples T-Test showed a significance value of 0.000 (Sig. < 0.05), proving a substantial gap in performance between both groups. The experimental group achieved a high average Normalized Gain (N-Gain) score of 0.72, surpassing the control group's score of 0.23. In conclusion, the AR integrated LKPD is validated as a viable, practical, and effective educational medium for advancing students' cognitive performance in industrial kitchen equipment topic.

Keywords: Augmented Reality; Industrial Kitchen Equipment; Student Worksheet; Vocational Education.

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Introduction

Vocational High Schools (SMK) in the Culinary Arts program hold a strategic role in preparing a skilled workforce capable of meeting the demands of the modern hospitality and food service industry. To achieve professional competence, students are required to master various foundational skills, including a comprehensive understanding of industrial kitchen equipment and its operation. However, vocational institutions frequently encounter structural challenges related to infrastructure procurement. The high acquisition costs, complex maintenance requirements, and rapid technological advancement of industrial kitchen equipment create a resource gap, preventing many schools from providing adequate access to real industrial tools for practical learning activities (Nurhadi, 2025; Supriyanto et al., 2023). As a result, students often experience difficulties in understanding the characteristics, functions, and operational procedures of industrial kitchen equipment through conventional

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learning resources alone. To address these challenges, the integration of innovative digital technologies into vocational education has become increasingly important.

Augmented Reality (AR) is recognized as a promising educational technology that combines virtual objects with real-world environments in real time, enabling users to interact with three-dimensional digital representations through mobile devices (Maimuna et al., 2024; Santoso, 2020). By providing realistic visualizations of equipment and processes, AR can reduce the limitations caused by the unavailability of physical learning facilities. Previous studies have reported that AR enhances students' conceptual understanding, learning motivation, spatial visualization abilities, and critical thinking skills by transforming abstract information into more concrete learning experiences (Bakri et al., 2020; Defita et al., 2025).

The integration of AR into Student Worksheets (LKPD) offers additional pedagogical advantages because it combines structured learning activities with interactive digital visualization. LKPD serves as a learning guide that facilitates students' knowledge construction through systematic activities, inquiry processes, and problem-solving tasks (Hikmah et al., 2021; Prastowo, 2015). Previous studies have demonstrated that AR-assisted worksheets can improve student engagement and learning effectiveness across various educational disciplines, including science, mathematics, thermodynamics, and biology (Bakri et al., 2020; Defita et al., 2025; Hidayani et al., 2025). Similar findings have also been reported in vocational education, where conventional learning media often fail to adequately support students' understanding of practical and equipment-oriented materials (Aryani et al., 2023; Kandriasari et al., 2024).

A review of previous studies reveals that AR-based worksheets have primarily been developed for science-related subjects, including physics, biology, thermodynamics, mathematics, and respiratory system learning. In addition, most studies were conducted in general education settings such as elementary, junior high, and senior high schools, with a primary focus on product feasibility, student engagement, and conceptual understanding. However, studies investigating AR-based worksheets for vocational culinary education, particularly for industrial kitchen equipment learning, remain scarce. Furthermore, comprehensive evaluations encompassing product validity, practicality, and effectiveness in improving students' learning outcomes are still relatively scarce.

Therefore, this study develops and evaluates an AR-based Student Worksheet (LKPD) specifically designed for industrial kitchen equipment learning in vocational culinary education. The study aims to assess the product's validity through expert evaluation, determine its practicality based on teacher and student responses, and examine its effectiveness in improving the cognitive learning outcomes of tenth-grade culinary arts students. The findings are expected to contribute to the development of innovative learning media that support competency-based vocational education while addressing limitations in educational facilities and equipment availability.

Method

This study employed a Research and Development (R&D) approach using the 4D development model proposed by Thiagarajan et al. (1974), which consists of four systematic phases: Define, Design, Develop, and Disseminate. The objective of this research was to develop an Augmented Reality (AR)-based Student Worksheet (LKPD) focused on culinary industry kitchen equipment materials for tenth-grade Vocational High School (SMK) students.

The research was conducted at SMK Widya Praja Ungaran during the 2025/2026 academic year. The research subjects comprised 69 tenth-grade students majoring in Culinary Arts, divided into two operational groups: an experimental class consisting of 35 students (Class X Kuliner 1) utilizing the AR based LKPD, and a control class consisting of 34 students (Class X Kuliner 2) utilizing conventional printed instructional materials. Additionally, an evaluation instrument try-out was conducted with 22 eleventh-grade students from Class XI Kuliner 1 to test the cognitive assessment tool.

The media development process utilized specific hardware and software tools. The visual layout and design of the LKPD were developed using Canva, while the structuring of contents, learning materials, working instructions, and evaluation components was compiled using Microsoft Word Office. The development of the Augmented Reality application was executed using Unity 3D integrated with the Vuforia Software Development Kit (SDK) as the image tracking and marker recognition system. Target markers were printed and embedded directly within the LKPD pages to project real-time three-dimensional (3D) visualizations of industrial kitchen equipment through Android mobile devices. The finalized application was exported into an Android Package Kit (APK) format to be installed on Android smartphones.

The research procedures followed the sequential stages of the 4D development model (Thiagarajan et al., 1974) as follows:

1. Define: Conducted by analyzing curriculum requirements, student characteristics, learning achievements, learning constraints, and the

core instructional needs regarding culinary industry kitchen equipment.
2. Design: Conducted by drafting the LKPD structure, designing visual layouts, compiling learning materials and tasks, placing the target markers, and designing the AR application user interface.
3. Develop: Conducted by building the AR based LKPD using Unity 3D and Vuforia SDK, performing product validation by material and media experts, revising the product based on validators' feedback, and implementing the media during classroom instruction in the experimental class.
4. Disseminate: Conducted through limited distribution of the finalized product within the vocational education environment.

Data collection techniques included product validation sheets, assessment instrument validation sheets, teacher and student response questionnaires, and learning achievement tests consisting of pre-tests and post-tests. Product validity was evaluated by material and media experts using structured validation instruments, while content validity was analyzed using Aiken's V coefficient (Aiken, 1985). The validity of the cognitive test instrument was evaluated through a try-out session involving 22 students from Class XI Kuliner 1. Product practicality was measured through teacher and student response questionnaires, while product effectiveness was determined based on student learning outcomes in both the experimental and control classes.

Data analysis was performed using descriptive and inferential statistical techniques. The reliability of the research instruments was analyzed using Cronbach's Alpha (Cronbach, 1951) and the Intraclass Correlation Coefficient (ICC) (Koo & Li, 2016). Practicality data were analyzed using descriptive percentage analysis. The evaluation of learning outcomes was computed using SPSS version 25 software. Prerequisite statistical analyses included normality tests using the Shapiro–Wilk method (Shapiro & Wilk, 1965) and homogeneity tests using Levene's test (Levene, 1960). Hypothesis testing was carried out using the Independent Samples T-Test to determine the significance of learning achievement differences between the experimental and control cohorts. The effectiveness level of learning improvement was evaluated using the Normalized Gain (N-Gain) score (R. Hake, 1998)

Instrument Validity and Reliability

The validity and reliability analyses indicated that the research instruments met the required standards for educational research. The media validation instrument obtained an Aiken's V coefficient of 0.81, while the material validation instrument achieved a coefficient of 0.96, both categorized as having high validity. Furthermore, 25 out of 30 cognitive test items were declared valid and retained for subsequent data collection. The reliability analysis showed excellent inter-rater agreement among experts, with ICC values of 0.799 for the media validation instrument and 0.818 for the material validation instrument. In addition, the student response questionnaire demonstrated excellent internal consistency, as indicated by a Cronbach's Alpha coefficient of 0.913. These findings confirm that the instruments were valid and reliable for evaluating the developed AR based Student Worksheet (LKPD).

Table 1. Instrument Validity and Reliability Results

Instrument	Analysis Method	Value	Category
Media Validation Instrument	Aiken's V	0.81	High Validity
Material Validation Instrument	Aiken's V	0.96	High Validity
Media Expert Agreement	I CC	0.799	Excellent
Material Expert Agreement	ICC	0.818	Excellent
Student Response Questionnaire	Cronbach's Alpha	0.913	Reliable

Result and Discussion

Product Feasibility

The feasibility of the Augmented Reality (AR) based Student Worksheet (LKPD) was evaluated through expert validation involving material experts and media experts. The assessment aimed to determine whether the developed product met the requirements for implementation in the learning process. The results of the feasibility assessment are presented in Table 1.

Table 2. Product Feasibility Assessment Results

Validator	Score (%)	Category
Material Expert	94.58	Very Valid
Media Expert	90.00	Very Valid

The results indicate that the AR based LKPD achieved a very feasible category according to both material and media experts. The material expert assessment showed that the content was relevant to the curriculum objectives, accurate, and appropriate for learning industrial culinary kitchen equipment. Meanwhile, the media expert assessment demonstrated that the worksheet design, Augmented Reality integration, three-dimensional visualization, and application usability met the criteria of an effective

learning medium. The high feasibility scores suggest that the developed AR based LKPD can be utilized as a learning resource in vocational education. The integration of three-dimensional visualization allows students to observe industrial kitchen equipment more concretely than conventional printed learning materials. This feature is particularly beneficial in vocational learning, where students are required to understand the structure, functions, and operational characteristics of industrial culinary equipment before engaging in practical activities.

Product Practicality

The practicality of the product was measured through teacher and student response questionnaires after the implementation of the AR based LKPD in the learning process. The results revealed a practicality score of 88.89%, which falls into the "very practical" category.

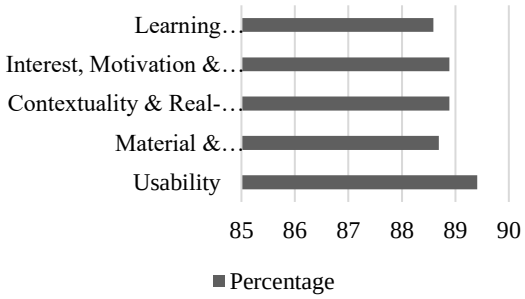

Figure 1. Student Response Percentage toward the AR Based LKP

The high practicality score indicates that the developed learning media was easy to use and accessible during classroom activities. Students were able to operate the application independently using Android devices and scan the embedded markers to display three-dimensional objects in real time. Furthermore, the interactive features enhanced student attention and engagement throughout the learning process.

From the teachers' perspective, the media facilitated content delivery by providing visual representations of industrial kitchen equipment without requiring the physical availability of the actual equipment, which is often costly and difficult to provide in schools. Therefore, the AR based LKPD can serve as a practical alternative learning medium for vocational culinary education.

Product Effectiveness

The effectiveness of the AR based LKPD was examined through pre-test and post-test results obtained from the experimental and control groups. The Independent Samples T-Test analysis revealed a significance value of 0.000 ($p < 0.05$), indicating a statistically significant difference in learning outcomes between students who used the AR based LKPD and those who learned using conventional printed materials.

Table 3. Independent Samples T-Test Results

Levene's Sig.	t	df	Sig. (2-tailed)	Mean Difference	Lower CI	Upper CI
0.631	7,248	69	0.000	13,530	9,806	17,254

To determine the magnitude of learning improvement, the Normalized Gain (N-Gain) score was calculated for both groups.

Table 4. Comparison of N-Gain Scores Between Experimental and Control Groups

Class	N-Gain Score	Category
Experimental Class	0.72	High
Control Class	0.23	Low

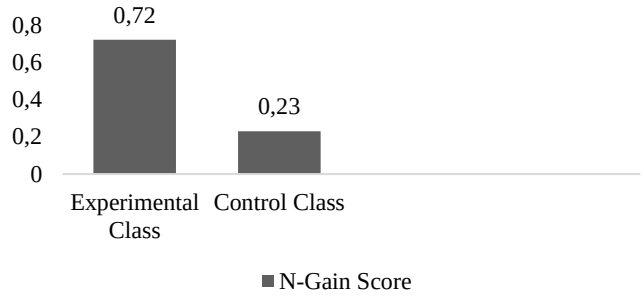

Figure 2. Comparison of N-Gain Scores

The experimental group achieved an average N-Gain score of 0.72, categorized as high, whereas the control group obtained an average score o f 0.23, categorized as low. These results indicate that the AR based LKPD was more effective in improving students' cognitive learning outcomes than conventional learning materials.

The effectiveness of the developed media can be attributed to the integration of interactive three-dimensional visualization, which enables students to observe the shape, components, and functions of industrial kitchen equipment more clearly. Such visualization supports conceptual understanding and facilitates the learning of equipment that may not be readily available for direct observation in schools.

In addition, the implementation of AR technology encouraged students to participate actively in the learning process. The combination of printed worksheets and digital interactive content created a

more engaging learning environment, leading to improved comprehension and retention of learning materials. The findings indicate that the developed AR based LKPD is highly feasible, practical, and effective for learning industrial culinary kitchen equipment. The feasibility assessment conducted by material and media experts yielded scores of 94.58% and 90.00%, respectively, placing the product in the very feasible category. These findings are consistent with previous studies reporting that AR-integrated learning materials generally achieve high levels of feasibility due to their ability to combine instructional content with interactive visualization features (Bakri et al., 2020; Hidayani et al., 2025).

The high feasibility score obtained from material experts demonstrates that the content of the developed LKPD aligns with curriculum objectives and learning outcomes. This result supports previous findings indicating that AR based worksheets can effectively facilitate concept delivery when instructional content is systematically designed according to learning objectives (Utama & Margunayasa, 2024). Likewise, AR assisted worksheets have been reported to achieve excellent material feasibility because they present learning content more clearly and interactively than conventional materials (Bakri et al., 2020).

The media feasibility results also confirm that the integration of Augmented Reality technology, worksheet layout, marker design, and application usability successfully met educational media standards. AR technology has been shown to enhance learning media quality by providing real-time interaction between virtual objects and physical learning resources (Damayanti & Sulisworo, 2022). In addition, marker based AR applications can improve students' understanding through immersive visualization experiences (Destiara et al., 2021).

The practicality assessment showed a score of 88.89%, indicating that the developed LKPD was very practical for classroom use. Students were able to operate the application independently using their smartphones and interact with three-dimensional representations of industrial kitchen equipment. Similar findings indicate that AR based learning materials are generally perceived as easy to use and helpful for independent learning (Yusnarti et al., 2022). Furthermore, well-designed worksheets can improve classroom management and student engagement by providing structured learning guidance (Rizky et al., 2023).

The effectiveness analysis revealed a significant difference between the experimental and control groups (Sig. = 0.000). Students who learned using the AR based LKPD achieved substantially higher learning outcomes than those who used conventional printed materials. These results support previous studies indicating that AR technology positively influences learning achievement by transforming abstract concepts into concrete visual experiences (Defita et al., 2025; Supriyanto et al., 2023).

The experimental group achieved a high N-Gain score of 0.72, while the control group obtained a low N-Gain score of 0.23. This substantial difference indicates that AR technology contributes significantly to learning improvement. Similar findings indicate that AR based learning environments enhance students' conceptual understanding and critical thinking skills (Defita et al., 2025). In addition, integrating AR into learning activities has been found to increase students' motivation and participation, ultimately leading to better academic performance (Sartika et al., 2026)

One of the major advantages of the developed LKPD lies in its ability to visualize industrial kitchen equipment through interactive three-dimensional models. AR visualization enables learners to observe objects from multiple perspectives, thereby improving spatial understanding (Fitriyana & Nurhadi, 2025). This characteristic is particularly relevant in vocational education, where students must understand the structure and operation of equipment before engaging in practical activities. Furthermore, AR technology strengthens visual-spatial skills that are essential for vocational competence development (Nurhadi, 2025).

The findings also demonstrate that AR technology can address limitations in educational facilities. Schools often face difficulties in providing industrial-scale equipment due to financial constraints. In this context, AR serves as an alternative solution by simulating industrial equipment digitally while maintaining meaningful learning experiences. Previous studies have shown that AR can compensate for the lack of laboratory equipment by providing virtual observation opportunities (Bakri et al., 2020). Similar conclusions emphasize the role of interactive digital media in supporting vocational education where access to specialized equipment is limited (Kandriasari et al., 2024).

Overall, the results confirm that the developed AR based LKPD successfully bridges the gap between theoretical knowledge and practical understanding. The integration of printed worksheets and AR technology creates an engaging learning environment that supports conceptual understanding, student motivation, and learning achievement. Therefore, the developed product has considerable potential for broader implementation in vocational education and other learning contexts requiring visualization of complex equipment and procedures.

Conclusion

The development of the Augmented Reality (AR) based Student Worksheet (LKPD) for industrial culinary kitchen equipment has demonstrated its potential as an innovative learning medium in vocational education. The integration of printed worksheets with AR technology provides students with a more interactive and contextual learning experience, enabling them to visualize industrial kitchen equipment that may not be readily available in schools. The implementation of the developed media supports student engagement, facilitates conceptual understanding, and enhances the overall learning process. This study contributes to the field of educational technology by providing an alternative digital learning solution that can support the teaching of practical and equipment-oriented subjects in vocational education. Furthermore, the findings highlight the potential of AR technology to be adapted and implemented in other vocational disciplines requiring the visualization of complex tools, equipment, and procedures.

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