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THE IMPACT OF NON-FORMAL STEAM EDUCATION ON STUDENTS SCHOOL PERFORMANCE: A CASE STUDY OF THE SKYLAB EDUCATION CENTER

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ABSTRACT. STEAM (Science, Technology, Engineering, Arts and Mathematics) education has been increasingly recognized as an effective approach for developing students academic performance, learning skills and 21st-century competencies. While STEAM initiatives are commonly implemented within formal school settings, there is limited empirical evidence regarding the impact of non-formal STEAM education supporting students success at school, espeacilly in North Macedonia. This study presents an empirical case study of a non-formal STEAM education program implemented at the SkyLab Education Center. Using a mixed-methods research design all the data were collected through surveys administered to students and parents in GoogleForms at SkyLab Education center. Quantitative data examined perceived changes in learning skills, academic confidence and school performance especially in science field and technology while qualitative responses provided deeper insight into students and parents experiences. The findings indicate that participation in STEAM-based activities contributes to improved problem-solving skills, higher learning motivation, increased self-confidence and better engagement with school subjects. Parents reported positive changes in students academic behavior, responsibility and interest in learning. This study contributes empirical evidence supporting the role of STEAM education as an effective approach for enhancing students school performance and highlights the importance of non-formal learning environments as a valuable complement to formal educationwith potential for gradual integration into formal school systems.

Key words and phrases. Steam Education, non-formal education, school performance, student learning, 21st-century skills.
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1. Introduction

For far too long in education we have been working with the presumption of teaching to ensure our students get a "good job". But what does that look like? We are preparing students for jobs that don't even exist. We are at a point where it is not only possible but imperative that we facilitate learning environments that are fluid, dynamic and relevant. None of us go outside and look at a tree and say, "that's a tree, so that's science" or "the sky is blue, so that's art". Our world is a beautiful, complex and intricate tapestry of learning all in its own right. Integrating concepts, topics, standards and assessments is a powerful way to disrupt the typical course of events for our students and to help change the merry-go-round of "school". It takes what we do when we open the doors to the real world and places those same practices in our cycles of teaching and learning. So we can finally remove the brick walls and classroom doors to get at the heart of learning. In the context of rapid scientific, technological, and societal change, education systems face increasing challenges in preparing students with the skills necessary for academic success and lifelong learning. STEAM (Science, Technology, Engineering, Arts, and Mathematics) education has emerged as a response to these challenges, emphasizing interdisciplinary learning, creativity, problem-solving, and real-world application of knowledge. Research consistently shows that STEAM education supports not only cognitive learning outcomes, but also affective and developmental skills essential for students' success in school and beyond. (Aray K. Amanova , Laura A. Butabayeva) Some studies indicate that STEAM-based learning positively influences students academic achievemen, motivation and engagement particularly when learning activities are hands-on and connected to authentic problems.(F. Javier Perales, José Luis Aróstegui) However, much of the existing research focuses on STEAM implementation within formal school curricula, while the role of non-formal STEAM education remains underexplored. Non-formal learning environments provide flexibility, experiential learning opportunities, and learner-centered approaches that are often difficult to achieve within traditional classrooms. Case study research suggests that STEAM programs implemented outside formal schooling can effectively support students learning processes and enhance their readiness for school-related

tasks(A. Dashdemirov, G. Sharifov) . This study contributes to the existing literature on STEAM education in several ways. Firstly it provides empirical evidence demonstrating that STEAM education when implemented in a non-formal learning environment supports students school performance, learning motivation also academic confidence. While previous research has emphasized the theoretical benefits of STEAM education this study strengthens the empirical base by incorporating perspectives from both students and parents. Second the findings highlight STEAM education as a complementary approach to formal schooling rather than an alternative. By fostering interdisciplinary studies (topics) creativity and problem solving skills STEAM education helps students better engage with school subjects and apply learned knowledge. Finally this study contributes to the growing body of case study research on STEAM education by demonstrating how mixed-methods data can be used to capture both measurable learning outcomes and lived educational experiences. The results support existing research indicating that STEAM education plays a critical role in developing academic, affective and developmental skills essential for students success in school. Students who engage in STEAM programs learn to think differently. They learn to approach problmes in new ways. They learn that failure is not just okay but it is essential for making progress. And they learn that the " real world" isn't separated into different subject areas.

2. Literature Review

2.1. **Conceptual Foundations of STEAM Education.**

STEAM education has emerged as an interdisciplinary educational approach that integrates science, technology, engineering, arts and mathematics with the aim of developing learners cognitive, creative and problem solving capacities. The addition of the arts to the traditional STEM framework is intended to foster creativity, design thinking and innovation while maintaining rigorous scientific and technological learning. Researchers emphasize that STEAM should not be understood as a simple aggregation of disciplines but as a transdisciplinary framework that enables learners to approach complex, real world problems holistically (Marja G. Bertrand and Immaculate K. Namukasa) (F. Javier Perales, José

Luis Aróstegui) Recent conceptual work highlights that effective STEAM education is characterized by meaningful disciplinary integration, collaboration, real-world relevance, creativity and learner empowerment. Chappell et al. propose that STEAM education is particularly well-suited to addressing "wicked problems" such as sustainability and societal challenges as it encourages learners to connect scientific knowledge with cultural, ethical and social dimensions.

2.2. **Impact of STEAM Education on Academic and Cognitive Outcomes.**

A substantial number of empirical research demonstrates that STEAM-based instruction positively influences students academic performance and higher-order cognitive skills. A recent systematic review of STEAM implementation in schools found consistent evidence that STEAM education improves learning achievement, conceptual understanding and disciplinary competencies particularly in science and mathematics. These improvements are attributed to inquiry-based learning, project-based tasks and problem-solving activities that actively engage learners. Case studies conducted in secondary school settings further indicate that STEAM education supports the development of key 21st-century skills, including critical thinking, creativity, collaboration, communication and self-regulation. Students participating in STEAM projects are more likely to demonstrate analytical reasoning and the ability to transfer knowledge across disciplines which are essential for academic success in formal schooling contexts.

2.3. **Affective and Motivational Effects of STEAM Learning.**

Beyond academic achievement, research consistently reports positive affective outcomes associated with STEAM education. Multiple studies highlight increased student motivation, self-confidence, interest in learning and positive attitudes toward science and technology. (Medine BARAN) integration of artistic and design elements is particularly associated with enhanced learner engagement as it allows students to express ideas creatively while working on scientific or technological problems. Expert-based qualitative studies reveal that STEAM education promotes a holistic learning experience by addressing both cognitive and emotional dimensions of learning. Experts emphasize that the inclusion of arts contributes to students' aesthetic awareness, imagination, and design skills, which in turn strengthens their sense of ownership and confidence in learning processes.

2.4. **STEAM Education in Non-Formal and Alternative Learning Environments.**

While much of the existing research focuses on formal school settings several studies underline the importance of non-formal learning environments such as learning centers, extracurricular programs and innovation hubs in delivering effective STEAM education. Case studies from countries including Finland, Singapore, South Korea and Thailand demonstrate that flexible, project-based STEAM models implemented outside traditional classroom structures can successfully support deep learning and skill development. Non-formal STEAM environments are characterized by learner-centered pedagogies, smaller group sizes, hands-on experimentation and real-world problem contexts. These features allow for personalized learning trajectories and increased student autonomy, which are often constrained in formal school curricula. Research suggests that such environments complement formal education by reinforcing conceptual understanding and fostering transferable skills relevant to school performance and lifelong learning.

2.5. **Pedagogical Models and Challenges in STEAM Implementation.**

Despite its benefits the literature also identifies pedagogical challenges associated with STEAM implementation. Some studies report difficulties related to curriculum alignment, assessment practices, teacher preparedness and the risk of superficial integration of disciplines. In particular, researchers caution that without careful instructional design, certain disciplines especially mathematics may receive less conceptual depth in integrated STEAM activities. To address these concerns, pedagogical models emphasizing structured learning stages, design-based learning and explicit learning objectives have been proposed. These models aim to ensure disciplinary rigor while maintaining the creative and interdisciplinary nature of STEAM education. Effective implementation therefore requires trained educators, supportive learning environments and intentional assessment strategies.

2.6. **Research Gap and Relevance to the Present Study.**

Although existing literature provides strong evidence for the academic, cognitive and motivational benefits of STEAM education, there remains a notable gap in empirical research examining non-formal STEAM education centers and their role in supporting students performance in formal schooling, particularly

within specific regional contexts. Most large-scale studies focus on school-based implementation, while fewer investigate learning centers that operate as complementary educational environments. Moreover, limited research has explored the combined perspectives of students and parents in evaluating STEAM learning outcomes beyond grades, including confidence, responsibility, and engagement with school subjects espeacilly in North Macedonia. Addressing this gap, the present study contributes empirical evidence from a non-formal STEAM education center, using a mixed-methods approach to examine perceived impacts on students' school performance and learning skills.

3. METHODOLOGY

3.1. **Research Design.**

This study is empirical case study research design using a mixed-methods approach. The case study design was selected as it allows for an in depth examination of educational phenomena within their real-life context, particularly when the boundaries between the phenomenon and the context are not clearly defined. In this study, the phenomenon under investigation was the impact of STEAM education on students school performance and learning development, examined within a non-formal educational setting. A mixed-methods approach was adopted to capture both quantitative trends and qualitative insights related to students learning experiences and academic development. This approach enabled triangulation of data from multiple sources, strengthening the validity of the findings by combining numerical survey data with participants perceptions and experiences.

3.2. **Research Hypotheses.**

Hipothesis 1 - Students who participate in STEAM-based activities report clear and positive perceived improvements in learning motivation, academic confidence and problem-solving skills related to school subjects.

Hipothesis 2 - Parents of students participating in STEAM-based education report clear and positive perceived changes in their children's school performance, learning behavior and academic engagement.

3.3. **Research Context.**

The research was conducted at the SkyLab Education Center, a non-formal education center that implements STEAM-based learning programs for students of age 6-14. The center provides interdisciplinary, hands-on learning experiences designed to support creativity, problem-solving and application of knowledge across science, technology, engineering, arts, mathematics. SkyLab operates independently from formal school curricules, allowing students to engage in STEAM activities that complement their school learning. For the purposes of this study SkyLab served solely as the context in which STEAM education was implemented and observed while the primary focus of the research remained on the educational value of the STEAM approach itself.

3.4. **Participants.**

The participants in this study consisted of two groups:

- Students enrolled in STEAM programs at the SkyLab Education Center.
- Parents of the participating students

TABLE 1. Student Survey Overview

Category	**Data**
Number of participants	105
Survey timeframe	2 weeks
Number of survey questions	45
Age range of students	6–14
Participant group	SkyLab Students
Average completion time	20 min

Parents participated by providing their perspectives on observed changes in their children's learning behavior, school performance and academic attitudes. Participation in the study was voluntary and all responses were collected anonymously to ensure confidentiality and reduce response bias.

3.5. **Research Instruments.**

Data were collected using structured student and parent surveys administered through Google Forms. The online format ensured standardized distribution, anonymous participation and efficient data collection. The student survey was structured 45 question and was completed by 105 students during their regular

TABLE 2. Parent Survey Overview

Category	**Data**
Number of participants	48
Survey timeframe	2 weeks
Number of survey questions	40
Participant group	Parents of SkyLab Students
Average completion time	20 min

STEAM classes at the SkyLab Education Center. Administering the survey during class time ensured a high response rate and allowed students to complete the questionnaire in a supervised environment. The parent survey was distributed electronically via the SkyLab parent communication group allowing parents to complete the questionnaire at their convenience. The survey gathered parents perspectives on changes in their children's school performance, learning behavior, motivation and academic engagement following participation in STEAM activities at SkyLab Education Center.

3.6. **Data Collection procedures.**

Data collection was conducted over a two-week period using online survey created with Google Forms. Prior to data collection participants were informed about the purpose of the study and assured that participation was voluntary and anonymous. The student survey was administered during regular STEAM classes at the SkyLab Education Center, allowing students to complete the survey in a supervised and consistent learning environment. The parent survey was distributed electronically through the SkyLab parent communication group enabling parents to complete the survey at a time convenient for them. Following data collection, all survey responses were exported from Google Forms into Microsoft Excel for data organization and analysis. The data were reviewed for completeness and consistency and responses were processed in aggregated form. Excel was used to calculate frequencies, percentages and summary tables, which supported subsequent descriptive and inferential analysis of the collected data

4. Results and Analysis

4.1. **Student Survey.**

4.1.1. **Demographic Characteristics and Participation Profile**

A total of 105 students participated in the survey. The age distribution indicates that the majority of respondents were between 9–11 years (52.4%, $n = 55$), followed by 12–14 years (41.0%, $n = 43$), while a smaller proportion belonged to the 6–8 years age group (6.7%, $n = 7$). Students were almost equally distributed across the three STEAM program packages: *Group Kids* (32.4%, $n = 36$), *Group Science* (33.3%, $n = 35$), and *Group Innovators* (32.4%, $n = 34$). Regarding duration of participation, 49% ($n = 51$) of students were in their first year at SkyLab, 26% ($n = 27$) had attended for two semesters, and 25% ($n = 26$) had participated for three or more semesters, indicating a mix of new and experienced learners.

4.1.2. **Learning Motivation, Engagement and Emotional State**

Students reported very high levels of satisfaction and emotional well-being at SkyLab. When asked whether they enjoyed attending SkyLab, 84.8% ($n = 89$) selected the highest rating, while only 4.8% ($n = 5$) provided a neutral response. Similarly, 74.3% ($n = 78$) strongly agreed that they felt welcomed and valued within their learning groups. All students (100%) reported that they learned new things every week, highlighting the perceived novelty and continuity of learning experiences. Additionally, 71.4% ($n = 75$) stated that participation in SkyLab increased their motivation toward science, technology, and art subjects at school, while only 23.8% ($n = 25$) reported no increase and 4.8% ($n = 5$) indicated occasional motivation.

4.1.3. **Perceived Quality of Learning Activities**

The perceived quality and appropriateness of learning activities were rated very positively. 70.5% ($n = 74$) of students strongly agreed that activities were understandable and appropriate for their age, while 88.6% ($n = 93$) strongly agreed that they enjoyed experimental and practical activities. Collaborative learning was also positively perceived: 67.6% ($n = 71$) strongly agreed that they enjoyed working in groups, and 67.6% ($n = 71$) reported that they learned things connected to everyday life. Furthermore, 84.8% ($n = 89$) strongly agreed that activities were fun and interesting.

4.1.4. **Preference for Practical Learning and STEAM Methodology**

A strong preference for hands-on learning was detected. When asked whether they preferred more experiments or more theory, 91.4% ($n = 96$) expressed a preference for activities and experiments, while only 8.6% ($n = 9$) preferred theory or discussion-based lessons. This preference aligns with students' perceptions of instructional clarity and support. 88.2% ($n = 90$) strongly agreed that instructors explained concepts clearly, and 96.2% ($n = 101$) strongly agreed that instructors were friendly and approachable. Moreover, 89.4% ($n = 93$) felt supported when asking questions or facing difficulties.

4.1.5. **Impact on School Performance**

Students reported notable perceived improvements in school-related understanding and skills. 61.9% ($n = 65$) strongly agreed that they understood science better than in school, and 72.4% ($n = 76$) strongly agreed that they understood technology and engineering concepts better compared to formal lessons at school.

Group work skills showed improvement, with 70.5% ($n = 74$) strongly agreeing that they had learned to work better with others and that this helped them at school. Additionally, 81.0% ($n = 85$) reported that SkyLab helped them discover their interests, while 57.7% ($n = 60$) strongly agreed that they felt more confident expressing their ideas without fear. Most importantly, 98% of students reported that SkyLab had helped them in school overall.

4.1.6. **Engagement, Retention, and Long-Term Motivation**

Indicators of engagement and retention were very strong. 89.3% ($n = 92$) reported that they attended SkyLab willingly, and 92.4% ($n = 97$) expressed a desire to continue attending SkyLab in future years. Additionally, 95.2% ($n = 99$) reported recommending SkyLab to others.

When asked whether SkyLab had changed the way they viewed science and technology compared to the previous year, 72.9% ($n = 35$) responded positively, while 20.8% ($n = 10$) reported partial change.

4.1.7. **Responding to Hypothesis 1**

Overall, the results provide strong empirical support for Hypothesis 1, indicating that participation in STEAM-based activities is associated with high learning motivation, positive emotional engagement, increased confidence, and perceived

improvement in school-related understanding. The consistently high percentages across multiple indicators suggest that STEAM education, as implemented in a non-formal learning environment, meaningfully supports students' learning experiences and complements formal schooling.

4.2. **Parent Survey.**

4.2.1. **Demographic Characteristics of Parent Respondents**

Parent survey responses indicate that children were enrolled across multiple STEAM program packages, with 37.8% ($n = 17$) registered in *Group Kids*, 29.0% ($n = 13$) in *Science*, 26.7% ($n = 12$) in *Innovators*, and 7.0% ($n = 3$) in *Stars*. Nearly half of the children (47.9%, $n = 23$) were attending SkyLab for the first time, while 35.4% ($n = 17$) had participated for two to three levels and 16.7% ($n = 8$) for more than three levels.

Regarding age, the majority of children were between 9–11 years (50%, $n = 24$) and 12–14 years (40%, $n = 19$), with a smaller proportion aged 7–8 years (10%, $n = 5$).

4.2.2. **Parental Engagement and Communication**

Parents reported high levels of engagement and communication with the center. A large majority (83.3%, $n = 40$) stated that they regularly read notifications and messages from SkyLab. Nearly half of parents (48%, $n = 23$) felt very involved in their child's learning process at the center, while 23% ($n = 11$) felt sufficiently involved. Communication quality was evaluated positively, with 58.3% of parents assigning the highest rating. Additionally, 75.0% ($n = 36$) expressed interest in having more access to observe or engage with activities conducted at the center.

4.2.3. **Parental Perceptions of STEAM Education on Learning, Motivation, and Skills** Parental perceptions strongly indicate positive learning outcomes. Most parents reported that their children were highly enthusiastic about attending SkyLab (70.8%), with only 2.1% expressing neutral enthusiasm. Importantly, 68.8% ($n = 33$) of parents reported significant improvement in their child's problem-solving skills, while an additional 25% ($n = 12$) observed moderate improvement. Children's emotional responses to SkyLab activities were also positive: 72.9% ($n = 35$) of parents described their children as very satisfied when

discussing SkyLab experiences at home. Moreover, 64.3% ($n = 31$) of parents reported noticeable improvements in their child's self-confidence or behavior.

4.2.4. **Teaching Quality, Environment, and Safety**

The quality of teaching at SkyLab was rated very highly. 62.5% ($n = 30$) of parents evaluated the quality of instruction as excellent, and 25% ($n = 12$) as very good. Parents also expressed strong confidence in the learning environment: 85.4% ($n = 41$) rated the center as very safe for their children. Classroom organization was positively perceived, with 60.4% ($n = 29$) rating it as very well organized. Furthermore, 59.6% ($n = 28$) reported being very satisfied with the balance between science, technology, engineering, arts, and mathematics within the program.

4.2.5. **Development of Social and Academic Skills**

Parents reported meaningful improvements in social and academic competencies. 70.2% ($n = 33$) observed improvements in group-work skills, and 63.8% ($n = 30$) noted enhanced communication abilities. Increased curiosity toward scientific and technological subjects was also evident, with 48.9% ($n = 23$) reporting strong growth and 38.3% ($n = 18$) reporting moderate growth.

Additionally, 29.8% ($n = 14$) of parents stated that their children frequently attempted to replicate activities at home, suggesting transfer of learning beyond the center.

4.2.6. **Perceived Impact on School Performance and Retention**

Parents reported positive changes in formal school outcomes: 36.2% ($n = 17$) strongly agreed that their child's school performance or interest in learning had improved, while 27.7% ($n = 13$) agreed moderately. Satisfaction with scheduling and program structure was high, with 65.2% ($n = 30$) expressing strong satisfaction with class schedules. Retention intentions were very strong: 80.4% ($n = 37$) expressed a clear desire for their child to continue at SkyLab in future levels, and 89.4% ($n = 42$) stated that they would recommend the center to other parents.

4.2.7. **Responding to Hypothesis 2**

Parents' survey results provide strong empirical support for Hypothesis 2, indicating that parents perceive statistically meaningful improvements in their children's learning behavior, motivation, confidence, and school-related performance

following participation in STEAM education. High satisfaction levels across instructional quality, learning environment, and student engagement further reinforce the role of STEAM-based learning as an effective complement to formal schooling.

5. Conclusion

This empirical case study demonstrates that participation in STEAM-based learning is associated with strong positive perceptions of student motivation, engagement and learning experiences. Students reported high enjoyment a sense of belonging and a preference for hands-on experiential learning while parents observed improvements in problem-solving skills, curiosity toward science and technology, teamwork and confidence. Both students and parents perceived a positive contribution of STEAM education to school-related outcomes, suggesting that non-formal STEAM learning can effectively complement formal education. The findings highlight the educational value of STEAM as an approach that supports active learning, interdisciplinary thinking and skill development relevant to school success. More broadly, the results suggest that wider implementation of STEAM methodologies within formal school settings could enhance student engagement and learning by integrating practical, student-centered and real-world learning experiences into the curriculum. These findings support STEAM education as a promising approach for strengthening academic development and preparing students for future educational challenges.

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