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Advancing vocational education with VocAR-Flip: Improving student's comprehension in the digital era

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Abstract: In the 21st century, globalization and digital transformation significantly changed patterns of life, including the education sector in Indonesia. Vocational schools were expected to prepare students to compete in the global market; however, they continued to encounter challenges in improving the quality and relevance of learning. This study aimed to develop and evaluate flipbook-based learning media integrated with Augmented Reality (AR) to strengthen students' engagement, conceptual understanding, and readiness for the digital era. The research employed a pre-experimental method with a one-group pretest–post-test design involving 149 vocational school students in West Java. Data analysis showed that the application of the VocAR-Flip model resulted in an N-gain score of 74.3%, which indicated a high level of effectiveness in improving students' academic achievement and conceptual understanding. The novelty of this research lies in combining the practicality of flipbook media with the immersive features of AR, producing an interactive learning model that had not been widely applied in vocational education in Indonesia. The findings contribute to the advancement of educational technology by offering an innovative and scalable model that supports Industry 4.0 skills. Furthermore, this research provides benefits for policy reference by highlighting the need to integrate AR-based learning media into vocational school curricula to enhance competitiveness in the global workforce.

Keywords: augmented reality; digital era; flipbook; vocational high school

1. Introduction

The era of globalization marks the 21st century; there are significant changes in life patterns compared to the previous century. This condition is in line with the current era of digital transformation, where digital technology is at the center of almost all aspects of life (Plekhanov et al., 2022; Faidlatul Habibah & Irwansyah, 2021). Rapid adaptation and competitive skills in seeking job opportunities are significant in this digital transformation era. Information technology has become the main foundation of human life, including in the education sector in Indonesia. Strong skills, especially those related to technology, are needed (Santoso et al., 2023). In the world of work, prospective workers must have mature readiness. Therefore, individuals must thoroughly prepare themselves to face technological changes and ever-changing market demands (Rahmawati & Nurachadija, 2023) (Popov, 2023). In addition, according to (Popov, 2023; Ismail & Hassan, 2019), educational institutions, primarily vocational education, must ensure that their graduates are ready to face these challenges by developing relevant skills to compete in the digital era.

Vocational education, as implemented in Vocational High Schools (in Bahasa *Sekolah Menengah Kejuruan*/SMK), is a particular type of education designed to prepare students to enter the world of work (Brunetti & Corsini, 2019). The main aim of this education is to prepare students to compete in the global market, such as in industry and the world of work, and to become professionals in their vocational fields. Vocational schools face the challenge of organizing students to develop skills that improve their quality of life, expand their abilities, and start businesses. This challenge is to the goals of SMK, which include three career paths: Work, Continuing Education, and Entrepreneurship, often referred to as BMW (Saputra, 2024; Santika et al., 2023). On the other hand, there is still an urgent need to strengthen the role of vocational schools in producing medium-skilled workers. Limited skills among vocational school graduates often result in low productivity (Choi et al., 2019), leading to high unemployment rates among those who have just entered the job market. According to data from the Indonesian Central Statistics Agency (BPS), as of February 2023, the unemployment rate among vocational school graduates reached 9.6%, the highest figure among other education levels. This shows the need for further efforts to improve the quality and relevance of vocational education so that vocational school graduates can be better prepared and able to compete in the world of work (Indrawati & Kuncoro, 2021; Kovalchuk et al., 2022).

Currently, industry and the world of work require competent workers who can compete to produce high-quality products. Therefore, industry and the world of work must be more careful in selecting prospective workers who suit the required skills. The demand for skilled and competent human resources is increasing now and, in the future, (Piwowar-Sulej, 2021). However, various factors, such as vocational school students' lack of interest in learning, cause concentration problems, which hurt the mastery of skills expected from graduates (Song & Xu, 2024; Kartini et al., 2022; Nupiah et al., 2022). One factor that influences low interest and learning achievement among vocational school graduates is less than ideal and interactive learning media (Rachmadtullah et al., 2019). Several methods, such as PowerPoint presentations and modules, often need to support an optimal learning process more effectively. Therefore, the author proposes that this research's solution is the development of virtual-based learning media, namely flipbooks equipped with Augmented Reality (AR), called VocAR-Flip (Vocational Augmented Reality with Flipbook). This innovation is designed to meet student needs and face the challenges and demands that arise in the era of digital transformation. By utilizing the latest technology, this solution aims to increase student engagement and skills amidst the rapid changes occurring in the world of education (Chiu, 2023; Okoye et al., 2021).

Flipbooks, as simple interactive media, can improve student learning motivation (Oronce et al., 2021; Bunari et al., 2024). On the other hand, Augmented Reality (AR) is a technology that allows the projection of virtual objects into a natural environment (Fitria, 2023; Sharma et al., 2022). This research focuses on applying flipbooks with AR as a learning tool in vocational schools, especially in vocational schools, considering that vocational school students need essential practical skills in the digital transformation era (Saari et al., 2021). This research aims to determine the effectiveness of Flipbook learning media with AR in vocational schools. The benefit of this research is that it presents alternative interactive learning media in flipbooks combined with AR, which can be applied to the learning process in vocational schools.

During the learning process, SMK has various fields of study included in the basic framework and curriculum structure. One of the subjects that covers the topic of Environmental Occupational Safety and Health (K3LH) is Basic Program K3LH is the responsibility of everyone who works, including students in practice (Kartika et al., 2023; Sutianah, 2022). Teachers provide K3LH material to understand and protect students while working, both at school and at work, and prevent

them from accidents. Therefore, K3LH is vital in vocational schools, especially when students interact with dangerous materials, equipment, and work environments (Sanusi et al., 2023). Vocational school students must study K3LH material because understanding it helps them understand the importance of maintaining security, health, and safety in the workplace and preserving the environment (Arief Alfiyanto et al., 2023; Rizbudiani & Jaedun, 2021; Bilgiç & Aytaç, 2024). This knowledge is essential for vocational school students before they start working.

2. Methods

This research adopts an experimental method, namely pre-experiment. This pre- experimental design research method was carried out on one group, the experimental group, which received treatment using the Flipbook with AR learning media. The design form used by researchers is One Group Pretest Posttest Design, where they are first given an initial test (pretest) before being treated. After being given treatment, they are tested again with the same test questions as the final (posttest) test. The research design can be seen in Figure 1.

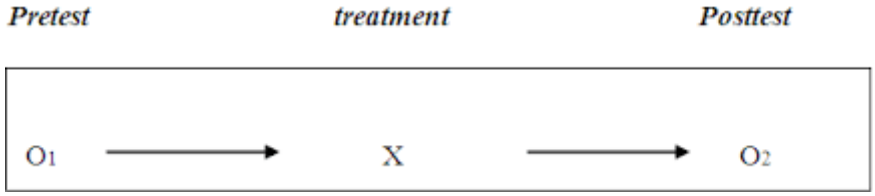

Figure 1. Pre-experiment one group pre-test post-test design

In this research, we conducted a trial of the test instrument, the results of which were analyzed using the advanced IBM SPSS Statistics 27 application. This trial was the first step in our process, allowing us to evaluate questions that could measure improvements in student learning outcomes. The aim of this trial was to assess the quality of the questions from various aspects such as validity, reliability, level of difficulty, and differentiating power of the questions before we conducted our main research (Maryani et al., 2021).

The validity of the questions is measured using the Product Moment Correlation formula. The test instrument consists of 20 questions for 20 class IX vocational school students with K3LH material. The validity of this instrument is assessed by comparing the calculated correlation value (count) with the correlation value contained in the criteria table (table). If the significance value of the test results is <0.05, then the instrument is considered valid; conversely, if the significance value is > 0.05, the instrument is considered invalid. The test results in Table 1 show that 15 questions have a count value exceeding the table value (0.468), namely 0.476 to 0.839, which concludes that the 15 questions can be used and are declared valid. A valid test instrument is a test tool that can measure what it should measure accurately and consistently.

Next, a reliability test was carried out using the Cronbach Alpha formula. Reliability measurement refers to the criteria listed in Table 2. This reliability test determines that if the r-Alpha value is positive and exceeds the table value, then the item is considered reliable; conversely, if the r-Alpha value is negative and smaller than the table value, then the question item is considered unreliable. The research results show a reliability value of 0.865, which is in the very high category. The reliability of test instruments is essential because it ensures the consistency and stability of repeated measurement results (Purwono et al., 2023).

Table 1. Question validity level

No item	Pearson correlation	Sig. (2-tailed)	Information
1	0.688**	0.001	Valid
2	0.544*	0.013	Valid
3	0.476*	0.034	Valid
4	0.557*	0.011	Valid
5	0.333	0.152	Invalid
6	0.313	0.179	Invalid
7	0.275	0.241	Invalid
8	0.512*	0.021	Invalid
9	0.647**	0.002	Valid
10	0.520*	0.019	Valid
11	0.763**	0.000	Valid
12	0.586**	0.007.	Valid
13	0.792**	0.000	Valid
14	0.513*	0.021	Valid
15	0.559*	0.010	Valid
16	0.839**	0.000	Valid
17	0.658**	0.002	Valid
18	0.613**	0.004	Valid
19	0.408	0.074	Invalid
20	0.712**	0.000	Valid
N	**20**		

Table 2. Question reliability level

Cronbach's alpha	N of items
0.865	15

The difficulty level formula detailed in Table 3 is used to evaluate the difficulty level difficulty of a question item. The difficulty level of a question is the opportunity to answer a question correctly at a certain level of ability, which is usually expressed as an index (Fitriani, 2021). The research results showed that nine of the 15 questions were in the medium category, while six were in the easy category, with a difficulty range between 0.35 and 0.90.

Table 3. Question difficulty level

No item	Pearson correlation	Sig. (2-tailed)
1	0.75	Easy
2	0.35	Currently
3	0.35	Currently
4	0.70	Currently
5	0.90	Easy
6	0.60	Currently
7	0.60	Currently
8	0.90	Easy

No item	Pearson correlation	Sig. (2-tailed)
9	0.70	Currently
10	0.80	Easy
11	0.80	Easy
12	0.80	Easy
13	0.40	Currently
14	0.60	Currently
15	0.70	Currently
N	**15**	

Finally, a discrimination test was conducted to prove that the answer choices were good. The research results in Table 4 show that the differentiating power of the questions used ranges from 0.275 to 0.839. The assessment of the differentiating power category is stated as moderate if the coefficient is in the range 0.2 to 0.4, said to be high if the coefficient is in the range 0.4 to 0.7, and very high if it is in the range 0.7 – 1.00 (Aviory & Susetyawati, 2021). From these results, it can be concluded that of the 15 questions used in this study, four questions had very high differentiating power, ten had high differentiating power, and 1 question had moderate differentiating power. Testing the discriminating power of questions is essential to ensure that the questions effectively differentiate between test takers with high and low abilities to provide more accurate and meaningful evaluation results (Anaya et al., 2022).

Researchers then use the question instruments that have been tested as a tool to measure the effectiveness of learning media in improving student learning outcomes through a comparison of pretest and post-test scores. The experimental class was treated by applying a flipbook with AR. Before treating students, researchers carried out normality and homogeneity tests to ensure that the data distribution was normal, and students had the same variance. After that, students were tested with a pretest and post-test to measure differences in their respective learning outcomes, ensuring the objectivity of the research.

Table 4. Question differentiating

No item	r_{count}	Differentiating power category
1	0.688	High
2	0.544	High
3	0.275	Currently
4	0.512	High
5	0.647	High
6	0.520	High
7	0.763	Very High
8	0.586	High
9	0.792	Very High
10	0.513	High
11	0.559	High
12	0.839	Very High
13	0.658	High
14	0.613	High
15	0.712	Very High
N	**15**	

The data collection technique used in this research is a test that aims to assess student learning outcomes, focusing on environmental, occupational safety, and health material. The analysis technique used in the research was to measure the effectiveness of the Flipbook learning media with AR by increasing learning outcomes before and after implementation using the N-gain formula. The N-Gain (Normalized Gain) score is used to measure the effectiveness of a research method. This score is calculated by comparing the pretest and posttest scores (Nasrul et al., 2022).

3. Results and discussion

3.1 Respondent demographics

This research involved 149 students from several vocational schools in West Java. The research subjects were students at level X who were studying the essential elements of the curriculum, including material regarding Environmental Occupational Safety and Health (K3LH). The participants were selected based on their relevance to the study program, and the focus of this research was to evaluate the understanding and application of K3LH material in the context of the skills they were studying. More details regarding respondent demographics can be seen in Table 5.

Table 5. Respondent demographics

Dimension	Category	Frequency	Percentage (%)
Gender	Male	75	50.3
	Female	74	49.7
Expertise Program	Construction and Housing Engineering	62	41.6
	Modeling Design and Building Information	87	58.4
Which school are from	State Vocational High School (SMKN) 1 Cibinong	62	41.6
	State Vocational High School (SMKN) 1 Sukabumi	29	19.5
	State Vocational High School (SMKN) 5 Bandung	58	38.9

Based on Table 5, it is known that in this study, 50.3% were men, and the rest were women. Apart from that, respondents came from vocational schools in West Java from the TKP and DPIB expertise programs, with details of 41.6% from SMKN 1 Cibinong, 19.5% from SMKN 1 Sukabumi, and the rest from SMKN 5 Bandung. The selection of respondents was based on specific criteria relevant to the research objectives, so the results obtained could provide in-depth insight into the level of knowledge between students from the various schools.

3.2 Normality test

Table 6 shows that the significance value of the normality test is 0.000. These results indicate that the data does not meet the normality test requirements, with a significance value smaller than 0.05, so it can be concluded that the data does not have a normal distribution. If the research data is not normally distributed, then in this study, nonparametric tests will be used for more accurate analysis (Annisak et al., 2024).

Table 6. Normality test results

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
Test		**Statistic**	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
Score	Pretest	.125	149	.000	.949	149	.000
	Post-test	.248	149	.000	.767	149	.000

3.3 Homogeneity test

In Table 7, the homogeneity test results show a Sig value of 0.000. This value indicates that the student data does not meet the homogeneity requirements because the Sig value is smaller than 0.05. Thus, the values obtained are outside the accepted limits for data homogeneity, indicating that the student data are not homogeneous.

Table 7. Homogeneity test results

Levene Statistic	dfl	Df2	Sig
77.337	1	296	.000

3.4 Wilcoxon test

The Wilcoxon signed test is a non-parametric test used to measure differences in unpaired data on an ordinal or interval scale. Still, the data is not normally distributed or homogeneous. This test is also known as the match pair test.

Table 8. Wilcoxon signed ranks test

		N	Mean Rank	Sum of Ranks
Post test - Pretest	Negative Ranks	0[a]	0.00	0.00
	Positive Ranks	144[b]	72.50	10440.00
	Ties	5[c]		
	Total	149		

Based on the data presented in Table 8, the analysis shows that 144 students experienced an increase in post-test scores compared to pretest scores, indicating improved learning outcomes after implementing the Flipbook learning media with AR. In contrast, only five students had the same score on the pretest and post-test, meaning there was no significant change in their learning results after treatment. These findings indicate that most students benefited from the intervention implemented, while few experienced no change in their understanding or skills. This data provides a general picture of the effectiveness of the treatment in improving student learning outcomes, as well as showing variation in the intervention's impact across student groups.

Table 9. Wilcoxon test

Z	-10.419[b]
Asymp. Sig. (2-tailed)	0.000

The results of the Wilcoxon test in Table 9 show that the Z value is -10.419, and the Asymp value is sig. (2-tailed) 0.000 is smaller than the alpha level of 5% (0.05), so it rejects h0. This shows a

significant change in the research results (Agustina & Noviasari, 2022). In other words, the observed differences in the data are unlikely to be due to chance alone, and the presence of a treatment effect can be considered accurate and significantly influencing the results.

3.5 Improved learning outcomes (N-gain test)

After testing the hypothesis using the Wilcoxon test, the n gain was tested to see the effectiveness of the learning media. Based on the data in Table 10, the N-gain score is 0.74, which means that this learning media has high effectiveness, while the N- gain percent has a value of 74.3%, which means it is effective. Using pre-tests and post-tests shows that student scores have increased after the learning process, with post-test scores being higher than pre-test scores (Mayada et al., 2024).

Table 10. N-gain test score

	N	Minimum	Maximum	Mean	Std. Deviation
N-Gain Score	149	0.00	1.00	0.7430	0.28524
N-Gain Percent	149	0.00	100.00	74.3029	28.52391

Thus, applying the VocAR-Flip model effectively improves student learning outcomes in the learning process, as evidenced by the analysis, which shows significant improvements in students' academic achievement and conceptual understanding. The details of the learning outcome scores before implementation and after implementation are visualized in Figure 2.

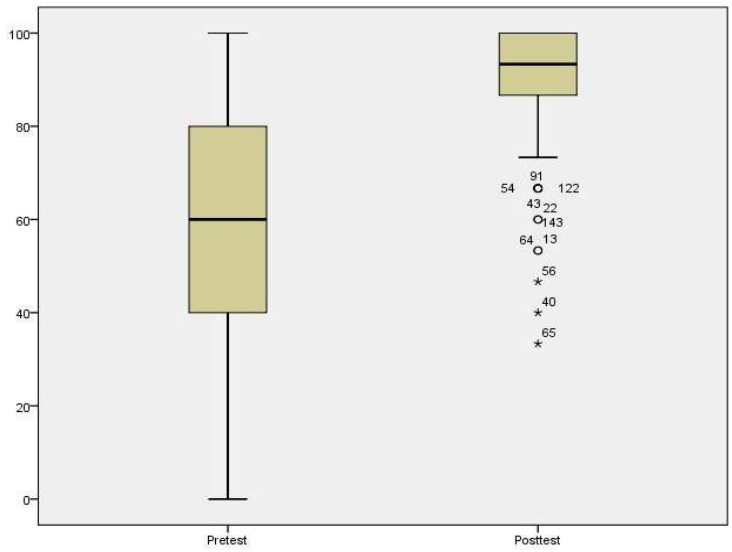

Figure 2. Box plot of pretest and post-test value data

Based on Figure 2, there is a significant difference in the distribution of scores between the two tests. In the pretest, the lowest score was 0, indicating that some participants needed to reach the minimum competency standard being measured. The scores on the pretest also reflected considerable variation, with the first quartile (Q1) being at 40, indicating that 25% of participants could only achieve that score or lower. The median, a measure of central tendency, was 60, indicating that half of the participants scored below 60 while the other half scored above it. The third quartile (Q3) is at 80, indicating that 75% of participants obtained a score of 80 or lower, and only 25% achieved a score above it. The highest score, or fourth quartile (Q4), was recorded at 100, the maximum achievement in this pretest.

In contrast, post-test results showed significant improvements in participants' performance. The minimum score increases drastically to 75, indicating an overall improvement in ability. The first quartile (Q1) was at 85, indicating significant improvement among participants at the bottom of the score distribution. The median increased to 90, indicating that half of the participants achieved or exceeded this figure, while the third quartile (Q3) was also at 90, indicating increasing consistency of performance among participants. The maximum score remains at 100, reflecting that although there has been a general improvement in the distribution of scores, the highest level of achievement remains unchanged, indicating that the maximum standard has been achieved and maintained by some participants. This analysis indicates a substantial score increase after the intervention or learning provided using VocAR-Flip.

Flipbooks allow lesson material to be presented in an interactive and visual format, which can help students understand complex concepts through pictures and animations (Roemintoyo & Budiarto, 2021). Students can interact with content in Flipbook, such as opening pages independently, thus providing a more personal and dynamic learning experience (Eliyasni et al., 2021). With an attractive and interactive design, Flipbook can increase student engagement, which positively impacts information retention (Firdaus et al., 2023). Augmented Reality allows students to experience learning concepts in three-dimensional form that they can see and explore from various angles, providing a more profound understanding (Zulfiqar et al., 2023; Zhao et al., 2023). Augmented Reality in learning creates unique and exciting experiences, which can increase students' motivation to learn (Prasetya et al., 2024; Khan et al., 2019). Augmented Reality can help explain abstract or complex concepts, such as human anatomy or natural phenomena, in a way that is easier to understand through direct visualization (Radu et al., 2023). Especially in K3LH learning, the use of augmented Reality can provide a direct picture of problem-solving that occurs in the field; augmented Reality allows students to learn in a realistic context, for example, seeing how a chemical reaction occurs in a virtual laboratory environment, which makes learning more relevant and accessible to remember (Garzón, 2021). Integrating Flipbook and Augmented Reality into the learning process can significantly improve student learning outcomes by providing a richer, more interactive, and practical learning experience (Abdilah & Wulandari, 2024).

4. Conclusion

This study demonstrated that the VocAR-Flip, a flipbook-based learning media integrated with Augmented Reality, was effective in enhancing vocational school students' learning outcomes. The results showed a significant improvement in conceptual understanding and academic achievement, with an N-gain score of 74.3%, which was categorized as high. These findings confirm the research objective that integrating AR into digital flipbooks can create more interactive learning experiences and support the development of students' cognitive skills. The implications of this study suggest that VocAR-Flip can be adopted as an innovative learning solution in vocational education to strengthen student engagement, improve readiness for the workforce, and foster critical and creative skills required in the digital era. Furthermore, the model holds potential for broader applications in other educational contexts, contributing to the advancement of interactive educational technologies in line with Industry 4.0 demands. However, this research was limited to a single group pretest–post-test design in one region and a relatively short implementation period. Future research is recommended to employ more diverse samples, longitudinal approaches, and comparative studies across different vocational fields to validate and extend the applicability of the VocAR-Flip model.

Author's declaration

Author contribution

Danny Meirawan: Conceptualization, Methodology, Supervision, Writing-review & editing. **Sri Rahayu**: Methodology, Validation, Formal Analysis, Writing-review & editing. **M. Muktiarni**: Investigation, Data Curation, Formal Analysis, Writing-review & editing. **Zahra Ghinaya**: Data Curation, Visualization, Writing-original draft, Writing-review & editing. **Zenita Sabitri**: Resources, Investigation, Project Administration, Writing-review & editing. **Aferro Ismail**: Validation, Formal Analysis, Writing-review & editing.

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Conflict of interest

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical clearance

Permission to conduct the study was obtained from the participating vocational schools, and informed consent was obtained from all student participants and/or their guardians.

Data availability

Data supporting the findings of this study are available from the corresponding author upon reasonable request.

AI statement

This article is the original work of the author without using AI tools for writing sentences and/or creating/editing tables and figures in this manuscript

Publisher's and Journal's note

Universitas Negeri Padang as the publisher, and the Editor of Jurnal Pendidikan Teknologi Kejuruan state that there is no conflict of interest towards this article publication.

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