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Teaching Factory Model Using Flipped Classroom and Knowledge Management System Based in Improving 21st Century Competencies in Vocational High Schools

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ABSTRACT

Vocational High School (hereafter, SMK) students are expected to possess skills aligned with industry demands. However, many SMK graduates face a mismatch between their competencies and the needs of the workforce, contributing to high unemployment rates. This study addresses the need for a more effective instructional model to bridge this gap. This research employed a Research and Development (R&D) approach using the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation). The goal was to develop a Teaching Factory model that integrates the Flipped Classroom approach and a Knowledge Management System (KMS). The developed model—Teaching Factory based on the Flipped Classroom and KMS—was evaluated for validity, practicality, and effectiveness. Results indicate that the model is a viable solution for enhancing students' 21st-century competencies, aligning them more closely with industry requirements. By integrating active learning strategies and systematic knowledge sharing, the model effectively supports students in acquiring skills relevant to Industry 4.0. It also represents an innovative adaptation of the Teaching Factory concept to modern educational and technological contexts. The Flipped Classroom and KMS-based Teaching Factory model proves to be a valid, practical, and effective instructional method. It supports the development of 21st-century competencies among SMK students and aligns educational outcomes with industrial needs.

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1. INTRODUCTION

The incompatibility of the skills and competencies possessed by Vocational High School (SMK) students with the needs of the industrial world has resulted in high unemployment rates for SMK graduates. The Central Bureau of Statistics records that the Open Unemployment Rate (in Indonesia:

TPT) of Vocational High School graduates is still the highest among all high school graduates. The TPT for SMK was recorded at 8.49%. TPT is an indicator measuring labor that is not absorbed by the labor market. February 2020 TPT was recorded at 4.99%. It means that out of 100 people in the workforce, there are around five unemployed people. This was also exacerbated by the Covid-19 Pandemic which forced the learning and training process from face-to-face to e-learning, e-training and online. The complexity of how to deal with the COVID-19 pandemic has forced the government to implement physical and social distancing policies to break the chain of the spread of the COVID-19 outbreak (Badan Pusat Statistik, 2020).

This policy has an impact on all aspects of life, including education. This policy requires both parties, namely schools and industry, to jointly develop the concept, this is intended to ensure compatibility between schools and industry (Dadang, 2011). The suitability in question is that the competencies acquired by students at school are the competencies needed in the industrial world. Industry must also play an active role in conveying technological advances to schools so that there is synchronization between the industrial world and the world of education (Ali et al., 2017; Rukun et al., 2018). One way to facilitate the linkage of the suitability of learning concepts between schools and industry is by applying Teaching Factory learning.

Teaching Factory learning, also known as industrial activity-based learning, serves as a strategic approach to bridging the gap between theoretical knowledge acquired in classrooms and the practical competencies required by industry (Kuswantoro, 2014). In response to the dynamic demands of the Industrial Revolution 4.0, there is a growing need to integrate information technology and 21st-century skills into the Teaching Factory model to enhance students' readiness for the workforce. One promising direction is the development of a Teaching Factory model that incorporates Flipped Classroom methods and a Knowledge Management System (KMS), which has been explored in previous studies as a way to align school-based learning with industrial expectations (Siswanto, 2021; Anggraeni, 2020).

Despite existing studies, there remains a significant research gap in the integration of Flipped Classroom strategies and KMS within the Teaching Factory framework at the vocational school level. Most prior research has examined these components in isolation—such as Vitriani et al. (2020), who tested the validity of a KMS-based training model—but has not addressed their combined implementation as a cohesive instructional system. Furthermore, little is known about how this integrated model can directly support the development of core 21st-century literacies, including data literacy, technology literacy, and human literacy, especially in the context of vocational education during disruptive events such as the Covid-19 pandemic (Nurwegiono et al., 2020).

The novelty of this research lies in the design and development of an integrated Teaching Factory model based on the Flipped Classroom and Knowledge Management System to enhance vocational students' competencies in alignment with industrial needs. This study aims to (1) develop a valid, practical, and effective instructional model, and (2) evaluate its potential to enhance 21st-century competencies in Vocational High Schools. Accordingly, this study explores how the Teaching Factory model can be effectively integrated with the Flipped Classroom approach and a Knowledge Management System to support vocational education. It also investigates the extent to which this integrated model enhances vocational students' 21st-century competencies in alignment with the evolving needs of the industrial sector.

2. METHODS

The method used is Research and Development with the ADDIE stages, which divide the instructional development process into 5 (five) stages: Analysis, Design, Development, Implementation and Evaluation (Putra, 2012). The research methods in this study are as follows:

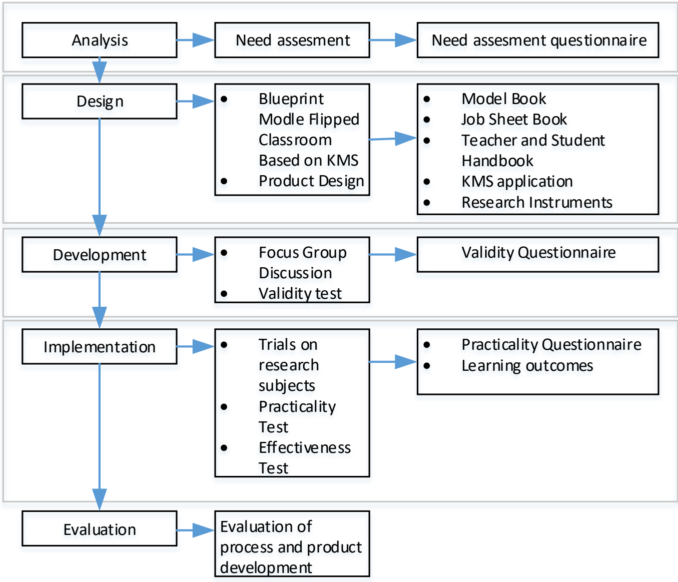

Figure 1. Research Method

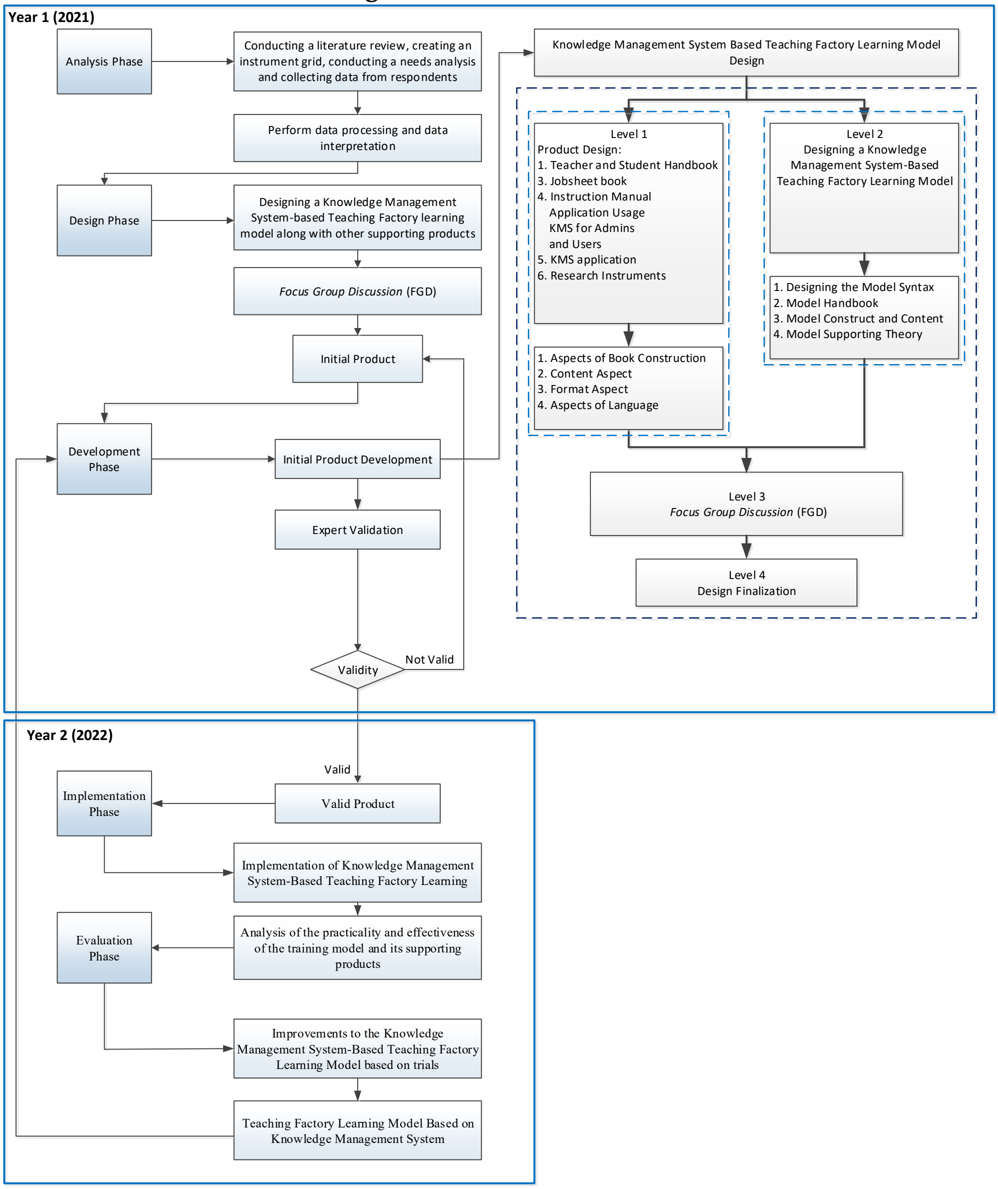

Figure 2. Research Flowchart

A more detailed explanation of the development procedure is described as follows.

1. Analysis
   Analysis is an activity that aims to analyze the needs of students. Such as identifying and analyzing the assignments given to students.
2. Design
   Design is an activity that aims to determine what product to produce and discuss plans that can achieve that goal.
3. Development
   After determining the product to be produced, the next step is to make the design of the product real. Building a product requires software, which is meant to be a support.
4. Implementation
   If the required products and multimedia are ready, at a later stage we can start implementing the learning system that we have created.
5. Evaluation
   After implementing it, the last thing to do is to evaluate the learning system that we have created using formative evaluation.

This research was implemented by teachers and students of Muhammadiyah 2 Vocational High School in Pekanbaru. The product trial was conducted after the learning model design was reviewed and deemed appropriate by several experts through a Focus Group Discussion (FGD). Once all trial requirements were prepared, the model was tested in stages, beginning with a small-scale trial followed by an expanded-scale trial.

3. FINDINGS AND DISCUSSION

In the 21st century, several innovative learning models have been developed by leading education experts. Among the most notable are the Flipped Classroom and Teaching Factory models. The Flipped Classroom approach was first introduced by Bergmann and Sams in 2007, while the Teaching Factory concept was initially implemented in Indonesia in the early 2000s. This study introduces a new instructional model that integrates both the Flipped Classroom and Teaching Factory approaches, enhanced by a Knowledge Management System (KMS) framework. The following section presents and discusses the key findings of this research in relation to the developed model (Ontario Public Service, 2016).

3.1. Learning Model Teaching Factory using Flipped Classroom-Based

The learning model developed in this study is an integration of two well-established instructional approaches: the Flipped Classroom and the Teaching Factory. This hybrid model is further supported by the application of a Knowledge Management System (KMS), which facilitates structured knowledge sharing, documentation, and continuous learning among students and teachers. The incorporation of KMS enhances the effectiveness of the model by enabling seamless access to learning resources and promoting collaborative knowledge construction—key competencies required in the 21st-century industrial context.

The development and implementation of this model followed the ADDIE framework, which consists of five systematic phases: Analysis, Design, Development, Implementation, and Evaluation. Each phase ensured the model was carefully crafted, tested, and refined to meet the demands of vocational education in the context of Industry 4.0. This structured approach allowed for iterative improvements based on expert input and empirical feedback, contributing to the model's overall validity, practicality, and effectiveness.

3.2. The Validity of Testing Result

According to Azwar, Aiken's V coefficient ranges from 0 to 1, with a value of 0.6 or higher indicating a high level of validity (Ali et al., 2017). A score of V ≥ 0.6 is considered to fall within the valid category. Based on the validators' assessments, the following recommendations were provided:

1) The research instrument's construct aspect validity test results from the validator are valid, with an Aiken's V value of 0.859. Aiken's calculations produced results that range from 0 to 1, and the value 0.600 can be construed as having a high coefficient. The valid category is V = 0.859 > 0.600.
2) The Teaching Factory learning model book's validity test results contain model syntax, social systems, reaction principles, support systems, instructional and accompaniment impacts, and support systems with an Aiken's V value of 0.812, which is valid. Aiken's calculations demonstrated effectiveness that ranged from 0 to 1, and the value 0.600 can be construed as having a rather high coefficient. Meanwhile, the valid category specifies the value V as 0.812 > 0.600.
3) The job sheet validity test findings covering the front page, table of contents, instruction indications, typography, and language are legitimate, with an Aiken's V value of 0.823. The results of Aiken's computations range from 0 to 1, and the value 0.600 might be regarded as having a high coefficient, where a valid category specifies the value of V 0.823 > 0.600.
4) An Aiken's V score of 0.845 indicates that the findings of the validity test of the lecturer's guidebook, which covered the component features of the front page, table of contents components, instruction indicators, typography, and language, are legitimate. Aiken's calculations yielded results that ranged from 0 to 1, and the value 0.600 can be construed as having a rather high coefficient. The result for a valid category is V = 0.845 > 0.600.
5) The Knowledge Management System's (KMS) validity test results, which cover characteristics of usability and information quality, are Valid with an Aiken's V value of 0.848. Aiken's calculations produced results that ranged from 0 to 1, and the value 0.600 can be construed as having a rather high coefficient. The category is considered valid by the value V 0.848 > 0.600.

The results of the validity test, are summarized in Table 1 below:

Table 1. The summary of Validity test

No	Validation	Aiken's V Score	Category
1	Instrument	0.859	Valid
2	Model Book	0.812	Valid
3	Jobsheet Book	0.823	Valid
4	Lecturer Guidance Book	0.845	Valid
5	Knowledge Management System (KMS)	0.848	Valid

3.3. The Practicality of Test Result

The Practicality Test score shows a very practical category with an average percentage of 88.75%. These findings show that the model practically makes it much easier for the lecturers to help the students and assist lecturers in understanding the concept of learning material. The practicality of the Flipped Classroom-Based Teaching Factory Model and Knowledge Management System based on student responses with an average percentage of 83.56% in the very practical category. According to these findings, it may be simpler for students to comprehend the subject matter if a very practical category is applied.

3.4. The Effectiveness of the Test Result

To evaluate the effectiveness of the intervention, students were given assessments both before (pre-test) and after (post-test) the learning process. The evaluation focused on student learning outcomes using multiple-choice tests, which measured the impact of implementing the Flipped Classroom-Based Teaching Factory model supported by a Knowledge Management System.

Prior to the intervention, students completed a pre-test designed to assess their initial understanding using the integrated Teaching Factory model based on the Flipped Classroom and

Knowledge Management System. The following data present the results of the students' pre-test:

Table 2. The statistic Result of Pre-test Score

N	Valid	20
	Missing	0
Mean		60.577
Median		57.692
Mode		54
Std. Deviation		11.428
Variance		130.606
Minimum		42
Maximum		81
Sum		1211.54

Source: The Processed Primary Data

Table 2 presents the statistical summary of the pre-test scores from 20 students, with no missing data recorded. The mean score was 60.58, indicating the average performance of the group before the intervention. The median score was 57.69, suggesting that half of the students scored below and half above this value. The most frequently occurring score (mode) was 54, pointing to a concentration of scores near the lower end of the distribution. The standard deviation was 11.43, which reflects a moderate spread of scores around the mean, while the variance was calculated at 130.61, further indicating variability in student performance. The minimum and maximum scores were 42 and 81, respectively, showing a wide range of achievement levels among students. The total sum of scores was 1211.54. These results highlight the initial variation in students' understanding prior to implementing the Flipped Classroom-Based Teaching Factory model supported by a Knowledge Management System. A visual representation of the distribution is provided in Table 3, and the histogram in Figure 3.

Table 3. Pre-test Value Frequency Distribution

No	Class Interval	Median	Frequency
1	42 – 48	45	3
2	49 – 55	52	6
3	56 – 62	59	3
4	63 – 69	66	3
5	70 – 76	73	2
6	77 – 83	80	3
	Total		20

Source: The Processed Primary Data

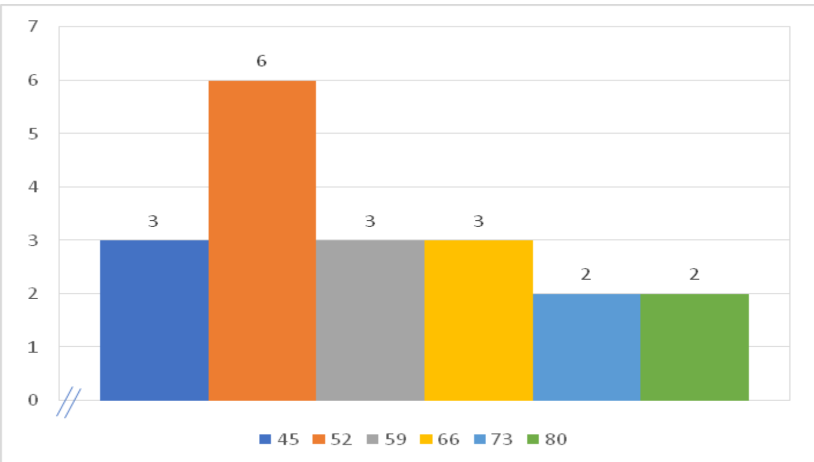

Figure 3. Pretest Score Histogram

1) The Post-test UsingTeaching Factory Model with Flipped Classroom and Knowledge Management System Based. Data on student posttest scores are described as follows.

Table 4. The statistical Result of Post-test

N	Valid	20
	Missing	0
Mean		80.385
Median		80.769
Mode		81
Std. Deviation		9.657
Variance		93.273
Minimum		62
Maximum		96.15
Sum		1607.69

Source: The Processed Primary Data

Table 4 presents the statistical summary of the post-test scores from 20 students, with no missing data reported. The average score (mean) was 80.39, indicating a significant improvement in student performance after the learning intervention. The median score was 80.77, closely aligned with the mean, suggesting a symmetrical distribution of scores. The mode, or most frequently occurring score, was 81, further supporting this pattern of consistency across student results. The standard deviation was 9.66, indicating a relatively moderate spread of scores around the mean, while the variance was 93.27, reflecting the degree of variation in the dataset. The minimum and maximum scores were 62 and 96.15, respectively, showing that all students achieved scores above the minimum passing criteria. The total accumulated score was 1607.69. These results suggest that the implementation of the Flipped Classroom-Based Teaching Factory model supported by a Knowledge Management System had a positive impact on students' learning outcomes. A detailed visualization of the score distribution is available in Table 5 and the histogram in Figure 4.

Table 5. The frequency distribution of Post-test

No	Class Interval	Median	Frequency
1	62 – 67	64.5	3
2	68 – 73	70.5	2
3	74 – 79	76.5	1
4	80 – 85	82.5	8
5	86 – 91	88.5	4
6	92 – 97	94.5	2
	Total		20

Source: The Processed Primary Data

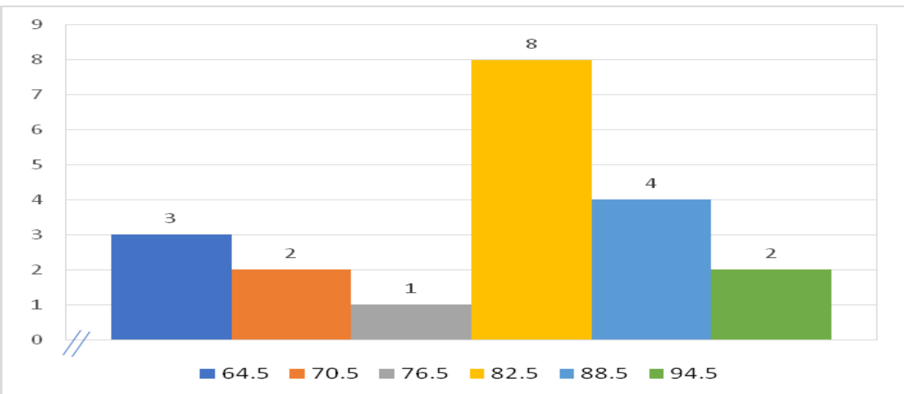

Figure 4. Post-test Score Histogram

Discussion

The results of this study demonstrate that the developed learning model—a hybrid integration of the Flipped Classroom and Teaching Factory approaches supported by a Knowledge Management System (KMS)—is highly effective in improving student learning outcomes. The average post-test score reached 80.38, placing it in the *"very effective"* category according to Ridwan's classification (Ali et al., 2017). This suggests a significant improvement in student performance following the implementation of the model, thus confirming its instructional effectiveness in vocational education settings.

This research has produced a comprehensive instructional model named Teaching Factory IR 4.0, designed to align with the evolving demands of 21st-century education and the Fourth Industrial Revolution. The model incorporates blended learning strategies, combining face-to-face instruction with digital tools facilitated by the KMS. It emphasizes both content mastery and the development of essential soft skills through practical engagement, collaborative activities, and digital literacy. The combination of Flipped Classroom and Teaching Factory approaches provides a structured yet flexible environment where students engage with theoretical content independently before applying their knowledge in hands-on, industrially-relevant tasks.

The model's validity was verified through a rigorous expert validation process. The results demonstrated high validity across all instructional materials. The instrument validity test yielded a V coefficient of 0.859, categorizing it as highly valid. Similarly, the model book (V = 0.812), job sheet (V = 0.823), lecturer's guidebook (V = 0.845), and the KMS application (V = 0.848) were all deemed valid. These values indicate that the components of the model are well-aligned with learning objectives and appropriate for classroom implementation.

Practicality was also a key focus of this study. The teacher evaluation showed an average practicality score of 88.75%, placing the model in the *"very practical"* category. This confirms that educators found the model easy to use and effective for guiding students through learning activities. From the students' perspective, the model received an 83.56% practicality rating, also in the *"very practical"* category. This suggests that students found the instructional materials accessible and engaging, which in turn facilitated their understanding of complex vocational concepts. The high practicality score demonstrates the model's usability and its potential to be integrated into real classroom settings with minimal adjustment.

The effectiveness of the Teaching Factory IR 4.0 model is particularly evident in its impact on student engagement and learning outcomes. Students became more active participants in their own learning process, were better able to grasp the material, and demonstrated higher-order thinking skills such as problem-solving, collaboration, and critical analysis. These outcomes are consistent with the intended design of the model, which emphasizes active, student-centered learning supported by real-world context and digital innovation.

The model also targets both instructional and accompanying impacts. Instructionally, it improves conceptual understanding, encourages the application of knowledge, and promotes communication and analytical skills. Accompanying impacts include increased student motivation, self-directed learning, and creativity. By engaging students more deeply in the learning process, the model not only enhances academic achievement but also nurtures professional competencies necessary for the modern workforce.

This research contributes to the growing body of evidence supporting hybrid learning models in vocational education. It aligns with findings by Azizah et al. (2019) and Irawan et al. (2020), who concluded that the Teaching Factory model significantly contributes to producing vocational graduates who are job-ready. Similarly, Arya Sadewa et al. (2019) emphasized the importance of integrating Knowledge Management Systems in educational settings to foster professionalism and competence. Siswanto (2021) also found that the Flipped Classroom model enhances student autonomy and writing skills, and fosters a positive learning environment—outcomes mirrored in the current study.

The implementation of this model presents several practical implications for education stakeholders:

1. Enhancing Skills and Competencies – Students develop essential 21st-century skills, such as critical thinking, creativity, communication, and collaboration.
2. Improving Work Readiness – By simulating real work environments, the model prepares students to adapt quickly to industry standards and expectations.
3. Increasing Learning Efficiency – The Flipped Classroom structure and use of KMS enable more efficient use of classroom time and personalized learning pathways.

Furthermore, this model can serve as a guide for future instructional development, particularly in designing learning environments that are both adaptive and aligned with industrial needs. It offers a sustainable approach to modern education by integrating technology, pedagogy, and workplace relevance in a single framework. Institutions such as the Padang State Polytechnic can leverage this model to enhance their curriculum and better prepare students for the dynamic demands of the labor market.

In conclusion, the Teaching Factory IR 4.0 model has been shown to be valid, practical, and effective, making it a valuable contribution to vocational education innovation. Its dual focus on knowledge mastery and skill development, supported by modern learning technologies, ensures that students are not only academically competent but also industry-ready. The model fosters a learning environment where students are motivated, engaged, and equipped to meet the challenges of the 21st century.

4. CONCLUSION

This research and development study concludes that the Flipped Classroom-Based Teaching Factory Model supported by a Knowledge Management System (KMS) is a valid, practical, and effective instructional model for vocational education in the 21st century. The model, formed by integrating the Flipped Classroom and Teaching Factory approaches, incorporates seven learning syntaxes: product analysis, group formation, task negotiation, planning and design, production, final product presentation, and e-commerce application—all implemented with the support of KMS at each stage. The validity of all instructional components, including the model book, job sheets, lecturer guide, research instruments, and the KMS platform, was confirmed through expert validation using Aiken's V, with all values falling within the valid category. Practicality was demonstrated through highly positive responses from both lecturers and students, indicating ease of use and engagement in the learning process. Effectiveness was evidenced by a significant increase in student learning outcomes from pre- to post-test, showing that the model enhances understanding and performance.

However, this study has limitations. It was conducted in a single vocational school setting with a limited number of participants, which may restrict the generalizability of the results to broader educational contexts. Additionally, the implementation relied heavily on technological infrastructure, which may not be accessible in all schools.

Future research is recommended to apply this model across various educational levels and institutions to assess its scalability and adaptability. Further studies could also explore long-term impacts on student competencies and examine integration with other digital platforms to enhance collaborative learning and knowledge sharing.

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