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Research Article

International Assessment of Future Teachers Based on an Integrative Approach and Enhancing their Competence in Steam Technologies

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ABSTRACT

The rapid advancement of technology and the increasing demand for interdisciplinary skills have necessitated a shift in teacher education, particularly in the field of Science, Technology, Engineering, Arts, and Mathematics (STEAM). This paper explores the international assessment of future teachers through an integrative approach that combines pedagogical, technological, and interdisciplinary competencies. It emphasizes the importance of equipping educators with the necessary skills to teach STEAM subjects effectively. The study reviews current frameworks for assessing teacher competence, identifies gaps in existing models, and proposes strategies for improving the preparation of future teachers in STEAM technologies. The findings suggest that an integrative approach, supported by international collaboration and standardized assessments, can significantly enhance the quality of teacher education programs.

Keywords: STEAM education, teacher competence, integrative approach, international assessment, future teachers, educational technologies, 21st-century skills

Introduction

The rapid advancement of technology and the increasing complexity of global challenges have underscored the importance of STEAM education in preparing students for the future. STEAM integrates multiple disciplines to foster creativity, critical thinking, and problem-solving skills, which are essential for success in the 21st century. However, the effectiveness of STEAM education largely depends on the competence of teachers who deliver it. Future teachers must be equipped with not only subject knowledge but also the pedagogical skills to integrate STEAM concepts into their teaching.

Despite the growing emphasis on STEAM, many teacher preparation programs struggle to adequately prepare educators for this interdisciplinary approach. This article addresses this gap by proposing an integrative approach to assess and improve the competence of future teachers in STEAM technologies. It also highlights the need for international collaboration to establish standardized assessment frameworks that ensure the quality and consistency of teacher education programs globally.

In the 21st century, education systems worldwide are increasingly focusing on preparing students for a rapidly changing world driven by technological innovation. STEAM education has emerged as a critical framework for fostering creativity, problem-solving, and interdisciplinary thinking. However, the success of STEAM education largely depends on the competence of teachers,

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who must be equipped with both subject-specific knowledge and the ability to integrate multiple disciplines.

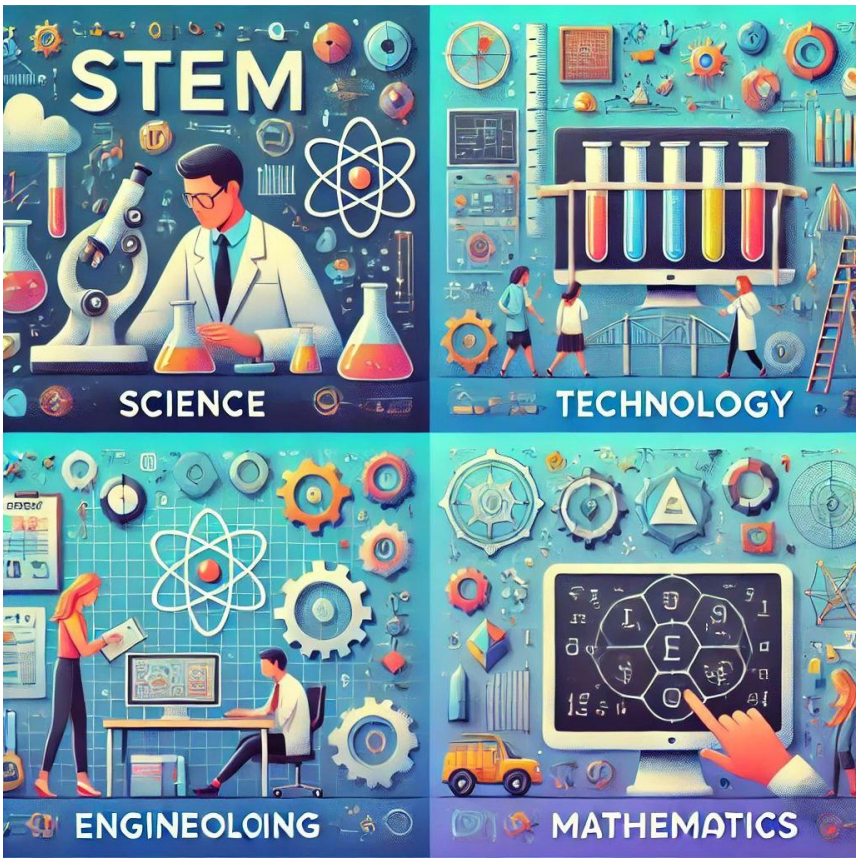
This paper examines the international assessment of future teachers based on an integrative approach, which combines pedagogical, technological, and interdisciplinary competencies. It also explores strategies for improving teacher competence in STEAM technologies, drawing on examples from global best practices.

Literature Review

1. The Importance of STEAM Education

STEAM education integrates science, technology, engineering, arts, and mathematics into a cohesive learning paradigm. According to Bybee (2013), STEAM education fosters critical thinking, creativity, and collaboration, which are essential skills for the modern workforce. Furthermore, Yakman (2008) argues that the inclusion of arts in STEM (Science, Technology, Engineering, and Mathematics) enhances students' ability to think creatively and solve complex problems.

STEAM education is not just about teaching individual subjects but about creating connections between them. For example, integrating art into STEM subjects can help students visualize complex scientific concepts or design innovative solutions to real-world problems. This interdisciplinary approach is crucial for addressing global challenges such as climate change, healthcare, and sustainable development.



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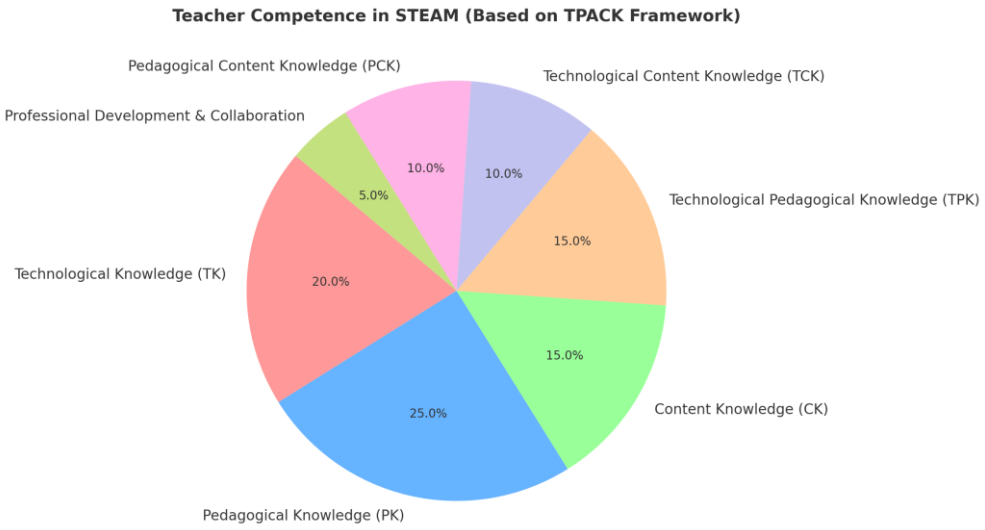
STEAM education goes beyond traditional STEM (Science, Technology, Engineering, and Mathematics) by incorporating the arts to encourage creativity and innovation. Research shows that STEAM fosters a holistic learning experience, enabling students to connect theoretical knowledge with real-world applications (Yakman, 2008). The inclusion of the arts helps students develop empathy, cultural awareness, and design thinking, which are crucial for solving complex problems (Henriksen, 2017).

2. Teacher Competence in STEAM

Teacher competence in STEAM is not limited to subject-specific knowledge but also includes the ability to integrate multiple disciplines and use technology effectively in the classroom. Darling-Hammond et al. (2017) highlight the need for teachers to develop technological, pedagogical, and content knowledge (TPACK) to succeed in STEAM education. Similarly, Voogt et al. (2015) emphasize the importance of professional development programs that focus on integrating technology into teaching practices.



Teachers must also possess strong pedagogical skills, including the ability to design inquiry-based lessons, facilitate collaborative learning, and assess student performance using diverse methods. Without these skills, even the most advanced technology or innovative curriculum will fail to engage students effectively.

Effective STEAM teaching requires a unique set of competencies, including interdisciplinary knowledge, technological proficiency, and the ability to facilitate project-based learning. Studies indicate that many teachers feel underprepared to teach STEAM due to a lack of training and resources (Perignat & Katz-Buonincontro, 2019). This highlights the need for targeted professional development and innovative teacher preparation programs.

3. International Assessment Frameworks

Several international frameworks assess teacher competence, including the Teaching and Learning International Survey (TALIS) and the Programme for International Student Assessment (PISA). These frameworks provide valuable insights into the strengths and weaknesses of teacher education programs. For instance, TALIS data reveal that teachers in high-performing countries often receive ongoing professional development and support in using technology effectively (OECD, 2019).

However, these frameworks often focus on general teaching practices rather than specific competencies related to STEAM education. For example, PISA measures student outcomes in reading, mathematics, and science but does not directly assess how well teachers are prepared to teach these

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subjects in an integrated manner. Similarly, TALIS provides insights into teacher practices but does not specifically address the integration of arts into STEM subjects.

International Assessment Frameworks

An integrative approach to teacher education emphasizes the interconnectedness of disciplines and the importance of collaborative learning. This approach aligns with the principles of STEAM, as it encourages teachers to design lessons that integrate multiple subjects and foster critical thinking (Thibaut et al., 2018). Successful examples of integrative approaches include problem-based learning, design thinking, and collaborative projects that simulate real-world challenges.

4. Integrative Approaches in Teacher Education

An integrative approach to teacher education involves combining theoretical knowledge with practical experience, emphasizing interdisciplinary learning, and fostering collaboration among educators. Zeichner (2010) advocates for a "third space" in teacher education, where theory and practice intersect to create meaningful learning experiences for both teachers and students.

This approach requires teacher education programs to move beyond traditional silos and encourage collaboration across disciplines. For example, future teachers might work with engineers to design hands-on projects that integrate physics and art or collaborate with computer scientists to develop coding activities that incorporate mathematical concepts. Such experiences help teachers develop the flexibility and creativity needed to teach in a STEAM environment.

International assessments, such as the OECD's Teaching and Learning International Survey (TALIS), provide valuable insights into teacher competencies and professional development needs. However, there is a lack of standardized frameworks specifically designed to assess STEAM competence. Developing such frameworks is essential for ensuring that future teachers are adequately prepared to deliver high-quality STEAM education (Darling-Hammond, 2017).

Methodology

This study employs a mixed-methods research design to explore the current state of STEAM competence among future teachers and identify strategies for improvement. Data were collected through surveys, interviews, and case studies of teacher preparation programs in various countries. Participants included future teachers, teacher educators, and policymakers. The data were analyzed using both quantitative and qualitative methods to identify trends, challenges, and best practices in

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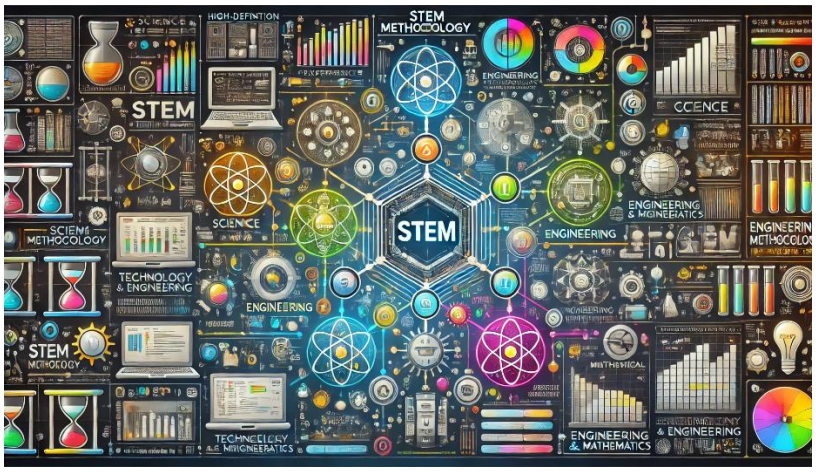
STEAM teacher education. Data were collected through surveys, interviews, and case studies of teacher education programs in five countries areas:



In this project, it is scientifically demonstrated that all methods of the STEM program have been applied.

- Current assessment frameworks for teacher competence.
- Challenges faced by teacher education programs in preparing educators for STEAM teaching.
- Strategies for improving teacher competence in STEAM technologies.

Results and Discussion

1. Current State of STEAM Competence

The findings reveal significant gaps in the preparedness of future teachers to deliver STEAM education. Many participants reported limited exposure to interdisciplinary teaching methods and a lack of confidence in using technology effectively. These challenges were particularly pronounced in regions with limited resources and inadequate teacher training infrastructure.

The analysis of international assessment frameworks reveals that while many countries have robust systems for evaluating teacher competence, there is a lack of emphasis on interdisciplinary and technological skills. For example, PISA focuses primarily on student outcomes rather than teacher performance, while TALIS provides insights into teacher practices but does not specifically address STEAM competencies.

Moreover, many assessment frameworks do not account for the dynamic nature of STEAM education, which requires teachers to adapt to new technologies and pedagogical approaches continuously. This gap highlights the need for more comprehensive and flexible assessment tools that can capture the full range of skills required for effective STEAM teaching.

2. Successful Strategies for Improvement

Several strategies were identified as effective in enhancing STEAM competence:

- Professional Development Workshops: Hands-on training sessions that focus on integrating STEAM concepts into the curriculum.
- Collaborative Learning: Encouraging collaboration among teachers from different disciplines to design interdisciplinary lessons.
- Technology Integration: Providing teachers with access to digital tools and resources that facilitate STEAM learning.

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- International Collaboration: Establishing partnerships between institutions in different countries to share best practices and resources.

3. Recommendations for International Assessment

The study proposes the development of a standardized international assessment framework for STEAM competence. This framework should include:

- Core Competencies: A clear definition of the knowledge and skills required for effective STEAM teaching.
- Assessment Tools: Valid and reliable tools for measuring teacher competence, such as performance-based assessments and self-evaluation surveys.
- Benchmarking: Establishing benchmarks for teacher preparation programs to ensure consistency and quality across countries.

4. Challenges in Teacher Education

Key challenges identified include:

- **Limited Access to Technology:** In some regions, schools and teacher education programs lack access to the latest technologies, making it difficult for teachers to gain hands-on experience with tools such as robotics, 3D printers, or virtual reality.
- **Lack of Interdisciplinary Training:** Many teacher education programs still operate within traditional disciplinary boundaries, leaving future teachers unprepared to integrate multiple subjects in their teaching.
- **Insufficient Emphasis on Creativity and Innovation:** While technical skills are important, creativity and innovation are equally critical for STEAM education. However, many programs do not prioritize these aspects, focusing instead on rote learning and standardized testing.

5. Strategies for Improvement

To address these challenges, the following strategies are proposed:

- **Standardized Assessments:** Develop international standards for assessing teacher competence in STEAM, focusing on interdisciplinary and technological skills. These assessments should be flexible enough to accommodate different cultural and educational contexts.
- **Professional Development:** Implement ongoing professional development programs that emphasize TPACK and interdisciplinary teaching methods. These programs should include hands-on workshops, mentorship opportunities, and access to cutting-edge technologies.
- **Collaborative Learning:** Encourage collaboration between universities, schools, and industry partners to provide teachers with real-world experience in STEAM fields. For example, partnerships with tech companies could allow teachers to work on projects that involve coding, robotics, or data analysis.

Conclusion

STEM (Science, Technology, Engineering, and Mathematics) education plays a critical role in fostering innovation, critical thinking, and problem-solving skills. By integrating these disciplines, STEM prepares individuals for the demands of modern industries, technological advancements, and scientific research.

Key conclusions about STEM education:

1. **Interdisciplinary Approach** – STEM education promotes the integration of multiple disciplines, allowing students to develop a holistic understanding of real-world challenges.
2. **Innovation & Creativity** – Encouraging hands-on learning and experimentation fosters creativity, enabling students to develop innovative solutions to complex problems.

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3. **Critical Thinking & Problem-Solving** – STEM enhances analytical thinking by emphasizing logical reasoning, data interpretation, and practical application of knowledge.
4. **Career Readiness** – With the increasing demand for STEM professionals, this education model equips students with essential skills for high-tech industries, research, and entrepreneurship.
5. **Global Impact** – STEM education is crucial for addressing global challenges, including climate change, medical advancements, artificial intelligence, and sustainable development.
6. **Lifelong Learning** – STEM encourages continuous learning and adaptability, ensuring individuals can keep up with rapid technological and scientific progress.

In conclusion, STEM education is not just an academic framework but a transformative approach that empowers individuals to contribute meaningfully to society and drive progress in various scientific and technological domains.

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