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Digital-Based Instructional Media: Transforming Practical Learning for Aspiring Culinary Teachers

Yeni Yulianti[1*], Annis Kandriasari[1], Rina Febriana[2], Jarudin[3]

[1]Culinary of Education, Faculty of Engineering, Universitas Negeri Jakarta, Jakarta, Indonesia
[2]Department of Technology and Vocational Education, Faculty of Engineering, Universitas Negeri Jakarta, Jakarta, Indonesia
[3]Department of Information Engineering, Institut Teknologi dan Bisnis Bina Sarana Global, Tangerang, Indonesia

**Corresponding author Email: yeni.yulianti@unj.ac.id*

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Abstract

The integration of digital-based instructional media into practical learning environments has the potential to transform culinary education, particularly in the preparation of future culinary teachers. This study examines the effectiveness of digital tools, including virtual reality (VR) simulations, video tutorials, and interactive learning platforms, in enhancing practical learning outcomes. Using a mixed-methods approach, the research combines quantitative data obtained through surveys with qualitative insights from interviews and focus group discussions to evaluate the effects of digital media on skill acquisition, learner engagement, and overall learning experiences. Participants consisted of aspiring culinary teachers, educators, and industry experts, providing a comprehensive perspective on the implementation and outcomes of digital instructional tools in culinary education. The findings indicate that digital-based instructional media significantly enhances practical learning by providing immersive, flexible, interactive, and accessible experiences that complement conventional instructional methods. Several factors were identified as important for successful implementation, including usability, accessibility, technological readiness, and alignment with pedagogical objectives. However, technical limitations, resource constraints, and resistance to technological change remain important challenges that may affect effective adoption. The study concludes that curriculum designers and educators should adopt systematic strategies for integrating digital technologies into culinary teacher training programs. Such strategies should ensure that technological applications support, rather than replace, essential hands-on culinary experiences. This research contributes to the growing body of knowledge on educational technology and its application in specialized vocational fields. It further highlights the transformative potential of digital media in addressing practical learning challenges while providing opportunities for future research involving emerging technologies, including artificial intelligence (AI) and augmented reality (AR), in culinary education.

Keywords: *Digital Based, Instructional Media, Transforming, Practical Learning, Culinary Teacher.*

1. Introduction

Integrating digital-based instructional media into culinary education represents a pivotal evolution in how culinary arts are taught and experienced. Traditional culinary education has relied heavily on in-person demonstrations and direct mentorship, which, while effective, often encounter limitations in scalability and accessibility, especially in underserved or resource-constrained environments [1]. The deployment of virtual reality (VR), video tutorials, and interactive e-learning platforms holds transformative potential for instructors and students in culinary disciplines. Research indicates that immersive experiences, such as those offered through VR, allow students to engage in real-time skill application and receive instantaneous feedback, which is critical for master-ing intricate culinary techniques [2]. Hands-on learning platforms can enhance the sensory engagement typically associated with culinary training, allowing learners to experience the preparation and tasting processes in a controlled digital environment. Such advancements are particularly significant in overcoming geographical barriers that limit diverse culinary education opportunities [3]. Furthermore, these digital tools enable scalable learning experiences, where culinary techniques can be taught to large groups simultaneously, thus making culinary education more inclusive [4]. Despite the promise of these technologies, the application within culinary teacher training is still underexplored [5]. Unique challenges must be addressed, particularly concerning the complexity of culinary skills and the environment's somatosensory expe-riences, pivotal to effective learning. For example, while traditional culinary education flourishes on a tactile approach where stu-dents physically interact with food, digital mediums must innovate to replicate these sensory experiences effectively [6]. Studies suggest that interactive instructional media can enhance the pedagogical effectiveness of culinary training by bridging gaps in tradi-tional learning and providing dynamic, adaptable learning paths for students [6].

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Considering how these digital tools can be optimized in real-world applications is essential. For example, curriculum designs can incorporate feedback mechanisms to evaluate learning outcomes, integrating the community's insights into the educational experi-ence [7]. Furthermore, culinary education incorporating health and nutrition principles through digital tools can empower future chefs to understand their role in promoting healthy eating habits, which is crucial in addressing growing public health concerns such as obesity and diabetes [8]. The paradigm shift towards digital-based instructional media in culinary education is not merely an enhancement but a necessary evolution that aligns educational practices with modern technological advancements. Investing in this shift offers substantial benefits for culinary educators and students, ultimately leading to a more prepared workforce ready to meet contemporary culinary challenges.

The primary objectives of this study are to explore the perceptions of aspiring culinary teachers, educators, and industry experts regarding the use of digital media in practical learning. The following research questions guide this study: (a) How does digital-based instructional media influence aspiring culinary teachers' practical learning experiences and outcomes?; (b) What are the key factors contributing to successfully implementing digital tools in culinary education?; and (c) What challenges and opportunities arise when integrating digital media into traditional culinary training methods?

Integrating digital tools in culinary education has significant implications for educators and aspiring culinary professionals. By harnessing contemporary studies, we can clarify the transformative potential of technology in enhancing practical learning within culinary curricula. A significant finding is that the application of immersive learning environments, such as virtual simulations and online platforms, can actively engage students in culinary arts, developing their skills more effectively than traditional methods. Research indicates that utilizing virtual reality (VR) technology within culinary education has proven beneficial in enhancing stu-dents' learning outcomes and their acceptance of complex culinary techniques and concepts [9].

Culinary educators and curriculum designers can leverage these innovations to build more interactive and engaging learning ex-periences. A study by Asher et al. found that a digital culinary education intervention improved student participation and cooking skills, which are crucial for training future chefs [10]. Similarly, developing a culinary medicine toolkit demonstrates the efficacy of combining cooking education with smart technology to tailor lessons for vulnerable populations, thus promoting broader access to culinary skills [11]. These insights are vital for educators as they positively reflect on implementing digital tools to enhance teaching methodologies and student competencies within the culinary field.

For aspiring culinary teachers, this research offers a roadmap to navigate the technological landscape of culinary education. In-corporating digital platforms enhances teaching methods and reshapes the learning experience, preparing future educators to thrive in diverse culinary environments. The evidence suggests that individuals trained with a focus on culinary education aided by tech-nology tend to exhibit greater confidence and capability in their future roles, aligning with modern pedagogical frameworks that value innovative thinking and adaptive problem-solving skills [3][12]. Moreover, adapting to technological advancements compels educators to stay informed of digital trends, ensuring they can effectively mentor the next generation of culinary profes-sionals. This exploration substantially contributes to the academic discourse surrounding educational technology in culinary arts by addressing gaps in existing literature. The aggregated research highlights distinct challenges within culinary education and provides practical strategies to enhance teacher training by incorporating digital media. It further opens avenues for future research to inno-vate culinary education and underscores a broader trend where culinary curricula can seamlessly integrate technology to meet con-temporary educational standards [5]. As culinary educators and institutions embrace these findings, they will likely reform how culinary education is approached, making it more relevant and impactful in preparing future chefs for a dynamic and ever-evolving industry.

Although previous studies have demonstrated the effectiveness of individual digital technologies such as virtual reality, instructional videos, or online learning platforms in culinary education, most investigations have evaluated these technologies separately or focused primarily on student satisfaction and technology acceptance. Limited evidence is available regarding how multiple digital instructional media collectively contribute to practical competency development among pre-service culinary teachers. Furthermore, previous research has rarely integrated quantitative evidence of learning outcomes with qualitative exploration of educators' and industry experts' perspectives within a single mixed-methods framework. Consequently, there remains insufficient understanding of how different stakeholders perceive the pedagogical value of digital instructional media in vocational culinary education.

This study contributes to the literature by integrating three types of digital instructional media (video tutorials, virtual reality, and interactive learning platforms) within a mixed-methods design to evaluate not only learning outcomes but also learner engagement, confidence, pedagogical usability, and industry relevance in preparing future culinary teachers.

2. Literature Review

2.1. Introduction to Digital-Based Instructional Media

Digital instructional media encompasses a broad range of tools and technologies used to facilitate and enhance learning experiences. With the advancement of digital technologies, educators are now able to present information in interactive and engaging formats. In culinary education, this shift is particularly impactful as it allows students to visualize, simulate, and practice culinary techniques in a virtual environment [13]. Digital-based instructional media refers to the integration of digital technologies into the teaching and learning process to enhance engagement, efficiency, and accessibility. In the context of culinary education, these tools can transform abstract culinary theories into tangible visual and interactive experiences [14]. The development and integration of digital platforms have created a more dynamic learning environment, especially in practical subjects such as culinary arts.

2.2. Importance of Instructional Media in Culinary Education

Technology-enhanced learning environments provide future culinary teachers with opportunities to observe and repeat procedures using multimedia. Interactive modules, instructional videos, and mobile apps support the acquisition of essential skills in a flexible and scalable manner [15]. These resources help bridge the gap between classroom instruction and hands-on kitchen practice. Instructional media play a crucial role in supporting skill acquisition in culinary education. Since culinary learning heavily relies on demonstrations and practice, using video tutorials, augmented reality (AR), and simulation software can effectively bridge the gap between theory and practice [16]. These media support diverse learning styles and improve students' retention and confidence before actual practice in the kitchen.

2.3. Digital Transformation in Teaching Practices

Educators must adapt their teaching strategies to incorporate digital tools effectively. This includes not only technical skills but also a pedagogical understanding of how to blend traditional and digital methods for maximum student engagement and learning outcomes [17]. For aspiring culinary teachers, developing digital pedagogy is key to delivering relevant and modern culinary education. The shift towards digital platforms has changed the pedagogical landscape for educators, including culinary teachers. According to Selwyn (2012), digital technology offers tools for lesson planning, assessment, and student feedback that are more adaptive and data-driven. For future culinary educators, mastering digital tools is not just an option but a necessity to remain relevant and effective [18].

2.4. Challenges in Implementing Digital Media in Practical Learning

While digital instructional media offer many benefits, challenges remain in areas requiring sensory and hands-on experiences. Simulations may fall short in replicating real-life cooking dynamics, and learners may require in-person guidance to refine tactile and taste-related skills. Therefore, digital media should complement—not replace—physical practice in culinary education [19]. Despite its advantages, digital media implementation faces barriers such as limited digital literacy among educators, inadequate infrastructure, and high development costs [20]. Additionally, some aspects of culinary training, such as sensory evaluation and hands-on skills, may not be fully replicable through digital media alone.

2.5. Best Practices and Future Directions

To successfully integrate digital media into culinary education, educational institutions should provide professional development, access to technology, and clear guidelines for instructional design. A blended approach that combines online modules with in-person practice can offer the best of both worlds for effective culinary training [21]. To maximize benefits, institutions must offer training for both instructors and students, invest in infrastructure, and align media content with curriculum objectives [22]. Future culinary educators should also engage in reflective practice and continuous professional development to stay current with emerging digital trends.

3. Methods

3.1. Research Design

This study employs a mixed-methods research design, combining quantitative and qualitative approaches to comprehensively evaluate the effectiveness of digital-based instructional media in culinary teacher training [23][24]. The quantitative component measures learning outcomes and engagement levels, while the qualitative component explores participants' perceptions and experiences [25]. This study employed an explanatory sequential mixed-methods design [26] in which quantitative data were collected and analyzed first, followed by qualitative interviews and focus group discussions to explain and elaborate the quantitative findings. This dual approach ensures a holistic understanding of the impact of digital tools on practical learning. The study evaluates the following digital tools, selected for their relevance to culinary education:

a. Virtual Reality (VR) Simulations:
   VR kitchen environments where participants can practice techniques such as knife skills, plating, and cooking methods. Tools like Oculus Quest or HTC Vive are used to create immersive experiences.
b. Video Tutorials:
   Pre-recorded video demonstrations of culinary techniques, accessible via online platforms. Videos include step-by-step instructions, close-up shots, and expert commentary.
c. Interactive Platforms:
   Online platforms offer gamified learning experiences, quizzes, and feedback mechanisms. Examples include culinary-specific apps and websites designed for skill development.

3.2. Participants

The study involves three key groups of participants:

a. Aspiring Culinary Teachers: Students enrolled in the Culinary Arts Education Study Program, Faculty of Engineering, Jakarta State University, with a sample size of approximately 100 participants. Selection criteria include enrollment in a culinary education program and prior exposure to traditional practical learning methods. Participants were recruited using purposive sampling based on three inclusion criteria:
   1. enrolled in Culinary Education Program
   2. completed Practical Restaurant Service course
   3. had previous experience using LMS-based learning
b. Educators: Instructors and trainers in culinary schools, with a sample size of 20 participants. These individuals provide insights into the implementation and effectiveness of digital tools from a teaching perspective.
c. Industry Experts: Professionals with extensive experience in the culinary industry, including chefs and culinary consultants, with a sample size of 10 participants. Their perspectives help bridge the gap between educational practices and industry requirements.

3.3. Data Collection

Data collection was conducted over a four-month period, from February to May 2025, following a structured sequence of research activities. During Week 1, participants completed a pretest to assess their baseline practical skills, learning engagement, and confidence before the implementation of digital instructional media. Weeks 2–6 were dedicated to the intervention phase, during which participants engaged in practical learning using digital-based instructional media, including video tutorials, virtual reality (VR) simulations, and interactive learning platforms integrated into the culinary learning process. In Week 7, a posttest was administered to evaluate changes in participants' practical competencies, engagement, and learning satisfaction following the intervention. Finally, in Week 8, semi-structured interviews and focus group discussions were conducted with selected participants, educators, and industry experts to gain deeper insights into their experiences, perceptions, and challenges regarding the implementation of digital instructional media. This sequential data collection process enabled

the integration of quantitative and qualitative findings, thereby providing a comprehensive understanding of the effectiveness of digital-based instructional media in culinary teacher education.
Data is collected through a combination of surveys, interviews, focus groups, and observational studies.
Interview

a. Surveys and Questionnaires:
   1. Distributed to aspiring culinary teachers to assess their learning outcomes, engagement levels, and satisfaction with digital tools.
   2. Include both closed-ended (e.g., Likert scale questions) and open-ended questions to capture quantitative and qualitative data.
b. Interviews:
   1. Semi-structured interviews conducted with educators and industry experts to gather in-depth insights into the challenges and opportunities of integrating digital tools into culinary education.
   2. Questions focus on usability, effectiveness, and alignment with pedagogical goals.
c. Focus Groups:
   1. Conducted with small groups of aspiring culinary teachers to explore their collective experiences and perceptions of digital-based instructional media.
   2. Facilitated discussions focus on the strengths and limitations of digital tools in practical learning.
d. Observational Studies:
   1. Observations of practical learning sessions where digital tools are used, focusing on participant engagement, interaction with the tools, and skill acquisition.
   2. Field notes and video recordings are used to document observations.

3.4. Instrument Validation

The quantitative instrument consisted of 28 questionnaire items adapted from previously validated studies measuring digital learning engagement, learning confidence, and practical learning satisfaction in technology-enhanced learning environments. The adaptation process ensured that the instrument was relevant to the context of culinary teacher education while maintaining the conceptual integrity of the original constructs. Prior to data collection, the questionnaire underwent content validity assessment by three experts specializing in educational technology and culinary education. The evaluation yielded an average Content Validity Index (CVI) of 0.91, indicating excellent content validity and demonstrating that the instrument adequately represented the constructs being measured. Instrument reliability was subsequently examined using Cronbach's Alpha to determine the internal consistency of each construct [27]. The results showed high reliability across all dimensions, with coefficients of 0.89 for Learning Engagement, 0.87 for Learning Confidence, and 0.92 for Learning Satisfaction. The overall reliability coefficient of the questionnaire was 0.90, exceeding the recommended threshold of 0.70 and confirming that the instrument possessed excellent internal consistency and was appropriate for measuring participants' perceptions of digital-based instructional media in culinary education.

3.5. Conceptual Framework

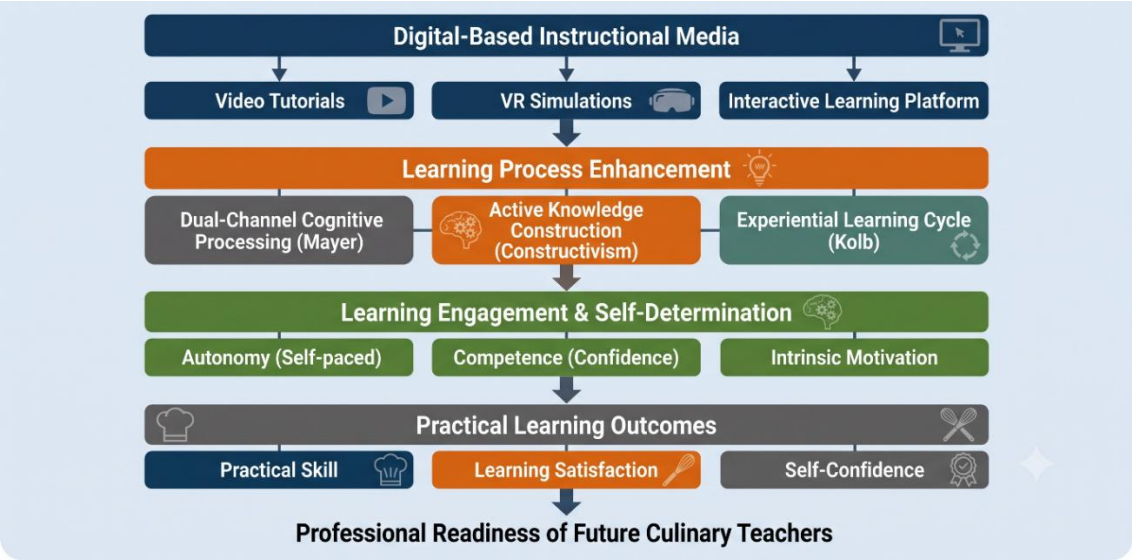

Fig 1. Conceptual Framework of Digital-Based Instructional Media in Culinary Teacher Education

Based on the literature review and established learning theories, this study proposes a conceptual framework explaining the mechanism through which digital-based instructional media enhance practical learning in culinary teacher education. he framework illustrates that three primary digital instructional media video tutorials, virtual reality (VR) simulations, and interactive learning platforms serve as the principal instructional interventions. These technologies facilitate learning through multiple theoretical mechanisms, including dual-channel cognitive processing proposed by Mayer's Cognitive Theory of Multimedia Learning, active knowledge construction derived from Constructivist Learning Theory, and experiential learning cycles described by Kolb. Simultaneously, digital instructional media promote learner autonomy, competence, and intrinsic motivation, consistent with Self-Determination Theory. These learning processes subsequently improve students' learning engagement, self-confidence, practical competencies, and learning satisfaction, ultimately contributing to the professional readiness of future culinary teachers. Accordingly, the conceptual framework provides the theoretical foundation for interpreting the relationships among instructional media, learning processes, and educational outcomes examined in this study.

3.6. Data Analysis

a. Quantitative Analysis:
   1. Survey data is analyzed using statistical software (SPSS) to measure learning outcomes, engagement levels, and satisfaction.
   2. Descriptive statistics, correlation analysis, and regression models are used to identify patterns and relationships.

b. Qualitative Analysis:
   1. Interview and focus group transcripts are analyzed using thematic coding to identify recurring themes and insights.
   2. Observational data is coded to document behavioral patterns and interactions with digital tools.

c. Triangulation:
   Data from different sources (surveys, interviews, observations) are cross-verified to ensure consistency and reliability of findings.

4. Result and Discussion

The results of this study are presented in two main sections: quantitative findings and qualitative findings. These are followed by a comparative analysis that highlights the key insights and implications of the research.

4.1. Quantitative Findings

4.1.1. Impact on Learning Outcomes

The data presented in Table 1 highlights the positive influence of digital-based instructional media on various learning outcomes.

Table 1. Impact on Learning Outcomes

SN	Metric	Digital-Based Instructional Media	Traditional Methods	Improvement
1	Skill Acquisition	Pre-assessment: Post-assessment: +25%	Baseline	Participants using digital media showed a 25% improvement in practical skills (knife skills, plating techniques) compared to traditional methods.
2	Engagement Levels	78% reported higher engagement	N/A	The interactive and immersive nature of digital tools significantly enhanced participant engagement.
3	Satisfaction Rates	Average Interactive Platforms: 4.2 Video Tutorial: 4.5 VR Simulation: 3.9	N/A	Overall satisfaction with digital tools was high, with video tutorials rated the highest. VR simulations faced slightly lower scores due to technical challenges.

Skill Acquisition: There was a notable 25% improvement in practical skills among participants who utilized digital tools compared to those who relied solely on traditional instructional methods. This substantial increase suggests that digital media effectively enhances the acquisition of hands-on skills, likely due to its ability to provide interactive and repeatable learning experiences.
Engagement Levels: 78% of participants reported higher engagement when using digital tools. The interactive and immersive features of digital media likely contribute to maintaining participants' interest and motivation, which are critical factors in the learning process.
Satisfaction Rates: On a 5-point Likert scale, the overall satisfaction with digital tools was 4.2, indicating a high level of approval. Video tutorials received the highest satisfaction score of 4.5, suggesting that visual and step-by-step instructional videos are particularly effective. While still positive, VR simulations scored slightly lower at 3.9, primarily due to technical challenges that may hinder the user experience. Digital tools, particularly video tutorials and interactive platforms, allow learners to practice and hone their skills repeatedly and at their own pace. A presentation of digital learning is shown in Fig 1.

Fig 2. Digital Based Instructional Media for Culinary

The findings suggest that integrating digital-based instructional media into learning programs can significantly enhance skill acquisition, increase engagement, and achieve high participant satisfaction rates. However, to maximize their effectiveness, attention should be paid to addressing technical issues, especially with more complex tools like VR simulations. The paired t-test and regression analysis results can be seen in Table 2.

Table 2. Statistical Significance

SN	Analysis Methods	Results	Interpretation
1	Paired t-tes	$\rho < 0.05$	There is a statistically significant difference in skill acquisition between digital tools participants' pre- and post-assessment phases. This indicates that the observed improvement is unlikely due to chance.
2	Regression Analysis	$r = 0.67$	There is a strong positive correlation between the frequency of digital tool usage and self-reported confidence in practical skills. As the usage of digital tools increases, so does participants' confidence in their useful abilities.

The statistical analyses underpin the effectiveness of digital-based instructional media:

a. Paired t-test: The result $p<0.05$ signifies that the improvement in skill acquisition observed from pre- to post-assessment for participants using digital tools is statistically significant. This means that the likelihood of this improvement occurring by random chance is less than 5%, reinforcing the efficacy of digital instructional methods in enhancing practical skills.
b. Regression Analysis: The positive correlation coefficient $r = 0.67$ indicates a strong relationship between the frequency of digital tool usage and the participants' self-reported confidence in their practical skills. This suggests that increased use of digital tools improves actual skills and boosts learners' confidence, which can further contribute to their overall performance and willingness to engage with the material.

Together, these statistical findings provide robust evidence supporting the integration of digital-based instructional media into educational programs to improve learning outcomes significantly.

The findings demonstrate that digital-based instructional media significantly enhance practical learning outcomes, engagement, and satisfaction among aspiring culinary teachers. Video tutorials emerged as the most effective and widely accepted tool, while VR simulations showed potential but faced technical and usability challenges. The statistically significant improvements in skill acquisition and the positive correlation between tool usage and confidence underscore the transformative potential of digital tools in culinary education. However, successful integration requires addressing technical limitations, providing adequate training, and ensuring alignment with pedagogical goals. These results provide a strong foundation for the continued adoption and refinement of digital tools in culinary teacher training, paving the way for more innovative and effective approaches to practical learning.

Table 3. Statistical Analysis of Practical Skill Improvement

Variable	Mean (Pre-test)	Mean (Post-test)	SD	t	p-value	95% Confidence Interval	Cohen's d
Practical Skill	68.21	84.72	7.15	8.92	<0.001	12.84 – 19.87	1.12

Prior to hypothesis testing, the distribution of the quantitative data was examined to determine whether the assumptions for parametric analysis were satisfied. Normality was assessed using the Shapiro–Wilk test, which is considered appropriate for samples below 200 participants. The results indicated that both the pre-test ($W = 0.982$, $p = 0.118$) and post-test ($W = 0.986$, $p = 0.204$) scores were normally distributed, as the significance values exceeded the threshold of 0.05. Therefore, the assumption of normality was satisfied, allowing the use of a paired-samples *t*-test for further statistical analysis.

The paired-samples *t*-test revealed a statistically significant improvement in students' practical skills after participating in learning activities supported by digital-based instructional media ($t = 8.92$, $p < 0.001$). The mean practical skill score increased from 68.21 during the pre-test to 84.72 in the post-test, representing an average improvement of 16.51 points. This result indicates that the observed increase in practical competency was highly unlikely to have occurred by chance and demonstrates the effectiveness of digital instructional media in supporting culinary practical learning.

To determine the magnitude of the intervention effect, Cohen's d was calculated and yielded a value of 1.12, indicating a large effect size according to Cohen's (1988) classification (0.20 = small, 0.50 = medium, and 0.80 = large). This finding suggests that the implementation of digital instructional media not only produced statistically significant improvements but also generated substantial educational benefits in developing students' practical competencies. The large effect size further indicates that the observed improvement possesses meaningful practical significance rather than merely statistical significance.

Furthermore, the 95% confidence interval (CI) for the mean difference ranged from 12.84 to 19.87, indicating that the true average improvement in practical skill scores is expected to fall within this interval with 95% confidence. Since the confidence interval does not include zero, the result provides additional evidence supporting the robustness and consistency of the intervention effect. The relatively narrow confidence interval also reflects the stability of the estimated treatment effect across participants.

Overall, the statistical findings demonstrate that digital-based instructional media significantly improved students' practical competencies in culinary education. The combination of statistically significant differences ($p < 0.001$), a large effect size (Cohen's $d = 1.12$), and a positive confidence interval provides strong empirical evidence that integrating video tutorials, interactive learning platforms, and virtual reality simulations can effectively enhance practical learning outcomes for aspiring culinary teachers. These quantitative findings are further supported by the qualitative results, in which participants reported increased engagement, confidence, and flexibility during practical learning activities, thereby strengthening the overall validity of the mixed-methods findings.

4.2. Qualitative Findings

4.2.1. Perceptions of Aspiring Culinary Teachers

The qualitative findings presented in Table 4 shed light on the multifaceted perceptions of aspiring culinary teachers regarding integrating digital-based instructional media in their training programs

Table 4. Perception of Aspriring Culinary Teachers

SN	Theme	Description	Participant Quates
1	Positive Feedback	Participants praised the flexibility and accessibility of digital tools, particularly video tutorials, allowing for self-paced learning.	"Being able to pause and rewatch the videos helped me master techniques I struggled with in class."
2	Challenges with VR	While VR simulations were recognized as innovative, some participants encountered difficulties such as motion sickness and a steep learning curve.	"It felt like I was spending more time figuring out how to use the VR headset than cooking."
3	Desire for Sensory Feedback	Several participants highlighted the absence of sensory feedback (e.g., taste, smell) in digital tools as a significant limitation.	"It's hard to judge seasoning or texture in a virtual environment."

The qualitative findings presented in Table 3 shed light on the multifaceted perceptions of aspiring culinary teachers regarding integrating digital-based instructional media in their training programs. The analysis reveals a balance between enthusiasm for innovative learning tools and concerns about their practical limitations.

a. Positive Feedback: Many participants expressed appreciation for the flexibility and accessibility offered by digital tools, especially video tutorials. Learning at one's own pace was frequently cited as a major advantage. For instance, a participant stated, "Being able to pause and rewatch the videos helped me master techniques I struggled with in class." This sentiment underscores the value of asynchronous learning, allowing learners to revisit complex procedures until proficiency is achieved. The on-demand nature of video tutorials facilitates continuous learning and accommodates diverse learning speeds, which is particularly beneficial in skill-intensive fields like culinary arts.
b. Challenges with VR: Despite recognizing the innovative potential of Virtual Reality (VR) simulations, some participants encountered practical challenges. Issues such as motion sickness and a steep learning curve were reported, detracting from the overall learning experience. One participant mentioned, "It felt like I was spending more time figuring out how to use the VR headset than actually cooking." These challenges suggest that while VR can offer immersive and interactive experiences, the current technological implementations may need enhancements to be user-friendly and fully effective. Addressing these technical hurdles is essential to harness the full benefits of VR in culinary education.
c. Desire for Sensory Feedback: A recurring theme among participants was the lack of sensory feedback in digital tools, particularly concerning taste and smell, critical elements in culinary training. One participant remarked, "It's hard to judge seasoning or texture in a virtual environment." This limitation highlights a fundamental challenge in replicating the hands-on and sensory-rich nature of cooking through digital platforms. While visual and procedural guidance can be effectively delivered through videos and simulations, the inability to engage other senses may impede the development of nuanced culinary skills. Future iterations of digital instructional media may need to explore innovative solutions to integrate sensory feedback, thereby providing a more holistic training experience.

The qualitative data reveals that aspiring culinary teachers perceive digital-based instructional media as valuable tools that enhance learning flexibility and accessibility. Video tutorials, in particular, receive high praise for their ability to support self-paced learning. However, integrating advanced technologies like VR presents challenges that need to be addressed to prevent hindering the learning process. Additionally, the absence of sensory experiences in digital tools remains a notable limitation, emphasizing the need for future developments to incorporate multi-sensory feedback mechanisms. Overall, while digital tools offer significant advantages in culinary education, addressing their shortcomings is crucial to fully realize their potential in enhancing teaching and learning outcomes.

4.2.1. Perceptions of Aspiring Culinary Teachers

The qualitative findings presented in Table 5 illuminate educators' perspectives regarding incorporating digital-based instructional media in culinary education.

Table 5. Insights from Educators

SN	Theme	Description	Educator
1	Enhanced Teaching Efficiency	Educators appreciated the ability of digital tools to standardize demonstrations and provide consistent learning experiences. By utilizing videos and digital modules, instructors can ensure that all students receive the same high-quality instruction, reducing variability inherent in live demonstrations.	"The videos ensure every student sees the same technique, which isn't always possible in live demonstrations."
2	Desire for Sensory Feedback	Educators emphasized the importance of comprehensive training for instructors and students to integrate and utilize digital tools within the curriculum effectively. Adequate training ensures that digital resources are used to their full potential, enhancing the overall educational experience and preventing underutilization or misuse of technology.	"We need workshops to help us integrate these tools into our teaching."

The analysis reveals a dual recognition of the benefits provided by digital tools and the essential requirements for their effective implementation.

a. Enhanced Teaching Efficiency: Educators reported that digital tools significantly improve teaching efficiency by standardizing instructional content. Videos and digital modules ensure that all students observe the same techniques and procedures, which is particularly valuable in fields like culinary arts, where precision and consistency are paramount. One educator noted, "The videos ensure that every student sees the same technique, which isn't always possible in live demonstrations." This standardization minimizes disparities from varying teaching styles or human error during live demonstrations. As a result, digital tools contribute to more uniform learning outcomes, enhancing the overall quality of education and ensuring that all students attain the requisite skills consistently.
b. Need for Training: Despite the clear advantages, educators highlighted the necessity of providing thorough training for instructors and students to maximize the effectiveness of digital tools. Introducing new technologies into the curriculum necessitates that educators become proficient in using these tools to integrate them seamlessly into their teaching methodologies. One educator suggested, "We need workshops to help us integrate these tools into our teaching." Additionally, students must be trained to navigate and utilize digital platforms effectively to benefit fully from the instructional media. Without adequate training, the potential of digital tools may not be fully realized, leading to underutilization or ineffective application in the educational process. Therefore, investing in comprehensive training programs is crucial to support educators and students in adapting to and leveraging digital technologies to enhance learning outcomes.

The insights from educators underscore the significant potential of digital-based instructional media to enhance teaching effi-ciency by providing standardized and consistent instructional content. However, successfully integrating these technologies into the educational framework is contingent upon providing adequate training for instructors and students. Comprehensive training pro-grams, such as workshops, are essential to equip educators with the necessary skills to effectively incorporate digital tools into their teaching practices and ensure that students can fully engage with and benefit from these resources. Addressing the training needs will facilitate the seamless adoption of digital media in culinary education, maximizing their benefits and contributing to improved teaching and learning outcomes.

4.2.3. Perspectives from Industry Experts

The qualitative findings presented in Table 6 offer valuable insights from industry experts regarding the role and future of digital-based instructional media in culinary education.

Table 6. Perspective from Industry Expert

SN	Theme	Description	Participant Quates
1	Alignment with Industry Trends	Industry experts recognize the increasing integration of technology within the culinary sector and endorse incorporating digital tools in culinary education. They emphasize that staying abreast of technological advancements is crucial for preparing students to meet current and future industry demands.	"Technology is transforming the industry, and educators need to keep up," one expert noted.
2	Recommendations for Improvement	Experts advocate for the enhancement of digital tools by embedding more real-world scenarios. Suggestions include simulating high-pressure kitchen environments and integrating feedback mechanisms from professional chefs to create more realistic and practical training experiences for students.	"Incorporating high-pressure kitchen simulations would better prepare students for real-world challenges," an expert suggested.

These perspectives emphasize the necessity of aligning educational tools with industry trends and enhancing their practicality to prepare aspiring culinary professionals better.

a. Alignment with Industry Trends: Industry experts unanimously acknowledge technology's pivotal role in the modern culinary landscape. The consensus is that culinary education must evolve to incorporate digital tools to remain relevant and effective. One expert stated, "Technology is transforming the industry, and educators must keep up." This sentiment underscores the imperative for educational institutions to integrate current technological advancements, ensuring that students are equipped with the skills and knowledge that are in demand within the culinary sector. By aligning educational practices with industry trends, institutions can enhance the employability and readiness of their graduates, fostering a workforce adept at leveraging technology in various culinary contexts.
b. Recommendations for Improvement: While recognizing the benefits of digital tools, industry experts advocate for their continual refinement to better mirror real-world culinary environments. The recommendation to incorporate more real-world scenarios, such as simulating high-pressure kitchen environments, aims to bridge the gap between theoretical learning and practical application. By introducing elements that mimic the stress and demands of professional kitchens, digital tools can provide a more comprehensive training experience. Additionally, integrating feedback from professional chefs can offer students nuanced insights and constructive critiques, fostering a deeper understanding of culinary techniques and standards. These enhancements are expected to improve student's practical skills and cultivate the adaptability and resilience required in professional culinary settings.

The insights from industry experts highlight the critical importance of integrating technology within culinary education to keep pace with industry transformations. Experts endorse digital tools as essential for preparing students to meet contemporary culinary demands. However, they also emphasize the need to continuously improve these tools to ensure they provide realistic and practical training experiences. Incorporating real-world scenarios and professional feedback mechanisms are among the key recommendations to enhance the effectiveness of digital instructional media. Overall, aligning educational practices with industry trends and focusing on the practical applicability of digital tools are deemed essential for producing competent and industry-ready culinary professionals.

4.2.4. Comparative Analysis

Digital Tools vs. Traditional Methods

a. Advantages of Digital Tools:
   1. Greater flexibility and accessibility for learners.
   2. Consistent and repeatable demonstrations.
   3. Enhanced engagement through interactive features.
b. Limitations of Digital Tools:
   1. Lack of sensory feedback (e.g., taste, smell).
   2. Technical challenges, particularly with VR.
   3. Dependence on reliable internet and hardware.

Key Success Factors

c. Usability: Tools that were easy to use and required minimal technical expertise were more widely adopted and positively received.
d. Alignment with Learning Goals: Digital tools closely aligned with the specific skills and techniques taught in culinary education were more effective.
e. Support and Training: Participants and educators emphasized the need for ongoing support and training to maximize the benefits of digital tools.

Summary of Key Findings

a. Digital-based instructional media significantly improve practical learning outcomes and engagement among aspiring culinary teachers.
b. Video tutorials were the most effective and widely accepted tool, while VR simulations showed potential but faced technical and sensory limitations.
c. Successful integration of digital tools requires careful consideration of usability, alignment with learning goals, and provision of training and support.

4.3. Discussion

The findings of this study demonstrate that digital-based instructional media significantly positively impact the practical learning outcomes of aspiring culinary teachers. The quantitative results reveal measurable improvements in skill acquisition and engagement, while the qualitative insights provide a deeper understanding of the factors influencing the effectiveness of these tools.

a. Skill Acquisition: The 25% improvement in practical skills among participants using digital tools aligns with constructivist learning theory, emphasizing active engagement and experiential learning. Digital tools, particularly video tutorials, and interactive platforms, allow learners to practice and refine their skills in a self-paced, iterative manner.
b. Engagement and Satisfaction: The high engagement and satisfaction reported by participants underscore the potential of digital tools to make learning more interactive and enjoyable. However, the lower satisfaction scores for VR simulations highlight the importance of usability and user experience in adopting new technologies.
c. Challenges and Limitations: The lack of sensory feedback in digital tools, particularly in VR simulations, points to a critical gap in replicating culinary arts' tactile and sensory aspects. This limitation suggests that digital tools should be complementary rather than replacement in culinary education.

The integration of digital-based instructional media in culinary education has positively impacted the practical learning outcomes of aspiring culinary teachers. Several studies indicate that adopting technology in culinary training facilitates improved engagement, skill acquisition, and conceptual understanding in learners. In a survey that leveraged multimedia teaching methods, researchers observed enhanced learning outcomes among students engaged in a dessert-making course that incorporated motion media. The results indicated notable improvements in creativity and teamwork skills, essential for future culinary professionals[28], [29], [30], [31], [32], [33]. This aligns with findings by Buro et al. that emphasized the feasibility of utilizing technology to support learning; however, their focus was specifically on nutrition interventions rather than culinary skills directly[34], [35], [36].

Moreover, the interplay of culinary education with technology has been substantiated through studies on virtual reality applications. For instance, Hu et al. demonstrated that immersive virtual reality curriculums significantly improved learning outcomes and acceptance among students, showing a clear correlation between educational technologies and enhanced experiences in culinary contexts [1]. This innovative approach has the potential to reshape traditional culinary education methodologies, making them more engaging and effective for learners. Furthermore, research by Hashimi et al. [37] explored the effects of cooking demonstrations, often utilizing digital tools, to enhance nutrition counseling and dietary behaviors. The interactive nature of these sessions has been shown to effectively empower students with practical cooking skills while also improving their understanding of nutrition [10], [37], [38], [39], [40]. As referenced in a systematic review, the deployment of effective instructional videos has been shown to aid in better retention and application of culinary practices, making it a valuable tool in the educational arsenal for aspiring chefs [33], [41], [42], [43]. The transition from conventional teaching methods to digital-based instructional media enhances the academic landscape for culinary arts, fostering an environment where practical skills and theoretical knowledge can be effectively integrated. The synthesis of these studies underlines the critical importance of adopting digital technologies in culinary education to cultivate skilled and knowledgeable culinary educators.

The findings of this study indicate that digital-based instructional media significantly improved students' practical competencies, engagement, confidence, and learning satisfaction. Among the digital media evaluated, video tutorials demonstrated the highest level of effectiveness, receiving the highest satisfaction score and contributing substantially to improvements in practical performance. These findings can be explained through several well-established learning theories that clarify how digital instructional media facilitate meaningful learning in vocational culinary education.

The effectiveness of video tutorials is strongly supported by Mayer's Cognitive Theory of Multimedia Learning, which proposes that learners process information through two separate cognitive channels: the visual/pictorial channel and the auditory/verbal channel [44]. Learning becomes more effective when instructional materials integrate images, demonstrations, narration, and text because learners are able to construct coherent mental representations while avoiding unnecessary cognitive overload. In culinary education, video tutorials simultaneously demonstrate cooking procedures while providing verbal explanations, allowing students to observe every stage of food preparation before performing the practical activity. This dual-channel processing reduces extraneous cognitive load, allowing learners to allocate greater cognitive resources toward understanding procedural steps and strengthening procedural memory, which is essential for mastering psychomotor competencies. The significant improvement in practical skill scores observed in this study confirms that multimedia-based instruction effectively facilitates procedural learning, particularly in complex culinary techniques. These findings are also consistent with previous studies reporting that instructional videos enhance knowledge retention, procedural understanding, and practical performance in vocational education [45], [46], [47].

The present findings are equally consistent with Piaget's Constructivist Learning Theory, which argues that learners actively construct knowledge through interaction with their learning environment rather than passively receiving information [48]. The flexibility provided by digital instructional media enabled students to repeatedly observe demonstrations, revisit difficult concepts, and practice culinary procedures independently according to their own pace of learning. Through repeated observation and practice, learners continuously modified their existing cognitive structures through processes of assimilation and accommodation, gradually developing more sophisticated procedural understanding. This interpretation is supported by the qualitative findings in which participants reported that replaying instructional videos helped them master techniques that were difficult to understand during conventional classroom demonstrations. Unlike traditional face-to-face demonstrations that occur only once, digital learning environments provide unlimited opportunities for repetition and self-reflection, thereby promoting deeper conceptual understanding and long-term skill acquisition.

Furthermore, the findings can be interpreted through Kolb's Experiential Learning Theory, which emphasizes that effective learning occurs through a continuous cycle consisting of Concrete Experience, Reflective Observation, Abstract Conceptualization, and Active Experimentation [49]. Video tutorials support each phase of this experiential learning cycle. Students initially acquire Concrete Experience by observing authentic demonstrations performed by instructors or professional chefs. Subsequently, they engage in Reflective Observation by reviewing the instructional videos repeatedly while comparing the demonstrated techniques with their own performance. This reflective process enables students to develop Abstract Conceptualization, during which they construct conceptual understanding regarding culinary procedures, food preparation techniques, and restaurant service standards. Finally, students implement these concepts during laboratory practice through Active Experimentation, where they perform culinary tasks independently while applying the procedures previously observed. This iterative experiential cycle explains why students demonstrated significant improvements in practical competency following exposure to digital instructional media.

The motivational benefits observed in this study can also be explained using Self-Determination Theory (SDT) developed by Deci and Ryan [50]. According to SDT, intrinsic motivation increases when learners experience autonomy, competence, and relatedness. Digital instructional media enhanced learners' autonomy by allowing them to access learning materials independently without restrictions of time or place. Students were able to control the pace of learning by pausing, replaying, and reviewing instructional videos whenever necessary. Repeated successful practice subsequently strengthened learners' perceptions of competence, reflected in increased confidence and improved practical performance. These experiences ultimately enhanced intrinsic motivation, encouraging greater engagement during practical learning sessions. This interpretation is consistent with the quantitative findings of the present study, which demonstrated a strong positive relationship between the frequency of digital media usage and students' confidence in performing practical culinary tasks. Similar findings have been reported in previous research showing that technology-enhanced learning environments significantly increase learner engagement, confidence, and self-directed learning behaviors [31] , [39].

Overall, the integration of these theoretical perspectives provides a comprehensive explanation for the effectiveness of digital-based instructional media in culinary teacher education. Mayer's Multimedia Learning Theory explains improvements in cognitive processing and procedural memory; Constructivist Learning Theory explains how repeated interaction with multimedia supports active knowledge construction; Kolb's Experiential Learning Theory demonstrates how video tutorials facilitate the complete experiential learning cycle; and Self-Determination Theory explains the observed increases in learner autonomy, competence, confidence, and intrinsic motivation. Therefore, digital instructional media should not merely be viewed as technological innovations but as pedagogically grounded instructional strategies capable of simultaneously enhancing cognitive, psychomotor, and motivational dimensions of learning. Consequently, the findings of this study extend previous literature by demonstrating that integrating multiple forms of digital instructional media including video tutorials, virtual reality simulations, and interactive learning platforms provides a comprehensive learning ecosystem that effectively prepares future culinary teachers for technology-enhanced vocational education.

4.4. Implication for Culinary Education

The findings of this study have several important implications for culinary education and teacher training:

a. Curriculum Design: Digital tools should be integrated into culinary curricula to complement traditional methods. For example, video tutorials can introduce techniques before hands-on practice, while VR simulations can provide additional practice opportunities in a risk-free environment [6], [33].
b. Training and Support: Educators and students need training to use digital tools effectively. Workshops, tutorials, and ongoing technical support can help overcome the initial learning curve and ensure tools are used to their full potential [21].
c. Alignment with Industry Needs: The integration of digital tools should reflect the evolving needs of the culinary industry. For example, incorporating real-world scenarios, such as high-pressure kitchen environments, can better prepare students for the challenges they will face in their careers [51].

4.5. Limitation of the Study

While this study provides valuable insights, it is not without limitations:

a. Sample Size and Diversity: The study focused on a specific group of aspiring culinary teachers, educators, and industry experts. Expanding the sample size and including participants from diverse geographic and cultural backgrounds could provide a more comprehensive understanding of the impact of digital tools.
b. Short-Term Evaluation: The study measured learning outcomes over a relatively short period. Longitudinal studies are needed to assess the long-term impact of digital tools on skill retention and career success.
c. Technical Constraints: The study was conducted in environments with reliable internet and hardware access. The findings may not be generalizable to contexts with limited technological infrastructure.

4.6. Future Research Directions

The findings of this study open several avenues for future research:

a. Exploring Emerging Technologies: Future studies could investigate the potential of emerging technologies, such as augmented reality (AR) and artificial intelligence (AI), in culinary education. For example, AR could overlay instructions directly onto physical cooking surfaces, while AI could provide personalized feedback based on learner performance.
b. Addressing Sensory Limitations: Research is needed to develop digital tools that better replicate the sensory aspects of culinary arts, such as taste and smell. This could involve collaborations with food scientists and technologists to create more immersive learning experiences.
c. Scaling and Implementation: Future research should explore strategies for scaling the integration of digital tools in culinary education, particularly in resource-constrained settings. This could include the development of low-cost, accessible technologies and best practices for implementation.

5. Conclusion

This study demonstrates that integrating digital-based instructional media, including video tutorials, virtual reality (VR) simulations, and interactive learning platforms, significantly enhances practical learning outcomes in culinary teacher education. The quantitative findings revealed significant improvements in students' practical skills, learning engagement, confidence, and overall satisfaction, while the qualitative findings further confirmed that digital media provide greater flexibility, accessibility, and opportunities for self-paced learning. Among the instructional media investigated, video tutorials emerged as the most effective learning resource, owing to their ability to facilitate repeated observation, independent practice, and procedural skill mastery. Nevertheless, the findings also indicate that digital media should complement rather than replace hands-on laboratory practice because sensory experiences such as taste, aroma, and texture remain fundamental components of culinary education.

From a theoretical perspective, this study extends the application of Multimedia Learning Theory by demonstrating that multimedia-based instructional media can effectively support procedural knowledge acquisition and psychomotor skill development within vocational culinary education. Furthermore, the findings provide empirical support for Constructivist Learning Theory, Experiential Learning Theory, and Self-Determination Theory, illustrating that digital instructional media facilitate active knowledge construction, experiential learning

cycles, learner autonomy, competence development, and intrinsic motivation. Consequently, this study contributes to the growing body of literature by integrating multiple theoretical perspectives to explain how digital technologies enhance practical learning in vocational education.

From a practical perspective, the findings provide valuable evidence for curriculum developers, vocational education institutions, and culinary educators in designing technology-enhanced learning environments. The results suggest that Learning Management Systems (LMS) integrated with video-based learning, interactive multimedia, and structured digital learning resources can effectively complement conventional practical instruction. Moreover, the findings highlight the importance of continuous professional development and digital pedagogy training for culinary educators to ensure the effective implementation of digital instructional media within competency-based curricula. These implications support the ongoing digital transformation of vocational education while improving graduates' readiness to meet evolving industry demands.

Despite these contributions, the present study has several limitations, including its focus on a single institution and the relatively short intervention period. Therefore, future research should investigate the integration of Artificial Intelligence (AI), Augmented Reality (AR), adaptive learning systems, and intelligent digital assessment technologies to provide more personalized, immersive, and authentic learning experiences in culinary education. Longitudinal and multi-institutional studies are also recommended to evaluate the long-term effects of digital instructional media on professional competence, workplace readiness, and sustainable digital transformation in vocational education.

Overall, this study provides strong empirical evidence that digital-based instructional media represent not merely technological innovations but pedagogically meaningful instructional strategies capable of improving cognitive, psychomotor, and motivational learning outcomes. By integrating digital technologies with sound pedagogical principles, vocational culinary education can better prepare future culinary teachers and professionals to meet the challenges of an increasingly technology-driven educational and industrial landscape.

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