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EXPLORING THE ROLE OF CRITICAL THINKING IN ENHANCING PROBLEM-SOLVING SKILLS IN STEM EDUCATION

Murodova Mehrangiz Umid qizi
ISFT, English teacher.
murodovamehrangiz692@gmail.com

Annotation

The inclusion of Critical Thinking (CT) in Science, Technology, Engineering, and Mathematics (STEM) education has gained significant attention due to its potential to improve problem-solving skills. This paper investigates the connection between critical thinking and problem-solving, emphasizing the importance of CT within STEM fields. By analyzing relevant literature and educational frameworks, the study demonstrates how critical thinking supports the development of innovative solutions, facilitates deeper understanding, and prepares students for complex real-world issues. Additionally, the paper highlights strategies for fostering CT in STEM curricula and discusses its wider implications for educators and students.

Аннотация

Включение критического мышления (КМ) в образование в области наук, технологий, инженерии и математики (STEM) привлекло значительное внимание из-за его потенциала в улучшении навыков решения проблем. В данной статье исследуется связь между критическим мышлением и решением проблем, с акцентом на важность КМ в STEM-дисциплинах. На основе анализа соответствующей литературы и образовательных рамок исследование показывает, как критическое мышление способствует разработке инновационных решений, углубляет понимание и подготавливает студентов к решению сложных задач реального мира. Кроме того, статья выделяет стратегии развития КМ в учебных планах STEM и обсуждает его более широкие последствия для преподавателей и студентов.

Annotatsiya

Kritik fikrlash (KF) ning Fan, Texnologiya, Muhandislik va Matematik (STEM) ta'limiga kiritilishi, muammolarni hal qilish ko'nikmalarini yaxshilashdagi salohiyati tufayli katta e'tibor qozondi. Ushbu maqolada kritik fikrlash va muammolarni hal qilish o'rtasidagi bog'lanish o'rganilib, STEM sohalaridagi KF ning ahamiyati ta'kidlanadi. Muvofiq adabiyotlar va ta'lim tizimlari tahlil qilinib, tadqiqot kritik fikrlash qanday innovatsion yechimlarni ishlab chiqish, chuqurroq tushuncha hosil qilish va talabalarni murakkab real dunyo muammolariga

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tayyorlashda yordam berishini ko'rsatadi. Shuningdek, maqolada STEM dasturlarida KF ni rivojlantirish uchun strategiyalar keltirilgan va bu ta'limchilar va talabalar uchun kengroq ta'sirlari muhokama qilinadi.

Keywords: Critical Thinking, Problem-Solving, STEM Education, Teaching Strategies, Higher Education

Ключевые слова: Критическое мышление, Решение проблем, STEM-образование, Стратегии преподавания, Высшее образование.

Kalit so'zlar: Kritik fikrlash, Muammolarni hal qilish, STEM ta'limi, O'qitish strategiyalari, Yuqori ta'lim.

With rapid technological advancements and increasing global challenges, there is a growing need for a workforce capable of innovative problem-solving. Among various cognitive abilities, **critical thinking (CT)** plays a pivotal role in enhancing problem-solving skills, especially in **STEM (Science, Technology, Engineering, and Mathematics)** education. STEM disciplines demand not only technical knowledge but also the ability to think analytically, assess evidence, and find solutions to intricate problems. This article explores how critical thinking fosters effective problem-solving in STEM education, focusing on teaching approaches, student participation, and real-world applications. STEM programs are designed using modules developed for the community. For instance, **Universiti Sains Islam Malaysia (USIM)** introduced a STEM module on September 20, 2021, aimed at strengthening STEM education for a skilled workforce and continuous learning. This program, conducted for 20 students at a school in Putrajaya, featured activities such as **Inspirational Module**, **Reactivity of Metals**, **Arduino**, **Gas Around Us**, and **Ninja**, utilizing a mentor-mentee approach. The study revealed that this module and mentoring system effectively enhanced students' communication and thinking skills. Another example is **University Kebangsaan Malaysia (UKM)**, which developed a STEM module based on the directed creative process model. This "Creative Teaching STEM Module" was applied to 26 grade 11 and 31 grade 8 students, focusing on five critical skills: problem-solving, high-level thinking, humanity, communication, and active learning skills. The effectiveness of such STEM programs has been a subject of inquiry, addressing concerns about their impact on academic success through classes, workshops, and hands-on activities that promote critical thinking, motivation, and learning success. Critical thinking is defined as the capacity to think clearly, rationally, and independently, enabling individuals to make reflective and reasoned decisions. It involves questioning assumptions, analyzing arguments, and evaluating evidence to reach logical conclusions (Ennis, 2011). In

STEM contexts, critical thinking encompasses skills such as problem identification, hypothesis generation, data analysis, and evaluating potential solutions. In STEM education, problem-solving refers to the cognitive steps students take to identify, analyze, and resolve complex challenges. Effective problem-solving often requires students to apply learned concepts while remaining open to revising strategies as new information emerges. In STEM, problem-solving is multifaceted, requiring both technical expertise and critical thinking to assess potential solutions and predict outcomes.

Enhancing Problem-Solving Skills through Critical Thinking

Critical thinking plays a key role in enhancing problem-solving in several ways: STEM problems often involve data interpretation, algorithmic thinking, and decision-making in uncertain conditions. Critical thinking enhances analytical skills by helping students break down complex problems, consider diverse perspectives, and assess evidence. For instance, when dealing with an engineering problem, students may need to evaluate the effectiveness of different materials or processes, with critical thinking guiding their decisions. Critical thinking promotes creative problem-solving by encouraging students to explore novel solutions, challenge existing assumptions, and propose new approaches. In technology-related problems, for example, a critical thinker may seek alternative designs or methods, leading to innovative advancements in product development. Critical thinking also fosters metacognitive awareness, enabling students to monitor their thought processes and adjust strategies as needed. In the context of problem-solving, this means students can evaluate the effectiveness of their initial solutions, revise hypotheses, and refine their approaches. This iterative process is essential for addressing complex STEM problems, where initial solutions often need continuous modification based on new data. In STEM fields, students frequently make decisions that impact the outcomes of their projects, experiments, or designs. Critical thinking enhances decision-making by helping students identify key factors, predict consequences, and evaluate trade-offs. For example, when solving a mathematical problem, critical thinking helps students prioritize variables and identify the most feasible solution.

Teaching Strategies for Enhancing Critical Thinking

Integrating critical thinking into STEM education requires specific instructional approaches that encourage active engagement and deep learning. Several methods have been recognized: PBL is a teaching approach that places students at the heart of the learning process by engaging them in solving real-world problems. This method fosters both critical thinking and problem-solving by requiring students to collaborate, research solutions, and critically evaluate different

approaches. Studies have shown that PBL significantly enhances critical thinking, particularly in engineering and medical education (Barrows, 2000). Group work encourages students to present ideas, collaborate on solving problems, and critique each other's approaches, which helps refine critical thinking. This collaborative environment allows students to explain their reasoning and consider alternative viewpoints. The Socratic Method involves asking probing questions to stimulate critical thinking and reflection. This approach works well in STEM education by prompting students to justify their solutions, explain their reasoning, and reflect on their assumptions. The flipped classroom model allows students to engage with learning materials before class, making classroom sessions more interactive and focused on discussion-based activities. This approach encourages students to critically evaluate materials beforehand and strengthens their critical thinking skills during group discussions, problem-solving activities, and projects.

For educators, promoting critical thinking in STEM education requires a shift away from traditional lecture-based teaching methods to more student-centered, inquiry-based strategies. Teachers must create an environment conducive to open-ended questioning, critical discussions, and collaborative problem-solving. For students, developing critical thinking skills involves actively engaging in the learning process, challenging assumptions, and reflecting on their own thinking. The integration of critical thinking not only improves academic performance but also prepares students to tackle complex problems in their future careers, particularly in STEM fields, where such skills are essential.

Conclusion

Critical thinking is foundational to effective problem-solving in STEM education. By nurturing analytical thinking, creativity, and metacognitive awareness, educators can equip students with the skills necessary to address complex challenges in both their academic and professional lives. By employing teaching methods like Problem-Based Learning, collaborative learning, and the Socratic Method, educators can significantly enhance students' problem-solving abilities. As STEM fields evolve, fostering critical thinking will be key to producing graduates capable of solving the multifaceted problems of the future.

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