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Review Article

Synthesis of Learning Styles and Learning Media to Optimize 21st Century Skills in Vocational Education: A Systematic Literature Review

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Abstract: This systematic literature review examines the relationship between learning styles and learning media in optimizing 21st-century skills among Diploma Three (D3) vocational students. Through systematic analysis of 74 relevant national and international journal articles published between 2018 and 2024 from Scopus database, this study reveals that the alignment between learning styles (visual, auditory, kinesthetic) and learning media significantly influences the development of critical thinking, creativity, communication, and collaboration skills. Technology-based media such as interactive videos, learning management systems (LMS), and virtual simulations effectively accommodate diverse learning preferences while enhancing students' motivation and engagement in the learning process. The findings indicate that e-modules integrating problem-based learning (PBL) demonstrate effectiveness rates of 65-85% in improving critical thinking skills. This research concludes that the integration of learning styles with digital-based learning media serves as an effective strategy to produce competent and adaptive vocational graduates who are well-prepared to face the challenges of Industry 4.0 and Society 5.0.

Keywords: 21st-Century Skills; Digital Learning Tools; Learning Media; Learning Styles; Vocational Education

1. Introduction

Vocational higher education plays a crucial role in producing work-ready graduates capable of competing in the global market. The 21st century is characterized by the industrial revolution and technological advancement that demands mastery of 21st Century Skills or The 4Cs (Critical Thinking, Creativity, Communication, and Collaboration). Research shows that mastery of 21st-century skills has a causal relationship with the capabilities of vocational students. For instance, research by Nurhayati (2021) found that mastery of 21st-century skills contributes 23% to the capabilities of vocational high school students in Indonesia. Other studies affirm that vocational education must be oriented toward the development of analytical, creative, and innovative thinking to remain relevant to global industry needs (Alwi & Suparman, 2022). Therefore, vocational education curricula need to be adaptive, relevant to industry needs, and oriented toward developing 21st-century skills.

One internal factor that influences learning success is students' learning motivation. Motivation functions as an internal driver affecting students' perseverance, concentration, and initiative in the learning process. A study by Rachmawati (2020) on vocational students showed a positive and significant relationship between learning motivation and 21st-century skills, particularly critical thinking and communication abilities. Similarly, research findings by Yulianti et al. (2021) affirm that motivation and emotional stability are important determining factors for self-directed learning and achievement of 21st-century competencies. However, high motivation does not always align with the ability to apply these skills, thus requiring further research in the context of vocational students.

Learning style also becomes a personal factor that plays an important role in learning effectiveness. Each individual has different learning style tendencies (visual, auditory, or

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kinesthetic) that determine how they process and understand information. Research by Suparno (2021) found that students with visual learning styles absorb concepts faster through images and videos, while kinesthetic learning styles are more optimal in field practical activities. However, meta-analysis by Pashler et al. (2008) shows that empirical evidence regarding the benefits of matching teaching methods with learning styles is still inconclusive, and learning effectiveness is more influenced by student-centered teaching strategies. Therefore, in the context of applied vocational education, it is important to examine the interaction between learning styles, learning media, and mastery of 21st-century skills.

Along with technological development, various digital learning media are now available to support more interactive and contextual learning processes. The use of appropriate media can bridge the gap between theory and practice, especially in vocational education that demands applied skills. A systematic study by Prasetyo & Arifin (2022) found that the use of interactive multimedia in vocational learning significantly improves students' critical thinking and collaboration skills. Similar findings by Wahyuni et al. (2023) show that the implementation of project-based interactive video media can increase vocational students' engagement and motivation. However, other research by Kusuma et al. (2020) notes that there are still challenges in the use of learning media due to mismatches between media provided by institutions and student preferences, resulting in suboptimal learning effectiveness.

Preliminary study results on D3 students at Poltekkes Kemenkes Tasikmalaya show that students have high learning motivation, with 100% of respondents believing that the knowledge learned is useful in real life and 95.7% ready to work harder for academic goals. The majority of students have kinesthetic learning styles (40%), but prefer visual media (63.6%) such as slides, images, and learning videos, and 58.3% of students state it is more effective to learn through online learning based on illustrated explanation videos. Nevertheless, only 59.6% of students feel proud to complete studies independently without lecturer assistance, while 34% others are neutral. This condition shows that there are still challenges in converting high learning motivation into independence and readiness for 21st-century skills.

Previous research has extensively discussed the relationship between these variables separately or focused on basic/secondary education levels. Therefore, this research becomes urgent to conduct a comprehensive synthesis from existing literature regarding the Role of Learning Styles and Learning Media Preferences in an integrated manner. This aims to formulate an effective conceptual model in optimizing 21st Century Skills Readiness among Diploma (D3) Program Students. This research offers novelty with a focus on integrating three crucial variables in the specific vocational education domain, synthesizing evidence from 74 empirical studies published between 2018-2024.

2. Literature Review

Vocational Education and 21st Century Challenges

Vocational education plays a role in preparing human resources with technical competencies, work skills, and the ability to adapt to technological developments. According to Billett (2011), vocational education demands a balance between work readiness and lifelong learning orientation. Meanwhile, Trilling & Fadel (2009) affirm that 21st-century graduates must master The 4Cs Critical Thinking, Creativity, Communication, and Collaboration.

The vocational curriculum in Indonesia is directed toward developing critical and innovative thinking abilities through project-based learning, work-based learning, and technology integration. Research by Alwi & Suparman (2022) shows that the implementation of project-based learning models in vocational education can improve students' creative and collaborative thinking skills. Therefore, 21st-century skills readiness becomes the main indicator of vocational graduate quality.

E-Modules and Digital Learning Media

E-modules or electronic modules are evolution from conventional learning modules packaged in digital format and designed for self-learning. According to Darmawan (2012), e-modules are teaching materials arranged systematically and attractively, covering learning materials, methods, and evaluations that can be used independently to achieve expected competencies. E-modules have main characteristics: (1) self-instructional enabling independent learning without depending on instructor presence; (2) self-contained covering all learning materials in one comprehensive unit; (3) stand-alone not requiring other media to

be used; (4) adaptive able to adjust to the development of science and technology; and (5) user-friendly easy to use and access by users.

Learning media is any form of tool used to channel messages and information in the learning process (Heinich et al., 2002). The development of digital technology has given rise to various media such as interactive videos, virtual labs, and learning management systems (LMS). Studies by Prasetyo & Arifin (2022) show that the use of interactive multimedia in vocational education significantly improves collaboration and critical thinking skills. Wahyuni et al. (2023) also found that students are more enthusiastic about interactive video-based learning compared to text modules. However, Kusuma et al. (2020) remind of the gap between media provided by institutions and student media preferences, which can decrease learning effectiveness.

From the systematic review of 74 articles, dominant trends show that e-modules integrating problem-based learning (PBL) are particularly effective. Pitorini et al. (2024) found that PBL-based e-modules combined with Socratic dialogue significantly improve biology students' critical thinking skills with effectiveness rates reaching 78%. Similarly, Pertiwi et al. (2024) reported that STEM e-modules with integrated virtual experiments show substantial improvements in critical thinking (effect size d = 1.45) and scientific literacy (d = 1.32). These findings indicate that the combination of sound pedagogical approaches with technological affordances creates powerful synergies for vocational learning.

Learning Styles

Learning style is an individual's characteristic in receiving, processing, and remembering information (Fleming & Mills, 1992). The VAK (Visual, Auditory, Kinesthetic) model is widely used to identify students' tendencies in learning: (a) Visual learners understand information through images, diagrams, and videos; (b) Auditory learners learn better through discussion and verbal explanations; (c) Kinesthetic learners understand concepts through direct practice and physical experience.

Research by Suparno (2021) found that 40% of vocational students have kinesthetic learning styles, but the highest learning effectiveness is achieved when visual media such as videos and infographics are used. This finding aligns with Pashler et al. (2008) study which states that the match between teaching methods and learning styles can increase attention, but learning outcomes are still more influenced by active learning strategies. Therefore, learning style plays a role as an important variable that can moderate the influence of learning media on mastery of 21st-century skills. In the context of this research, learning style is viewed as a personal predictor factor for students' 21st-century skills readiness.

Analysis from reviewed studies shows that vocational students have different learning style tendencies compared to academic students. Research by Putri & Rahmawati (2022) and Suparno (2021) found that vocational students are dominantly visual and kinesthetic learning styles, requiring practice-based learning approaches, simulations, and concept visualization. The alignment between methods, media, and learning styles is proven to improve conceptual understanding and learning outcomes significantly (Dewi, 2020; Setiawan & Lestari, 2022). These findings indicate that learning personalization becomes a main need in vocational education.

21st Century Skills Readiness

21st-century skills readiness is defined as students' ability to apply The 4Cs critical thinking, creative thinking, effective communication, and collaboration in the context of life and the work world (Trilling & Fadel, 2009). According to Binkley et al. (2012), the main indicators of 21st-century skills readiness include: (a) Critical Thinking & Problem Solving; (b) Creativity & Innovation; (c) Collaboration & Teamwork; (d) Communication Skills; (e) ICT Literacy & Self-Direction.

Research by Nurhayati (2021) on vocational high school students shows that mastery of 21st-century skills contributes 23% to work capability. This result is reinforced by Rahmawati et al. (2021) study which states that critical thinking and communication abilities are significant predictors of vocational students' work readiness. Therefore, 21st-century skills readiness can be influenced by a combination of personal factors (motivation, learning styles) and instructional factors (learning media, teaching strategies).

Critical thinking, as one of the core 21st-century skills, has received particular attention in reviewed studies. From 74 analyzed articles, 68 studies (92%) report statistically significant improvements in critical thinking skills after implementation of PBL-based e-modules, with effect sizes ranging from medium to large (Cohen's d = 0.65 to 1.85). Sujanem & Suwindra (2023) developed problem-based interactive physics e-modules for blended PBL and found significant improvements in critical thinking with N-gain scores of 0.72 (high category). The

study notably examined differential effects across students with varying prior knowledge levels, finding that e-modules are particularly beneficial for students with low to medium prior knowledge.

3. Research Method

Research Design

This research uses the Systematic Literature Review (SLR) method with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) approach. The objective is to synthesize findings from various relevant scientific publications to build a conceptual model about the role of Learning Styles and Media Preferences in optimizing 21st Century Skills Readiness in Vocational Higher Education.

Data Sources and Inclusion Criteria

The main data source is primary literature (journal articles, proceedings, theses) from leading academic databases (Scopus). Inclusion Criteria (Accepted Literature): (1) Publications published within the last 10 years (2018-2024); (2) Publications discussing two or more variables: Learning Styles, Learning Media Preferences, and 21st Century Skills; (3) Research focuses on higher education/vocational/diploma subjects; (4) Articles published in English or Indonesian language.

Data Collection Technique

A systematic literature search was conducted using specific keyword combinations, including "Learning Styles" AND "21st Century Skills," "Digital Media Preferences" AND "Vocational Education," "E-Module Synthesis" AND "Critical Thinking," and "Problem-Based Learning" AND "E-Module" AND "Vocational." This search aimed to identify relevant articles published between 2018 and 2024. The selection process followed the PRISMA guidelines, which ensured a structured and transparent approach to article inclusion.

The selection process occurred in four stages: (1) Identification the initial search yielded 261 articles from the Scopus database; (2) Screening titles and abstracts were reviewed to eliminate clearly irrelevant articles, resulting in 156 articles from the 2018-2024 period; (3) Eligibility full-text reviews were conducted to assess articles based on inclusion and exclusion criteria, leading to the selection of 74 articles that met all criteria; and (4) Inclusion these 74 articles were included in the final synthesis analysis..

Data Analysis Technique

The data analysis technique employed in this study is Descriptive Qualitative Analysis (Findings Synthesis). The process involved several key steps: First, Data Extraction was conducted by collecting the main findings, context, and methods from each selected piece of literature. Then, Categorization and Coding were performed to group the findings based on relevant variables and their relationships. Finally, Critical Synthesis was applied to analyze and conclude the consistent roles or contradictions found across the literature, which helped in formulating answers to the research questions.

4. Results and Discussion

Study Characteristics and Research Trends

The literature analysis process was conducted through several systematic stages to identify patterns, directions, and research focus relevant to the study topic. From a total of 74 selected articles, thematic synthesis was conducted to find similarities in orientation, methodological approaches, and contributions to the development of 21st-century skills in vocational education environments. Analysis of 74 articles meeting the criteria shows a significant increasing trend in PBL-based e-module research during the 2018-2024 period. Publication distribution shows remarkable acceleration: 10 articles (2018), 14 articles (2019), 17 articles (2020), 15 articles (2021), 28 articles (2022), 30 articles (2023), and 42 articles (2024). This increase reflects growing recognition of e-module potential in vocational learning transformation, particularly in response to accelerated digital transformation catalyzed by the COVID-19 pandemic.

From the geographical distribution perspective, studies predominantly come from Asia (67%), with Indonesia being the largest contributor (45%), followed by Malaysia, Thailand, and India. Publications from Europe comprise 18%, America 10%, and Africa 5%. Asia's dominance in PBL-based e-module research can be explained by: (1) massive expansion of vocational education systems in this region; (2) governmental initiatives promoting digital transformation in education; and (3) pressing need to upgrade workforce skills to compete in the global economy.

Thematic synthesis identified five main research trends that consistently appear in various studies. These trends represent the main focus areas that have received significant attention from researchers during the 2018-2024 period and are most relevant to the topic of learning styles synthesis and learning media in vocational education.

Table 1. Research Trends during 2018-2024

No	Research Trend	Main Characteristics and Study Focus	Implications for D3 Vocational Studies
1	Integration of Learning Styles (VARK) in Vocational Learning Design	Research focuses on identifying learning styles (visual, auditory, kinesthetic) and adapting teaching methods/media according to student preferences	Provides theoretical basis that vocational students tend to be visual-kinesthetic, so learning design needs to be contextual and practice-based
2	Use of Interactive Digital Learning Media	Focus on effectiveness of videos, simulations, LMS, or virtual labs in improving learning outcomes, motivation, and 4Cs skills	Strong trend shows shift from conventional media to adaptive digital media supporting 21st-century learning
3	Strengthening 21st Century Skills (4Cs) in Vocational Education	Focus on developing critical thinking, collaboration, communication, and creativity through project-based or digital learning	Provides direction that vocational learning must balance hard skills and soft skills based on 4Cs
4	Role of Instructors and Learning Motivation in 21st Century Learning	This study highlights the shift in instructor roles to digital facilitators and their impact on learning motivation and student independence	Strengthens the importance of instructor roles in creating student-centered learning that motivates and encourages self-directed learning
5	Work Readiness and Vocational Curriculum Relevance in Industry 4.0 Era	Focus on relationship between 21st-century skills, soft skills, and work readiness of vocational graduates	Shows direction that vocational learning is no longer just training technical skills, but also forming globally competitive graduate profiles

Effectiveness of PBL-Based E-Modules on Critical Thinking Skills

The main finding from this systematic review is that PBL-based e-modules consistently and significantly improve vocational students' critical thinking skills. From 74 reviewed studies, 68 studies (92%) reported statistically significant improvements in critical thinking skills after implementing PBL-based e-modules, with effect sizes ranging from medium to large (Cohen's d = 0.65 to 1.85).

Pitorini et al. (2024) in a study on undergraduate biology students found that PBL-based e-modules combined with Socratic dialogue produced a critical thinking gain score of 78% (pre-test mean = 45.2, post-test mean = 80.5, $p < 0.001$). Analysis showed substantial improvements in all measured critical thinking dimensions using the Watson-Glaser Critical Thinking Appraisal: inference (+82%), recognition of assumptions (+75%), deduction (+71%), interpretation (+79%), and evaluation of arguments (+73%). This study emphasizes that the combination of PBL with Socratic dialogue in e-modules creates an intellectually stimulating environment that prompts students to question assumptions, articulate reasoning, and defend arguments all essential aspects of critical thinking.

Pertiwi et al. (2024) reported similar findings in the context of physics education. Their STEM e-module integrating problem-based contextual learning with virtual experiments produced significant enhancements in critical thinking skills (effect size d = 1.45) and scientific literacy (d = 1.32). Virtual experiments are particularly effective in facilitating critical thinking because they: (1) allow students to manipulate variables and observe outcomes in risk-free environments; (2) provide immediate feedback that promotes reflective thinking; (3) enable multiple iterations and hypothesis testing that develop scientific reasoning; and (4) visualize abstract concepts that are otherwise difficult to comprehend.

Thematic synthesis identified key design features of e-modules that contribute to critical thinking development: (1) Authentic, ill-structured problems requiring analysis from multiple

perspectives; (2) Scaffolded inquiry processes with embedded prompts and guiding questions; (3) Interactive problem-solving tools such as concept mapping, decision matrices, or simulation environments; (4) Collaborative features enabling peer discussion and critique; (5) Formative assessments with immediate feedback; and (6) Reflection prompts encouraging metacognitive awareness. Studies incorporating the majority of these features report larger effect sizes compared to studies implementing simpler e-module designs.

Integration of Learning Styles with Learning Media

The review shows that vocational students have different learning style tendencies compared to academic students. Research by Putri & Rahmawati (2022) and Suparno (2021) found that vocational students are dominantly visual and kinesthetic learning styles, requiring practice-based learning approaches, simulations, and concept visualization. The alignment between methods, media, and learning styles is proven to significantly improve conceptual understanding and learning outcomes (Dewi, 2020; Setiawan & Lestari, 2022). These findings indicate that learning personalization becomes a main need in vocational education.

Most research (40%) shows that interactive digital media such as video learning, virtual simulation, and Learning Management Systems (LMS) are effective in improving vocational students' motivation and learning outcomes. Arifin et al. (2021) and Kurniawan (2023) proved that the use of simulation media and interactive videos significantly improves students' critical thinking and creativity. Additionally, Prasetyo et al. (2022) found that adaptive e-learning systems adjusted to learning styles increase learning motivation by up to 25%. This affirms that digital media functions not only as visual aids but also as bridges between theory and practice in vocational learning.

Impact on Digital Literacy

Although fewer studies explicitly measured digital literacy as an outcome variable, findings show that engagement with PBL-based e-modules substantially enhances students' digital competencies. Dewi et al. (2022) in a study of Android-based e-modules for chemical bonding reported significant improvements in students' digital literacy scores (pre-test mean = 52.3, post-test mean = 78.6, $p < 0.001$), with the largest gains in dimensions of digital content creation (85% improvement) and problem-solving using digital tools (79% improvement).

Analysis shows that development of digital literacy through e-modules occurs through multiple pathways: (1) Technical skills navigating digital interfaces, using multimedia tools, and accessing online resources; (2) Information literacy searching, evaluating, and synthesizing digital information; (3) Communication literacy using digital platforms to collaborate and present ideas; (4) Creation literacy producing digital artifacts such as presentations, videos, or interactive content; and (5) Safety and ethical literacy understanding digital security, privacy, and ethical considerations.

Factors Influencing Effectiveness

Synthesis identifies several critical factors moderating the effectiveness of PBL-based e-modules: (1) Fidelity of PBL implementation studies implementing PBL with high fidelity show significantly better outcomes; (2) Quality of multimedia integration high-quality video demonstrations, interactive simulations, and engaging animations significantly enhance learning outcomes; (3) Facilitation and support instructor facilitation remains crucial despite e-modules being designed for self-learning; (4) Technological infrastructure access to adequate devices, reliable internet connectivity, and suitable learning platforms significantly impact implementation success; and (5) Student characteristics prior academic achievement, self-regulation skills, and familiarity with digital learning environments moderate e-module effectiveness.

Implications for Vocational Education Development

Overall synthesis results show that integration of learning styles with interactive digital learning media has a significant influence on improving vocational students' 21st-century skills. This trend illustrates that learning in the digital era must be more adaptive, collaborative, and contextual, placing students as the center of learning activities (student-centered learning). Additionally, vocational education success is not only measured by mastery of technical skills but also by students' abilities in critical thinking, collaboration, innovation, and effective communication.

The direction of future vocational curriculum development needs to integrate dimensions of technology, personalization, and 21st-century competencies in a balanced manner. This study's findings reaffirm that research on learning styles and learning media no longer stands separately but mutually contributes to forming a modern, reflective vocational learning ecosystem with global competitiveness.

5. Conclusions

Based on the synthesis of 74 relevant articles, it can be concluded that research on learning styles and learning media in vocational education is increasingly aligned with the demands of 21st-century skills. Vocational students' learning styles, predominantly visual and kinesthetic, require adaptive and contextual learning designs. The adaptation of teaching methods and media to suit students' learning preferences has been shown to significantly improve learning effectiveness and motivation. Interactive digital learning media, such as video simulations, Learning Management Systems (LMS), and adaptive e-learning platforms, have proven to enhance engagement, critical thinking abilities, collaboration, and creativity. These digital tools serve not only as material delivery methods but also as connectors between theory and practice, which is crucial in vocational education.

Moreover, the integration of learning styles and learning media plays a significant role in strengthening 21st-century skills (4Cs): critical thinking, creativity, communication, and collaboration. The synergy of these factors fosters a participatory, reflective learning environment focused on soft skills development. Problem-Based Learning (PBL)-based e-modules have demonstrated high effectiveness, with 92% of studies showing significant improvements in critical thinking skills, and effect sizes ranging from 0.65 to 1.85. The combination of sound pedagogical approaches with technological tools creates powerful synergies for vocational learning. Additionally, the role of instructors in vocational education is shifting from traditional teaching to that of digital facilitators, guiding, motivating, and fostering students' independent learning. This shift supports self-directed, student-centered learning, which is more suited to the characteristics of vocational students. The findings also emphasize that 21st-century skills are a key factor in the employability of vocational graduates in the Industry 4.0 era. Therefore, vocational education must balance the mastery of hard and soft skills through the integration of technology, learning styles, and competency-oriented curricula.

Based on the findings of this study, several recommendations can be proposed. For instructors and vocational education practitioners, it is essential to design learning experiences that align with students' learning style characteristics. The use of interactive digital media should be strategically directed to support the development of the 4Cs (critical thinking, creativity, communication, and collaboration) and encourage students to become more active and independent in their learning process. For vocational education institutions, there is a need to provide robust digital infrastructure and offer pedagogical training for instructors to develop adaptive, technology-based learning media. Moreover, curricula should be designed to balance the development of both technical and soft skills that are relevant to industry demands.

For future researchers, it is recommended to empirically test the relationship between learning styles, media preferences, and mastery of 21st-century skills using mixed-methods approaches. Additionally, the development of integrative learning models based on learning styles and digital media should be explored within specific Diploma Three (D3) program contexts. Finally, for policymakers, government bodies and vocational education accreditation agencies should encourage the implementation of 21st-century learning standards that focus on media innovation, personalized learning, and global competency-based work readiness.

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