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A Conceptual Framework for Implementing a Problem-Solving Based Mathematics Curriculum in Vocational Education

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Abstract: This study is a conceptual investigation aimed at developing a theoretical framework for implementing a problem-solving based mathematics curriculum in Intermediate Vocational Schools (SMK). The study is motivated by the need to bridge the gap between conventional mathematics learning approaches and the demands of the industrial world, which require students to possess critical, creative, and adaptive thinking skills. The research employed a systematic literature analysis using reputable international sources indexed in Scopus from 2015 to 2025. The synthesis of the literature reveals five key components of effective implementation strategies: (1) strengthening teacher capacity in designing problem solving oriented learning, (2) developing contextual instructional designs, (3) ensuring strong industry relevance, (4) applying competence-based and sustainable evaluation, and (5) fostering institutional support for innovation. The resulting conceptual framework provides theoretical contributions to the development of vocational mathematics curricula and offers practical guidance for teachers in designing learning activities aligned with the needs of the world of work.

Keywords: Curriculum Implementation, Learning Strategy, Mathematics Curriculum, Problem-Solving, Vocational Education

A. Introduction

The curriculum is a strategic plan in the implementation of education that serves to direct the entire learning process to align with the needs of students and society (Ornstein & Hunkins, 2018: 12). In the context of vocational education, the curriculum has a dual role: in addition to transmitting theoretical knowledge, it also develops practical competencies relevant to the world of work (Zhao & Lu, 2018: 236). Therefore, the curriculum in Vocational High Schools (SMK) must be designed so that students not only understand concepts but are able to apply them in real-world industrial and technological contexts. This is in line with the view of Tynjälä (2022: 8), who emphasizes the importance of a vocational curriculum that integrates theoretical learning and real-world work practices to develop sustainable professional competencies.

However, various studies show that the implementation of the mathematics curriculum in vocational schools is still oriented towards procedures and memorization, rather than the development of higher *-order thinking skills* (Wijaya, Retnawati, & Yamtinah, 2020: 1077). As a result, mathematics learning is often decontextualized and less able to foster the critical, creative, and reflective thinking skills needed in the modern workplace. Similar findings were also reported by Tanujaya and Mumu (2023: 14), who identified that most vocational teachers in Southeast Asia still use a procedure- and drill-based learning approach, rather than a problem-solving one. This condition indicates a gap between the competencies expected by industry and the competencies produced by vocational education institutions (OECD, 2023: 22).

Along with the changing paradigm of 21st-century education, the *problem-solving approach* has become an effective learning strategy to bridge this gap. This approach positions students as active subjects in the learning process through activities such as discovering, analyzing, and solving contextual problems relevant to their areas of expertise (Trigo, 2024: 4). Furthermore, research by Savery (2021: 18) confirms that *problem-solving* encourages the development of critical and collaborative thinking skills, which are core to 21st-century competencies. Thus, students not only understand mathematical concepts theoretically but are also able to apply them in real-world situations and dynamic work environments.

Globally, vocational education institutions are required to integrate industry-based learning with a curriculum that is adaptive and responsive to technological change (UNESCO, 2020: 45). In Indonesia, this transformation still faces challenges in terms of teacher readiness, the suitability of teaching materials, and evaluation mechanisms that support the development of *problem-solving skills* (Setiawan et al., 2021: 63). Therefore, a mathematics curriculum implementation framework is needed that is not only innovative and systematic but also relevant to the needs of the workplace and developments in digital technology.

This study attempts to develop a conceptual framework for implementing a *problem-solving -based mathematics curriculum* in vocational high schools. The novelty of this research lies in its comprehensive integration of the *problem-solving approach* with industry-based vocational learning principles. The results are expected to strengthen the role of vocational education in preparing competent, adaptive graduates who are ready to face the challenges of the digital era. This study attempts to answer the question: how can a conceptual model for implementing a problem-solving-based mathematics curriculum be developed in the context of vocational education?

B. Methods

This study uses a conceptual approach *to* develop a theoretical model based on a systematic synthesis of scientific literature. This approach was chosen because the focus of the research is not on empirical data collection, but rather on building a conceptual framework through an in-depth analysis of theories and previous research findings. Consistent with the views of Henderson (2021: 7) and Jabareen (2009: 51), a conceptual approach allows for the integration of various academic perspectives to produce a coherent model that can be used as a reference in implementing the mathematics curriculum in vocational education.

The data sources in this study come from reputable international journal articles indexed by Scopus and Web of Science published between 2015 and 2025. In addition, this study also examines educational policy documents and global reports from international institutions such as UNESCO (2020: 45), OECD (2021: 13), and the World Bank (2022: 28). The literature selection was carried out selectively by considering three main criteria: studies focusing on *problem-solving approaches* in mathematics learning, research discussing curriculum design and implementation in vocational high schools (SMK), and articles highlighting the relationship between education and industrial relevance.

The literature analysis process was conducted systematically by adapting the conceptual analysis steps proposed by Miles, Huberman, and Saldaña (2019: 101). The analysis included identifying key concepts such as *problem-solving*, curriculum implementation, and vocational mathematics; then synthesizing the literature through a comparison of various conceptual models, frameworks, and pedagogical approaches; and concluding with the development of a new conceptual framework that integrates the theoretical findings into a *problem-solving- based mathematics curriculum implementation model* in vocational high schools. To ensure theoretical validity, theoretical triangulation was conducted by comparing research findings from various credible academic sources, both those supporting and those with differing views (Trigo, 2024: 5). The model development process was carried out iteratively through repeated analysis to ensure consistency and integration between pedagogical principles, vocational relevance, and curriculum design. Through this approach, the study is expected to be able to produce a strong and applicable theoretical framework, so that it can function as a reference for teachers, curriculum developers, and policy makers in implementing a *problem-solving- based mathematics curriculum* that is in line with the needs and dynamics of today's industrial world.

C. Results and Discussion

The results of a literature synthesis indicate that the implementation of a *problem-solving- based mathematics curriculum* in Vocational High Schools (SMK) requires

integration between curriculum design, learning strategies, and industry relevance. These three aspects are interrelated and form a learning system that is oriented not only toward concept transfer but also toward developing higher-order thinking skills and student work readiness. This study confirms that contextual and problem-based mathematics learning is the primary foundation for the transformation of vocational education in the digital era. In terms of curriculum design, the analysis found that the mathematics curriculum in vocational schools needs to be designed with an emphasis on the relationship between theoretical concepts and workplace practices. Clements and Sarama (2021: 84) stated that a contextual curriculum helps students construct conceptual meaning through authentic experiences. This approach aligns with findings from the OECD (2020: 73), which emphasizes the importance of integrating theory and practice in vocational learning to enhance adaptability to industry needs. Therefore, the mathematics curriculum design in vocational schools should be flexible, dynamic, and able to adapt to technological developments and rapidly changing job market demands.

In terms of learning strategies, the *problem-solving approach* has proven effective in fostering students' analytical skills, creativity, and reflection. According to Trigo (2024: 5), *problem-solving* positions students as active subjects who play a role in finding solutions to contextual problems through mathematical modeling and evaluation of results. Polya (2004: 6) emphasizes four important steps in this process: understanding the problem, planning a strategy, implementing the solution, and reviewing the results. This process not only improves conceptual understanding but also trains critical thinking skills needed in the modern workplace. Similar findings were expressed by Anderson and Krathwohl (2019: 122) and Widodo (2021: 90), who found that problem-based learning can significantly improve *higher-order thinking skills (HOTS).* However, implementing this approach also faces challenges. Hasan and Yasin (2021: 44) note that limited time, learning resources, and teacher preparedness often hinder the effective implementation of problem-based learning. Teachers also need to be able to design problems relevant to industrial contexts so that learning activities are truly meaningful for students (Marzano, 2020: 61). Therefore, the successful implementation of a *problem-solving- based mathematics curriculum* depends not only on curriculum design but also on the teacher's capacity as a facilitator of reflective learning.

Furthermore, the relevance of mathematics learning to the industrial world is a key factor in the context of vocational education. Zhao and Lu (2018: 236) emphasize that synergy between educational institutions and industry must be systematically built through partnerships and project-based programs. UNESCO (2020: 45) also highlights that industry-oriented learning can improve graduates' job readiness and adaptability. This is reinforced by research by Tan and Lim (2023: 98), who found that students who participated in *problem-solving- based learning* had higher problem-solving and collaboration skills than those who studied conventionally. However,

Park and Shin (2022: 112) caution that without direct support from the industrial world, this type of learning can lose its practical relevance.

Based on the synthesis results, it can be concluded that the successful implementation of a *problem-solving- based mathematics curriculum* in vocational high schools rests on three main pillars: contextual curriculum design, reflective learning strategies, and industry collaboration. These three pillars form an integrated conceptual framework that positions students as the center of learning and as potential workers capable of critical, creative, and adaptive thinking. The curriculum developed through this approach not only prepares students to understand mathematical concepts in depth but also equips them with the ability to apply that knowledge in real-world work situations. Theoretically, this conceptual model reinforces the view that *problem-solving* is not simply a learning method, but rather a vocational education strategy capable of bridging the gap between education and industry. Practically, the results of this study provide a basis for teachers and curriculum developers to design mathematics learning that is more contextual, reflective, and oriented toward 21st-century competencies.

D. Conclusion

This study concludes that the implementation of a *problem-solving- based mathematics curriculum* in Vocational High Schools (SMK) is an effective strategy to bridge the gap between learning theory and the needs of the industrial world. Based on the results of the conceptual synthesis, three main pillars were obtained that became the foundation for developing an implementation model, namely: (1) contextual curriculum design that links mathematical concepts to real situations in the world of work, (2) *problem-solving- based learning strategies* that encourage students to think critically, creatively, and reflectively, and (3) collaboration between schools and industry in supporting the relevance and sustainability of learning. These three pillars interact with each other to form a comprehensive and adaptive learning system to technological developments and the needs of 21st-century competencies. Theoretically, this research enriches the study of the integration between vocational education and the *problem-solving approach* in mathematics learning by offering a systematic conceptual framework that can be used as a reference for further research. Meanwhile, practically, the results of this study provide important implications for teachers and curriculum developers in designing relevant, applicable, and competency-oriented learning. The implementation of an integrated *problem-solving approach* in the curriculum is believed to improve students' higher *-order thinking skills* and prepare them to become adaptive and innovative workers in the digital era. Further research is recommended to test the empirical validity of this conceptual framework through field studies in various vocational schools with varying characteristics. This way, the resulting implementation model will not only be theoretically sound but also practically and contextually tested to meet the needs of vocational education in Indonesia.

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