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Alignment of Learning Outcomes in the Technique and Technology Curriculum in Serbia with Key Competencies for Lifelong Learning: A Mixed-Method Convergent Design Approach

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Abstract: This study comprehensively analyzes the alignment of the Technique and Technology curriculum for grades 5–8 in Serbia's primary education system with key competencies for lifelong learning, following the 2018 Council of the European Union Recommendation. Using a mixed-method approach, specifically a convergent design as outlined by Creswell, this study combines qualitative content analysis with descriptive statistics to assess the distribution of competencies across grades. The integration of qualitative and quantitative data provides a more comprehensive understanding of the curriculum's alignment with key competencies. Findings reveal an imbalance between theoretical and practical outcomes, particularly in digital literacy, where practical skills are prioritized over theoretical understanding. Similarly, entrepreneurial modules lack activities promoting critical thinking and initiative. The curriculum emphasizes practical skills but needs to improve its theoretical framework, especially in programming and entrepreneurial finance. It also lacks activities that develop positive attitudes, such as innovation and teamwork, which are crucial for lifelong learning. Recommendations include increasing practical Science, Technology, and Engineering (STE) projects, enhancing theoretical content in digital and entrepreneurial modules, and fostering activities that build positive attitudes. Further research is needed to track students' attitudes towards technology and entrepreneurship across grades and to assess the impact of continuous professional development for educators on effectively integrating these competencies.

Keywords: key competencies for lifelong learning; science; technology and engineering competencies; digital competencies; entrepreneurial competencies; teaching outcomes; Technique and Technology curriculum; technical and technological education

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1. Introduction

In contemporary society, characterized by rapid technological changes, education must prepare students for the complex challenges of the labor market and everyday life and responsible action in the context of sustainable development. This study focuses on the learning outcomes of the Technique and Technology (TT) subject in primary education, as it is crucial for developing the technical and technological knowledge, skills, and attitudes needed for further education and life in general. TT in primary schools in Serbia is taught from the fifth to the eighth grade within the second cycle of eight-year primary education. It is a mandatory subject in the curriculum that plays a key role in developing thinking and acquiring knowledge and skills for TT education. The Ministry of Education, Science, and Technological Development of the Republic of Serbia developed the TT curriculum [1,2] with the support of education and technology experts. The Ministry periodically revises it to align with modern technological trends, labor market needs, and international educational standards, incorporating feedback from teachers and students.

Educational authorities assess the curriculum's effectiveness through student evaluations, monitoring teacher performance, conducting external evaluations by academic institutes, and analyzing student results in national and international tests. The Institute for Improvement of Education [3] and the Institute for the Evaluation of Education Quality [4] conduct external evaluations of the teaching process. These institutes monitor and analyze the alignment of teaching practices with curriculum objectives, providing recommendations for improvement. Feedback from the business sector and the academic community also helps assess how well the curriculum meets the labor market's and society's needs. Based on these assessments, the Ministry of Education identifies areas for improvement and ensures that the curriculum remains relevant and adapted to contemporary challenges.

The current curriculum, issued in 2018, defines the subject's objectives, the teaching content with program areas and units, learning outcomes, correlation with other subjects, guidelines for lesson planning and teaching, program implementation, and methods for monitoring and evaluating student success and the quality of teaching itself.

Learning outcomes, as part of the curriculum, represent specific results that students should achieve after covering certain teaching units. For example, the outcome for the fifth grade in the field of digital and technical literacy is stated as follows: "The student should independently draw a simple object using a sketch and technical drawing". It is student-centered and defines specific knowledge, skills, and abilities that the student should develop, which are clearly measurable and focused on the final result of the educational process. Clear outcomes allow teachers and students to assess progress and success in learning.

Outcomes can be classified according to different domains, including cognitive (development of knowledge and understanding), affective (development of attitudes and values), and psychomotor (development of practical and technical skills), ensuring a comprehensive approach to education and promoting the overall development of students. In technical education, the outcomes specifically focus on developing key lifelong learning competencies, enabling students to acquire practical skills, critical thinking, and problem-solving abilities. The achieved competencies prepare students to adapt and thrive in the modern technological environment. Research shows that technical education prepares students for a dynamic labor market and a technology-driven society focused on sustainable development.

Bloom's Taxonomy provides a valuable framework for structuring and evaluating educational outcomes within the Technical and Technology curriculum. Through its three primary domains—cognitive, psychomotor, and affective—it enables a comprehensive approach to defining and achieving educational goals. The cognitive domain fosters intellectual skills, from basic memory and understanding to higher analysis, evaluation, and creation levels. The psychomotor domain guides students in acquiring practical skills through precision, dexterity, and physical coordination, which is crucial for the hands-on aspects of technical education. The affective domain, encompassing the development of attitudes, values, and emotions, contributes to shaping positive values towards learning, teamwork, and responsible behavior in technical and technological activities. Integrating Bloom's Taxonomy with Kolb's experiential learning theory [5] makes the TT curriculum more structured, enabling the balanced development of theoretical knowledge, practical skills, and social–emotional competencies.

With these theoretical foundations in place, this study examines how well the TT curriculum aligns with Bloom's and Kolb's principles by balancing theoretical and practical components to foster essential competencies. According to the [6], Serbia's primary school program successfully balances theoretical and practical content, emphasizing practical outcomes in lower grades and gradually shifting focus toward theoretical content in higher grades. The study recommends increasing theoretical content in the early grades, strengthening the affective domain, and integrating digital technologies to align the program with modern educational needs, preparing students for today's technological challenges. This approach ensures comprehensive student development, equipping them to adapt effectively to contemporary professional environments.

The European framework for key competencies for lifelong learning recognizes eight competencies closely linked to sustainability, enabling individuals to develop the skills and knowledge needed to understand, address, and adapt to sustainable development challenges [7]. This paper will explore three competencies closely related to technical and technological education: competencies in Science, Technology, and Engineering (STE), digital competencies (DC), and competencies for entrepreneurship and innovation (EC).

Competencies in STE help one understand and apply scientific and technological principles crucial for solving issues related to climate change, energy, resource conservation, and ecological balance.

Digital competence is essential for accessing information and digital tools that support sustainable initiatives, such as renewable energy technologies, ecosystem monitoring, or digital platforms for eco-activism.

Entrepreneurial and innovation competencies encourage innovative solutions and the development of business models that are environmentally, socially, and economically sustainable, thus contributing to economies that do not harm the environment and society.

Integrating these competencies within the context of sustainability equips individuals to think, act, and learn in ways that contribute to society's long-term well-being and the preservation of natural resources. The teaching of TT lays the foundation for this. Applying Kolb's experiential learning theory [5] in TT classes further strengthens this approach by connecting the theoretical and practical aspects of learning.

Kolb's experiential learning theory [5] provides a foundational framework for structuring TT curriculum activities. Through a cyclical model that includes concrete experiences, reflective observation, abstract conceptualization, and active experimentation, Kolb's model allows students to gain hands-on experience with technology. In contrast, reflective and conceptual phases help students internalize theoretical knowledge. Additionally, Kolb's Learning Style Inventory 4.0 provides insights into diverse learning preferences, supporting a customized approach that enables students to navigate all learning cycle stages, thereby developing a balanced set of competencies [8].

Teaching TT through practical activities such as laboratory exercises, simulations, and project work allows students to apply theoretical knowledge and develop skills such as precision, manual dexterity, technical literacy, and creativity, all essential for the modern labor market. By linking these activities to sustainability, students can engage in projects that emphasize the responsible use of technology, such as recycling, using renewable energy sources, or developing products with a reduced environmental impact.

The National Qualifications Framework of Serbia (NOKS) and the European Qualifications Framework (EQF) support the development of these competencies as key factors for economic and social development, emphasizing the need for continuous learning and adaptation to changes in the labor market, as well as the development of awareness about sustainable development [9,10]. Serbia's Action Plan for implementing the Industrial Policy Strategy (2024–2025) and the Science and Technological Development Strategy highlight the importance of digitalization and artificial intelligence and the need for practical education that prepares students to apply technologies in line with sustainability principles [11,12].

Aligning the theoretical and practical components of the curriculum with national and European strategies enables students to gain technological literacy, develop essential skills necessary for the labor market, and contribute to sustainable technological and industrial progress. In addition to Kolb's experiential learning model, which is applied within the national curriculum for the subject TT, other pedagogical models also contribute significantly. For example, Dewey's approach to active learning emphasizes the role of practical experiences and problem-solving in education, allowing students to gain a deeper understanding of technical concepts through direct application [13]. Vygotsky's theory of the Zone of Proximal Development (ZPD) facilitates skill development through collaboration and guided instruction, enabling students to gradually acquire skills they cannot master independently but can develop with the support of teachers and peers [14].

Project-based learning further empowers students to work on real-world projects, connecting theory and practice while fostering creativity and teamwork [15]. Additionally, interdisciplinary teaching integrates different subjects and areas, allowing students to gain a broader understanding of issues and develop the ability to connect technical, scientific, and social aspects in solving complex challenges [16].

Combining these models in teaching TT facilitates students' comprehensive development, preparing them for modern society, technology, and sustainable development challenges.

The paper aims to analyze the alignment of learning outcomes from the TT curriculum with the key competencies for lifelong learning according to the Council of the European Union's recommendation to identify gaps and provide recommendations for curriculum improvement. This significant analysis offers insight into how competencies in STE (Science, Technology, and Engineering), digital skills, and entrepreneurship are developed and essential for student success in a contemporary technological society and the global labor market.

The hypotheses were developed based on a comprehensive review of the relevant literature and previous research on developing key competencies through technical and technological education. Taking into account the objectives of the TT curriculum and the strategic goals outlined in the National Qualifications Framework of Serbia (NOKS) and the European Qualifications Framework (EQF), the hypotheses are structured to evaluate the alignment of practical and theoretical outcomes with the Council of the European Union's recommendations. The hypotheses use comprehensive content analysis to assess the balance and development of competencies across different grades and identify any gaps that need improvement.

The key research hypotheses are as follows:

H1. *The learning outcomes in the TT curriculum are significantly aligned with key competencies in Science, Technology, and Engineering (STE), digital skills, and entrepreneurship, with the strongest alignment observed in STE competencies.*

H2. *There are no significant differences in the opportunities provided across all grades for achieving and developing key competencies in STE, digital skills, and entrepreneurship.*

H3. *There are no significant differences between the representation of theoretical and practical outcomes within STE, digital, and entrepreneurial competencies.*

H4. *The TT curriculum enables a balanced development of theoretical and practical competencies across all grades, supporting progressive development in STE, digital skills, and entrepreneurial knowledge.*

The research findings can contribute to developing educational policies that better integrate the competency approach and the concept of sustainability into the educational process, thereby increasing student readiness for global technological, economic, and environmental challenges.

2. Materials and Methods for Evaluating the TT Curriculum

The analysis of the national TT curriculum for students from fifth to eighth grade in Serbian primary schools employs a methodological approach based on a combination of qualitative analysis and descriptive statistics—mixed methods, according to John Creswell's approach [17]. This combination of qualitative and quantitative analysis enables a comprehensive understanding of the curriculum and an assessment of its alignment with key competencies, such as Science, Technology, and Engineering (STE) competencies, as well as digital and entrepreneurial skills, by European and national educational standards.

The researchers selected this methodological approach to thoroughly analyze the curriculum and understand how theoretical and practical outcomes contribute to the development of student competencies. In this study, "outcome" represents a specific, measurable achievement expected from students at the end of instructional units, such as passing grades or meting criteria, which relate to acquiring knowledge, skills, or attitudes within STE, digital, and entrepreneurial competencies. Qualitative analysis, specifically textual content analysis, provides insights into the structure and content of the curriculum, enabling the identification and classification of learning outcomes according to competencies and their domains (knowledge, skills, and attitudes).

Research Design: Mixed-Method Approach for Competency Analysis

According to Creswell, this research design uses mixed methods, combining qualitative analysis and descriptive statistics to achieve a comprehensive and detailed curriculum assessment [17]. The qualitative component analyzes textual content from the TT subject curriculum to identify key competencies and domains (knowledge, skills, and attitudes) related to student development. The quantitative component relies on descriptive statistics, which enables precise measurement and objective observation of the distribution of outcomes by competencies within the curriculum.

Clear Classification and Analysis of Outcomes: The first step involved identifying and classifying learning outcomes according to key competencies. All outcomes were analyzed and classified into domains: STE, digital, and entrepreneurial competencies. Each competency was further divided into knowledge, skills, and attitudes, providing an overview of students' educational and developmental aspects.

Some outcomes regarding their association with specific competencies were ambiguous or unclear during the classification process. To ensure an accurate depiction of each outcome, ambiguous outcomes were resolved through teamwork with educational experts, achieving consensus on classification. In cases where outcomes remained unclear, the team consulted European and national educational standards as additional guidance in making the final decision.

Descriptive Statistics: Descriptive statistics allow for numerical assessment and quantification, determining whether the curriculum covers all necessary aspects of student development, including theoretical knowledge, practical skills, and attitude development. Quantification was conducted by determining the number and percentage representation of outcomes within each competency and grade, enabling an objective assessment of the distribution between theoretical and practical domains.

Percentage Representation Analysis: To provide better insight, the percentage representation was calculated for each grade and competency. For example, in the fifth grade, STE competencies comprise 58.70% of all outcomes, while digital competencies account for 21.74%. This analysis provides a deeper understanding of the curriculum's structure and which educational segments are predominantly represented in each grade.

Cross-Grade Comparison and Evaluation: The consistency and progression in competency development throughout the educational cycle were evaluated by comparing the distribution of outcomes across grades. This analysis enables researchers to track the progressive increase in the complexity of learning outcomes and alignment with lifelong learning goals. For example, it was observed that STE competencies are highly represented across all grades, while digital and entrepreneurial competencies gradually increase in higher grades, especially in the seventh and eighth grades.

Classification of Outcomes by Theoretical and Practical Categories: Within STE, digital, and entrepreneurial competencies, learning outcomes were further classified into theoretical and practical categories to assess the curriculum's structure and balance in detail. Theoretical outcomes focus on acquiring knowledge and conceptual skills, while practical outcomes involve applying knowledge through technical and practical tasks.

Combining mixed methods enables researchers to capture both the quantitative and qualitative dimensions of analysis, ensuring a balanced understanding of the curriculum's effectiveness in developing student competencies.

3. Analysis of TT Curriculum Outcomes by Key Competencies

Section 3 analyzes the TT curriculum's outcomes, focusing on their connection with key competencies and assessing the alignment of theoretical and practical outcomes. Section 3.1 examines how the outcomes are linked to competencies. In contrast, Section 3.2 evaluates how these competencies are represented and balanced through theoretical and practical aspects of education.

3.1. Mapping TT Curriculum Outcomes to Key Competencies

The TT curriculum outcome analysis aimed to categorize and link learning outcomes with key competencies: STE, digital, and entrepreneurial competencies. The classification covered four grades (from fifth to eighth grade), and this subject is taught to assess how well the curriculum aligns with these competencies (see Figure 1).

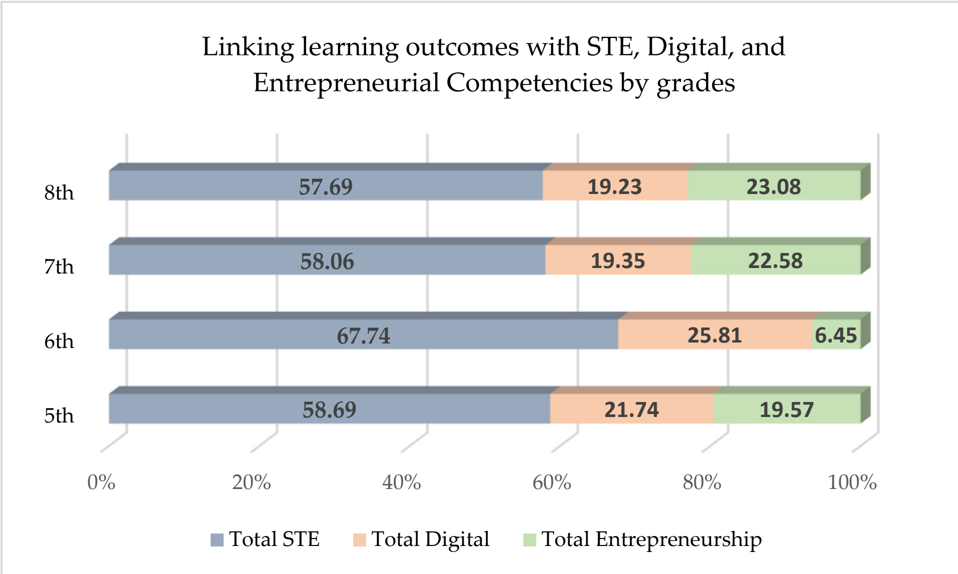

Figure 1. Linking learning outcomes with STE, digital, and entrepreneurial competencies by grade.

Figure 1 illustrates the distribution of three key competencies (STE, digital, and entrepreneurial) as percentages across grades 5 to 8. Here are the main insights:

1. STE Competencies:
   - STE competencies dominate all grades, constituting the largest percentage of learning outcomes.
   - The highest percentage of STE competencies is observed in the sixth grade (67.74%), while the other grades remain relatively consistent at around 57–58%.
   - This dominant presence suggests a strong curricular focus on developing scientific, technological, and engineering skills.
2. Digital Competencies:
   - Digital competencies hold the second-largest percentage across all grades but are less represented than STE competencies.
   - The highest presence of digital competencies is in the sixth grade (25.81%), with a slight decrease in the eighth grade (19.23%).
   - This decline in digital competencies in the upper grades may indicate a reduced focus on digital skills as students progress, suggesting an area for potential enhancement in later stages of education.
3. Entrepreneurial Competencies:
   - Entrepreneurial competencies are the least represented among the three categories, with varying percentages across grades.

- The highest representation of entrepreneurial competencies is in the eighth grade (23.08%), while the sixth grade shows the lowest at 6.45%.
- This increase in the eighth grade may reflect a late introduction of entrepreneurial topics and skills, which could help prepare students for the workforce. However, it also suggests an opportunity to integrate entrepreneurial skills earlier in the curriculum.

The chart indicates that the curriculum is strongly oriented toward STE competencies throughout all grades, while digital and entrepreneurial competencies are less emphasized, particularly in the lower grades. To achieve a more balanced approach, it is recommended to consider introducing entrepreneurial skills earlier and maintaining a consistent focus on digital competencies across all grades. This approach would support the holistic development of skills essential for the modern workforce and society.

The second step, after linking learning outcomes to key competencies, is that the outcomes were further classified according to the domain they impact, i.e., knowledge, skills, and attitudes (see Figure 2).

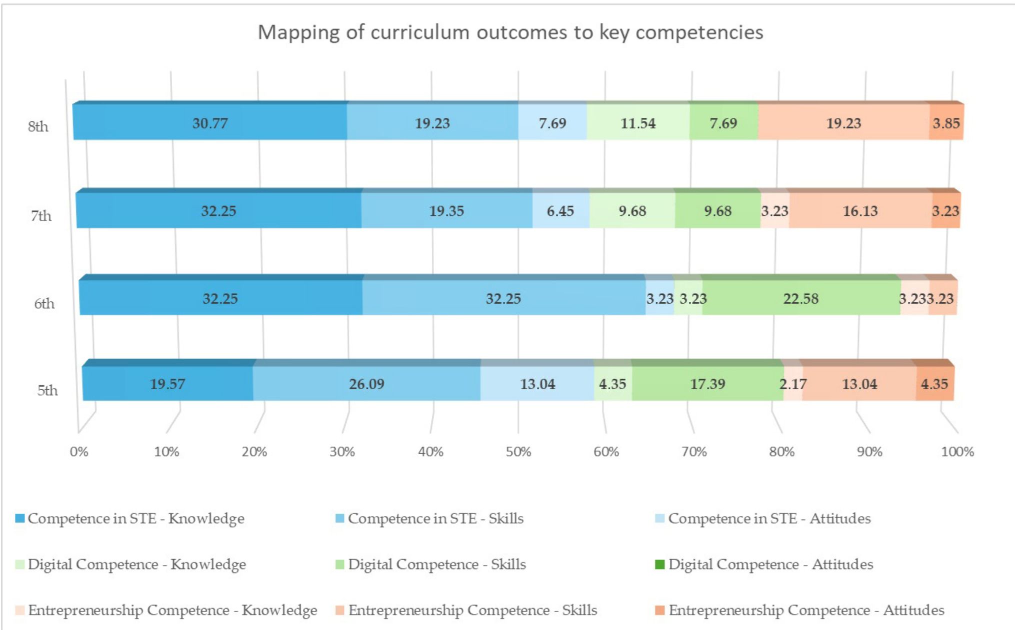

Figure 2. Mapping of curriculum outcomes to key technological competencies.

Here is a thorough interpretation of the results:

1. Competence in STE (Science, Technology, and Engineering)
    - STE Knowledge: This domain shows a relatively high and stable representation across all grades, peaking in the sixth grade (32.25%) and slightly decreasing in higher grades (30.77% in the eighth). This stability suggests that the curriculum consistently emphasizes theoretical knowledge in STE across the grades.
    - STE Skills: STE skills are most represented in the fifth and sixth grades (26.09% and 32.25%, respectively) but decline in the seventh and eighth grades, reaching about 19%. This indicates a reduced focus on practical STE applications as students progress, potentially suggesting that practical activities are more focused in the earlier grades.
    - STE Attitudes: Attitudes in STE are notably less emphasized, particularly in the sixth grade (3.23%), but increase slightly in higher grades. This may imply a curriculum focus prioritizing knowledge and skills over fostering positive attitudes or motivation in STE.
2. Digital Competence

- Digital Knowledge: This area has a modest presence, with percentages increasing progressively from the fifth grade (4.35%) to the eighth grade (11.54%). The gradual increase suggests an incremental approach to building digital knowledge, emphasizing the upper grades.
- Digital Skills: Digital skills are most prominent in the fifth and sixth grades, with a notable decline in the upper grades (7.69% in the eighth grade). As students advance, this decrease in practical digital skills may indicate a gap in continuous digital skill development in the later years, which could impact students' preparedness for real-world digital applications.
- Digital Attitudes: Digital attitudes are absent across all grades, indicating a lack of focus on developing students' motivation, responsibility, or positive outlook toward digital technologies. This absence may be a gap in the curriculum, as attitudes towards technology are crucial for responsible and motivated technology use.

3. Entrepreneurship Competence
    - Entrepreneurship Knowledge: This domain shows minimal representation, peaking only slightly in lower grades. The lack of theoretical grounding in entrepreneurship may limit students' understanding of fundamental entrepreneurial concepts.
    - Entrepreneurship Skills: Practical entrepreneurial skills show a strong presence in the fifth (13.04%) and eighth grades (19.23%), indicating hands-on activities in early and later stages. However, there is a lack of continuity in the middle grades, suggesting that practical entrepreneurial skills are not consistently developed throughout all grades.
    - Entrepreneurship Attitudes: Attitudes are under-represented, with small percentages appearing in the fifth, seventh, and eighth grades. This minimal emphasis on fostering entrepreneurial attitudes may limit students' long-term interest and motivation in entrepreneurial pursuits.
4. Overall Patterns and Implications
    - High Emphasis on STE Knowledge and Skills: The curriculum prioritizes knowledge and practical skills in STE, especially in the earlier grades. However, practical STE skills decline in the later grades, suggesting an opportunity to reinforce practical applications as students advance.
    - Inconsistent Focus on Digital and Entrepreneurial Skills: Digital skills are emphasized in the lower grades, while entrepreneurial skills are resurgent in the eighth grade. The inconsistent development of these competencies may lead to gaps in students' practical abilities in both domains by the end of primary education.
    - Limited Emphasis on Attitudes: Across STE, digital, and entrepreneurial competencies, the attitudes domain is consistently under-represented or absent (as in Digital Competence). This under-representation suggests a lack of focus on cultivating positive attitudes, motivation, and responsibility toward these competencies. This could impact students' engagement and motivation in these fields in the long term.

Recommendations:

1. Increase Practical Activities in Higher Grades: Strengthening practical activities in STE and digital areas can ensure a balanced development of practical skills.
2. Introduce Attitude Development Activities: Activities that foster a positive attitude, motivation, and responsibility towards STE, digital, and entrepreneurial areas would enable a more holistic development of students.
3. Ensure Continuity in the Development of Digital and Entrepreneurial Skills: Consistent development of digital and entrepreneurial skills across all grades can improve students' preparation for the modern workforce.

The results indicate that while there is a strong foundation in developing theoretical knowledge and initial practical skills in STE areas, the curriculum could be enhanced with a greater focus on continuity in digital and entrepreneurial skill development, as well as the introduction of activities that foster students' attitudes.

3.2. Evaluating Alignment of TT Outcomes with Theoretical and Practical Competencies

The classification of outcomes across the TT curriculum is organized into theoretical and practical categories within the STE, digital, and entrepreneurial competencies (see Figure 3).

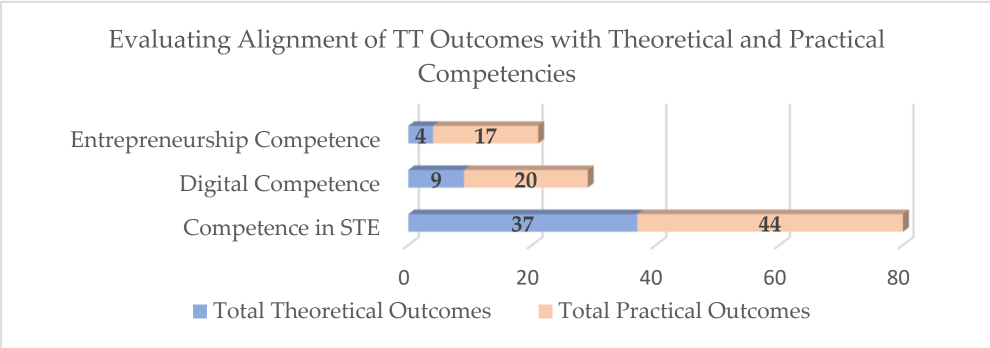

Figure 3. Evaluating alignment of TT outcomes with theoretical and practical competencies.

Figure 3 provides an overview of the distribution of theoretical and practical learning outcomes across three competency domains: STE (Science, Technology, and Engineering), digital competence, and entrepreneurship competence.

Key Observations:

1. STE Competence:
    - This domain shows the highest number of outcomes, with 37 theoretical and 44 practical outcomes.
    - The relatively balanced distribution between theoretical (37) and practical (44) outcomes indicates a strong alignment between conceptual knowledge and hands-on application in STE. This balance is ideal for fostering a comprehensive understanding in students, as they can apply theoretical concepts in practical contexts.
2. Digital Competence:
    - Digital Competence outcomes include nine theoretical and twenty practical outcomes.
    - The higher number of practical outcomes compared to theoretical outcomes (twenty vs. nine) suggests a strong focus on applying digital skills in real-life situations. However, the comparatively lower number of theoretical outcomes might indicate a gap in foundational digital knowledge, which could be addressed to ensure students understand the principles behind the practical skills they are developing.
3. Entrepreneurship Competence:
    - For entrepreneurship, there are only four theoretical outcomes and seventeen practical outcomes.
    - This domain has the least emphasis on theoretical knowledge, with a significant skew towards practical skills (seventeen vs. four). While practical skills are essential in entrepreneurship, the lack of theoretical grounding may limit students' understanding of underlying entrepreneurial concepts, potentially impacting their ability to strategize and make informed business decisions.

Interpretation and Recommendations:

- Balance of Theoretical and Practical Outcomes:

While STE competence shows a balanced approach, digital and especially entrepreneurship competencies lean heavily towards practical outcomes. Adding more theoretical outcomes in these areas could provide students with a more well-rounded understanding, especially in digital literacy and entrepreneurial principles.

- Enhancing Foundational Knowledge:

Increasing theoretical content in the digital and entrepreneurship domains would give students a stronger foundation. For instance, introducing basic digital theory and entrepreneurial concepts might support long-term skill retention and adaptability.

- Curriculum Refinement:

To promote a holistic education, it would be beneficial to address these imbalances by enhancing theoretical knowledge in digital and entrepreneurship competence, which could ensure that students are equipped with both the knowledge and skills required for practical application in these fields.

These data highlight the need for a more balanced approach to theoretical and practical competencies across all domains to foster comprehensive skill development in students.

4. Results of the Analysis

Based on the distribution of outcomes, it can be concluded that learning outcomes in the TT curriculum show significant alignment with key competencies in Science, Technology, and Engineering (STE), digital skills, and entrepreneurship, with the strongest alignment observed in STE competencies. These findings confirm hypothesis H1: the learning outcomes in the TT curriculum are significantly aligned with key competencies in Science, Technology, and Engineering (STE), digital skills, and entrepreneurship, with the strongest alignment observed in STE competencies.

Hypothesis H2 states that there are no significant differences in the opportunities provided across all grades for achieving and developing key competencies in STE, digital skills, and entrepreneurship. This is not confirmed based on the distribution of outcomes. While STE competencies demonstrate stability across all grades, digital skills and entrepreneurship competencies vary. Digital skills decline in higher grades, while entrepreneurial competencies are least represented in the sixth grade. These findings indicate an inconsistency in providing equal opportunities for developing all competencies across grades.

Data analysis reveals that hypothesis H3, which states no significant differences between the representation of theoretical and practical outcomes within STE, digital, and entrepreneurial competencies, has not been confirmed. Although the balance between theoretical (37) and practical (44) outcomes in STE competencies is relatively close, there is a significant disparity in digital and entrepreneurial competencies. Digital competencies show a greater emphasis on practical outcomes (20) compared to theoretical ones (9), while entrepreneurial competencies have considerably more practical outcomes (17) than theoretical ones (4). This suggests that the curriculum emphasizes applying and developing practical skills, focusing less on a theoretical foundation, especially in the digital and entrepreneurial domains, indicating that a balance between theoretical and practical outcomes has not been achieved.

Hypothesis H4, which states that the TT curriculum enables a balanced development of theoretical and practical competencies across all grades, supporting progressive development in STE, digital skills, and entrepreneurial knowledge, has not been fully confirmed based on the data analysis. Although the STE domain shows a relatively balanced representation between theoretical and practical outcomes, providing students with a comprehensive educational experience in this area, digital skills and entrepreneurship competencies reveal a lack of theoretical outcomes and inconsistent skill development across grades. Digital skills are most prominent in the fifth and sixth grades but decline in higher grades, while entrepreneurial skills fluctuate without clear progression. This discrepancy indicates that, although practical skills are being developed, the theoretical foundation is insufficient, particularly in digital and entrepreneurial domains, potentially leading to knowledge gaps that could impact skill development in later grades.

Integrating and balancing theoretical and practical outcomes across all domains is essential to ensure consistent and progressive development of students' knowledge, skills, and attitudes across grades. Addressing these gaps and confirming H4 could significantly enhance the curriculum. This approach would provide students with a comprehensive learning experience, equipping them with the competencies required for lifelong learning and adaptation to a rapidly changing technological environment.

5. Discussion: Implications for Competency Development in TT Curriculum

The analysis of the alignment of learning outcomes in the TT curriculum [2,18] with key competencies shows that competencies in the STE (Science, Technology, and Engineering) fields are the most developed and align closely with the recommendations of the European Council on key competencies for lifelong learning [1]. This alignment is most prominent in the upper grades (seventh and eighth), indicating a systematic approach to developing technical and technological skills as students progress. It is important to consider how students' success in developing STE competencies in earlier grades might impact their achievement in later stages. Additionally, the term "competency" is defined here as a combination of knowledge, skills, and attitudes that students acquire through education, enabling them to perform specific tasks effectively.

Interpretation of Decline in STE Skills: The results suggest that the curriculum places a strong emphasis on theoretical knowledge in STE areas, while the practical application of STE competencies is less stressed in later grades. Theoretical outcomes provide students with fundamental knowledge of technical principles and concepts, but without practical application, these skills remain at an abstract level of understanding, as highlighted by sources [19,20].

As emphasized by previous studies, there is a need for greater integration of practical tasks in later stages to ensure students transition from theoretical knowledge to practical skills [21]. The cited research underscores the importance of linking theoretical knowledge and practical skills for students' comprehensive development, and this study's results confirm a high correlation between theoretical and practical outcomes.

Digital Skills Decline and Importance of Attitudes: However, the analysis shows that digital skills are most prominent in the fifth and sixth grades, while they decline in higher grades. This inconsistency in the development of digital competencies suggests introducing additional practical activities in digital skills in the upper grades to ensure continuous progression and steady skill development among students. Further discussion on students' attitudes toward digital competencies is also crucial, as attitudes can significantly impact learning outcomes. The absence of a focus on digital attitudes in the curriculum may be a gap that limits students' motivation and responsibility toward technology use. Similarly, although entrepreneurial skills are highlighted through practical outcomes, the theoretical foundation and affective domain are under-represented, which may impact students' long-term development of entrepreneurial thinking and motivation.

Importance of Balance Among Competencies: The imbalance between theoretical and practical outcomes across different competencies highlights the need for curriculum revision. While STE competencies show a relatively balanced representation between theoretical and practical outcomes, this balance is not seen in digital and entrepreneurial competencies. For example, the emphasis on practical digital skills in lower grades is not sustained, creating a gap in students' ability to build upon and expand their digital literacy as they progress. Similarly, entrepreneurial competencies focus more on practical outcomes, such as project management and teamwork, but lack sufficient theoretical support to provide a fundamental understanding of entrepreneurial principles. Achieving a balance among STE, digital, and entrepreneurial competencies is essential, as each contributes uniquely to students' holistic development and readiness for the modern workforce. Ensuring that all three competencies are well-integrated and balanced is significant for fostering adaptable, skilled, and motivated students.

To ensure that the curriculum fully supports the goals of modern educational policies, such as those defined in the recommendations of the European Council [1] and Serbia's strategies [12], specific adjustments to the curriculum are necessary. It is recommended, for instance, to enhance and better integrate theoretical and practical knowledge and to emphasize developing students' attitudes [22]. Developing positive attitudes toward science, technology, and entrepreneurship could contribute to their long-term interest and motivation in these fields. Additionally, incorporating more practical STE activities in the upper grades could help bridge the gap between theoretical knowledge and its application in the real world.

Practical Activities to Enhance Engagement and Skill Application: Examples could include laboratory exercises, model building, and technology-based projects directly connected to sustainable development topics, such as renewable energy systems or recycling. Practical activities like technical exercises, experiments, and project work allow students to apply acquired theoretical knowledge and develop precision, technical literacy, and creativity [23,24]. Furthermore, practical tasks encourage teamwork and real-time problem-solving, which are particularly important for success in STE and entrepreneurship [25]. Such practical experiences enable students to apply theoretical knowledge in real, concrete situations, significantly improving their understanding and skills.

Adding Theoretical Content to Digital and Entrepreneurial Competencies: Additionally, it is recommended that more theoretical content related to digital and entrepreneurial competencies be integrated. For digital competencies, this would involve introducing modules that explore the theoretical foundations of information technology, digital ethics, and the social impacts of digital transformation. Providing students with a deeper understanding of market dynamics, resource management, and sustainable business models is essential for entrepreneurship. This integration would create a foundation for the practical skills already present in the curriculum, ensuring that students gain practical experience and a conceptual understanding of the digital and entrepreneurial environment.

Developing Positive Attitudes Across Competencies: The research emphasizes the importance of developing attitudes toward technology and entrepreneurship, which are currently under-represented in the curriculum. Encouraging students to engage positively in technological and entrepreneurial activities could contribute to their long-term interest and motivation in these fields. For example, integrating activities that promote innovation, collaboration, and responsibility in using technology can develop proactive attitudes, aligning with the principles of lifelong learning.

Addressing these areas can help adjust the curriculum to ensure that all key competencies—STE, digital, and entrepreneurial—are consistently and effectively developed across all grades, providing students with the necessary skills and knowledge for lifelong learning and adaptation to future challenges.

Recommendations for Improving the Curriculum

Based on the TT curriculum analysis and the identified shortcomings, the following recommendations for curriculum improvement are proposed, along with specific implementation examples:

First, increase practical activities in higher grades. Strengthening practical activities in STE and digital areas can ensure a balanced development of practical skills. Given that the balance between theoretical and practical outcomes decreases in the seventh and eighth grades, projects such as building technical models (e.g., solar panels or mini wind turbines) already exist, but their implementation and scope must be enhanced. For example, students should be given more freedom in design and innovation, allowing them to independently construct and test their models using more advanced tools and materials. Additionally, organizing school innovation fairs, where students present their projects and explain the creation process, can further boost their motivation and application of skills in real situations.

Second, strengthen theoretical content in digital and entrepreneurial competencies and include attitude development activities: the analysis showed a significant imbalance between theoretical and practical outcomes, particularly in digital and entrepreneurial competencies, and a lack of content that develops students' attitudes and values.

In digital competencies, adding workshops that encourage students to think critically about the impact of technology on society and the environment can increase their digital responsibility and awareness. Similarly, in entrepreneurship, mentorship programs with local entrepreneurs or business challenge simulations can foster a positive attitude toward innovation and entrepreneurship.

Third, ensure continuity in the development of digital and entrepreneurial skills. Consistent development of digital and entrepreneurial skills across all grades can improve students' preparation for the modern workforce. For example, digital competence could be developed through a digital literacy course in the fifth grade, programming in the sixth grade, and website development in the seventh and eighth grades. Similarly, in entrepreneurship, the program could start with the basics of business planning in the fifth grade, continue with small business simulations in the sixth and seventh grades, and conclude with advanced projects such as creating marketing strategies and financial analyses in the eighth grade.

Fourth, promote project-based learning and real-world application. The discussion could highlight project-based learning as an effective method for integrating theoretical and practical skills. Examples could include building models, technical sketches, and managing school-based businesses, which provide students with a concrete understanding of concepts and enhance their engagement and retention.

These examples and recommendations clarify approaches that allow teachers to enhance the teaching process and provide students with dynamic, hands-on learning. Implementing these recommendations could significantly improve the TT curriculum, ensuring balanced and progressive development of key competencies, and preparing students for the challenges of the modern technological environment and labor market, which align with sustainable development principles.

6. Conclusions

This study's analysis of the TT curriculum shows that it establishes a strong foundation for developing STE competencies, yet it requires enhancements to ensure a consistent and balanced integration of theoretical and practical skills across all grades, particularly in the areas of digital and entrepreneurial competencies.

The findings reveal gaps in the continuity and balance between theoretical and practical outcomes, as well as an insufficient focus on the affective domain (attitudes) across all key competencies. These gaps highlight a need for curriculum revision and adjustment. Implementing targeted recommendations—such as expanding existing practical activities, adding new modules in digital and entrepreneurial literacy, and placing a greater emphasis on fostering positive attitudes toward science, technology, and entrepreneurship—can significantly improve the curriculum's overall effectiveness.

An integrated approach that incorporates both theoretical and practical elements, along with attitude development, would allow students to acquire comprehensive knowledge, hands-on skills, and motivation for lifelong learning. Such an approach would better align the curriculum with modern educational standards and labor market demands, thereby preparing students for an evolving technological environment and the challenges of sustainable development.

In particular, a greater focus on the consistent development of practical digital competencies in the upper grades and stronger theoretical content in entrepreneurship would help ensure that students achieve well-rounded literacy in technical and technological education.

Future Research Directions: To continue refining the TT curriculum and better adapt it to the contemporary needs of society and the labor market, future research should focus on conducting longitudinal studies to assess the impact of curriculum adjustments. This could include examining how consistent digital and entrepreneurial skill development impacts long-term student outcomes, tracking changes in student attitudes toward technology and entrepreneurship, and evaluating the role of continuous teacher training. Such research would provide valuable insights into how curriculum changes affect student engagement, skill retention, and preparedness for real-world challenges.

By implementing these curriculum improvements, the TT program can ensure the balanced and progressive development of key competencies, thereby equipping students with the skills, knowledge, and attitudes needed to thrive in a modern technological environment and to contribute to sustainable societal growth.

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