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THE ROLE OF PHYSICAL EDUCATION IN STEAM LEARNING

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Abstract: This paper investigates the integration of Physical Education (P.E.) into STEAM (Science, Technology, Engineering, Arts, and Mathematics) education, set against a backdrop of declining physical activity and increasing health concerns among European youth. The question is how P.E. can enhance STEAM learning and address these health challenges. Utilizing a comparative analysis of P.E. programs across Europe, the study reviews educational policies and curricula to understand the current positioning of P.E. in schools. This involves examining the time allocation and emphasis on P.E. in different educational systems. Current findings reveal a consistent underrepresentation of P.E. in academic settings, with significant discrepancies in the attention and resources allocated to it. This neglect is juxtaposed against the recognized need for holistic education that synergizes physical well-being with academic proficiency. Some examples of interdisciplinary work is given in the paper.

Keywords: physical education, STEAM, physical activity, youth and health concerns

INTRODUCTION

In the rapidly evolving landscape of modern education, STEAM—an acronym for Science, Technology, Engineering, Arts, and Mathematics—stands out as a beacon of interdisciplinary learning. This educational framework, celebrated for its holistic approach, seamlessly integrates these traditionally separate disciplines, fostering an environment where innovation, creativity, and critical thinking are not just encouraged but are fundamental. STEAM education transcends the conventional boundaries of subject-specific learning, preparing students for a future where interdisciplinary knowledge is not just valuable, but essential.

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STEM is an integrated educational approach to learning and teaching, which requires an intentional connection between curriculum learning objectives, standards, assessments, and lesson design/implementation. STEM literacy means "(1) awareness of the roles of science, technology, engineering, and mathematics in modern society; (2) familiarity with at least some of the fundamental concepts from each area; and (3) a basic level of application fluency (e.g., the ability to critically evaluate the science or engineering content in a news report, conduct basic troubleshooting of common technologies, and perform basic mathematical operations relevant to daily life)" (Margot & Kettler, 2019).

In recent years, various concepts and modifications of STEM have been introduced with the idea of implementing other areas into the STEM concept such as STEAM – Science, Technology, Engineering, Arts and Mathematics (Aguilera & Ortiz-Revilla, 2021; Diego-Mantecon, et al., 2021; Tran, et al., 2021), iSTEM – Integrated Science, Technology, Engineering and Mathematics (Razi & Zhou, 2022; Wilson, et al., 2022), i-STEAM – Integrated Science, Technology, Engineering, Arts and Mathematics (Ortiz-Revilla, et al., 2021), STEMM – Science, Technology, Engineering, Mathematics and Medicine (Lee, et al., 2015).

The extension of the STEM concept is mostly focused on the implementation of Arts into STE(A)M to enhance the role of creativity and innovation in contemporary learning. STEAM applies meaningful science, technology, engineering, arts, and mathematics content to solve real-world problems through hands-on learning activities and creative design. Including the arts in STEM learning enhances teaching and student achievement, inquiry and problem-solving skills, and creative thinking, raises students' interest in science and its application, and provides multiple access points for students to engage in the creative process and meet objectives in all subject areas (Dell' Erba, 2019).

What stands out as a special question is whether it is possible—and if so, how—to incorporate the field of physical education into the STE(A)M model (Erwin, 2017; Osada, et al., 2022). The priority of today's educational policies is the advancement of students in the field of technology and information systems, but in addition to improving problem-solving skills, and collecting and analyzing information, an individual's personality should be depicted through the integrity of mind and body (Osada, et al., 2022).

The current status of society characterizes technological development and an overall decrease in physical activity (P.A.). P.A. levels are declining in all parts of the world. Wealthy, middle or low-income countries share a decline in physical activity (WHO, 2018, 2022). The World Health Organization reports that the extent of the obesity problem has reached "epidemic proportions." Already at deadly levels, the WHO asserts that obesity rates are "still escalating,"

meaning that the stop to the increase in overweight and obesity rates is not in sight. Childhood obesity is at a constant rate of increase. A Large-scale pre-epidemic study published in *Lancet Journal* suggests that in 2017 there were 10 times more obese children than four decades ago (Abarca-Gómez et al., 2017). Statistically, Serbia is among the five European countries hit by the obesity epidemic the hardest (WHO European Regional Obesity Report 2022). A similar situation is in the USA where childhood obesity is a serious problem as well. Obesity prevalence among children and adolescents is still too high. The prevalence of obesity was 19.7% and affected about 14.7 million children and adolescents (Stierman et al., 2021).

Even during the last decade, studies in Europe and the U.S. found that moderate-to-vigorous physical activity among children attending elementary school age is significantly decreasing (Riddoch, 2004; Nader, 2008). In Europe, there is a cut in half from 9-year-olds to 15-year-old children (48% for boys & 54 % for girls); in the US, physical activity dropped by 75% within the same age period. The last published estimations (Lee, 2017) from the US suggest that only 32% of 8-11-year-old children have sufficient physical activity (exercise for 25 minutes a day/three days a week according to the guidelines by the Sports and Fitness Industry Association), which is significantly below the WHO recommendations. Maintaining the current level of physical activity will result in 8.1 million of these children being overweight or obese by 2020 in the US. A significant amount ($21.9 billion) in additional medical costs and lost wages could be avoided if only half of the children obtained sufficient physical activity (Lee, 2017).

P.E. in school is the only sure opportunity for every school-age child to access health-enhancing physical activities. It is estimated that for over 80% of the children, P.E. is only physical activity during the day (EC, 2015). It is formally recognized and is a mandatory subject in the curricula in all European countries. The relative share of time allocated to P.E. is around 9-10% but some countries have even less than 5%, even in primary education. Additionally, there are many problems in the implementation and realization of P.E. classes in schools. Many elementary school teachers consider P.E. as a nonessential subject and neglect it. In order to respond to the increased demands for achievements in core subjects, teachers often devote more time during total school time to those subjects and decrease time for nonessential subjects such as physical education. In the U.S., after No Child Left Behind Act of 2001, in the efforts to hinder decreased funding for schools, 44% of school administrators reported that instructional time for evaluated subjects (literacy and mathematics) was increased at the expense of time devoted to P.E. physical education and other nonessential subjects (Center on Education Policy, 2007, 2008). Similar trends in school ranking and funding is being considered at the moment in

Serbia and some European courtiers. Also, the perceived importance and total teaching time allocated to P.E. is lower compared to other subjects (Eurydice, 2012b). The difference between the total time allocated is highest in primary education where in some countries from one-sixth to one-fifth of teaching time is devoted to P.E. compared to language or mathematics (Eurydice, 2013). The legal and perceived actual status of P.E. and its teachers is a contentious issue. The majority of P.E. teachers considered that their subject has an inadequate status. The evidence of the lower status of P.E. can be observed in little interest in P.E. such as: low levels of awareness of its usefulness and intrinsic/extrinsic values; being non-examinable, less curriculum time allocation, greater emphasis on other subjects, etc. In comparison to the rest of the world, the situation is the best in Europe where only 46% of P.E. teachers considered that P.E. has a lower status than other subjects (UNESCO report, 2013). In practice, many teachers find themselves asking how they are supposed to achieve educational goals in key subjects without increased time allocated to these subjects or taking the time from some other less important subject like P.E.

The importance of P.E. is increasing since most diseases become clinically manifested mainly during adulthood, but the actual problem begins in childhood when lifestyle habits such as physical activity are established (Summary report Pediatrics, 2011). Increases in the level of physical activity by encouraging involvement in everyday physical activity can be one of the most effective ways for the magnitude decline and for overcoming this problem.

Similarly, there are recommendations for STEM education to begin from the earliest years (Campbell & Speldewinde, 2022) and that fundamental STE(-PA)M; science, technology, engineering, physical education, arts, and mathematics skills should be established in primary school. The primary years are the time when students develop a self-belief in their ability as STEM learners. Students' experiences in the primary and early secondary years of schooling establish a sense of competence that students have in the foundations of mathematics and science and can encourage their interest in science related fields (Ainley, Kos & Nicholas, 2008). At the same time, early childhood is the ideal time for establishing healthy lifestyle habits (Summary Report Pediatrics, 2011).

APPLICATION OF SCIENCE, TECHNOLOGY, ENGINEERING, AND P.E.

In Physical Education (PE), the fusion of Science, Technology, and Engineering creates a multifaceted learning environment that enriches students' understanding and experience of physical activities. The scientific aspect is deeply rooted in understanding human biology and physiology, where students explore the biomechanics of movement, the physiological impacts of exercise,

and nutritional science. This comprehensive approach enables them to grasp how muscles function, the significance of cardiovascular health, and how various physical activities affect their bodies.

Complementing this, technology plays a pivotal role in PE through advanced tools like fitness trackers, health apps, and virtual reality systems. These technological interventions allow students to delve into data analysis by monitoring their physical activities, comprehending heart rate variations, and understanding how technology is employed by athletes for performance optimization.

Moreover, engineering principles are seamlessly integrated into PE, enhancing the practical experience. This integration is evident in the design and utilization of sports equipment and facilities. Students learn about the engineering concepts behind protective gear, the aerodynamics of balls, and the intricacies of designing athletic footwear. Material science also comes into play, offering insights into the development of better, safer, and more efficient sports gear and equipment.

A notable instance of the successful integration of science into physical education is the *Physical Education in Physics* (https://pefja.kg.ac.rs/fizicka-priprema/) project, an initiative supported by the National Center for Science Promotion. This project conducted a few years ago serves as an exemplary model showcasing the synergistic potential between physical education and scientific disciplines, in this case, physics.

The project aimed to blend the theoretical concepts of physics with the practical applications found in physical education. By doing so, it provided students with an immersive and engaging learning experience, where theoretical physics was not just a subject confined to the classroom but a living, breathing part of their physical activities.

The *Physical Education in Physics* project, known in its native language as *Физичка припрема* (https://pefja.kg.ac.rs/fizicka-priprema/), represents an innovative educational initiative aimed at intertwining physical education with the principles of physics. The project's primary objective is to familiarize participants, particularly students in younger grades who have not yet started formal physics education, with the laws of physics as they apply to various physical activities and sports movements.

Organized by the Faculty of Education, University of Kragujevac, the project targets students in the 4th and 5th grades. Through a series of diverse and engaging workshops, the project brings to life concepts such as the human body and movement, lever systems, force, and power; *Newton on the Horizontal Bar*; *Archimedes in the Water Park*; statics and dynamics in martial arts; and the physics in football, among others.

These workshops, conducted within the framework of Physical Education – a subject often favored by most students – aim to spark curiosity and foster an interest in learning and studying the physical laws governing our world. The approach is both creative and captivating, making complex scientific principles accessible and relatable to young learners.

By bringing these content areas closer to the students in an engaging manner, the project not only enhances their understanding of physical laws but also increases their interest in future physics lessons in higher grades. This proactive approach to education serves as an exemplary model of how interdisciplinary teaching methods can significantly benefit student learning and engagement.

The *Physical Education in Physics* project is a testament to the effectiveness of integrating academic disciplines, in this case, physics, with physical education. It exemplifies how teaching methods that combine physical activity with theoretical learning can lead to a deeper understanding and appreciation of both subjects, ultimately resulting in a more holistic educational experience for students.

Picture 1. Workshop Physical preparation – preparation for Physics

ART IN PHYSICAL EDUCATION

Art holds a significant place in physical culture, permeating all its areas, including physical education, sports, and recreation. Physical education fulfills

numerous educational, health-hygienic, recreational, and educational tasks. The educational aspects are directed towards the complete, harmonious, versatile, and creative development of personality, of which aesthetic values and abilities are a crucial part. These can be successfully developed within physical culture. During the process of physical education, aesthetic values are realized through the development and perfection of body movements, as well as by nurturing a sense of harmony, gracefulness, and the beauty of movement.

Art is also considerably present in sports. Athletes, with their movements, strokes, and skills, can be said to create their artistic works. Moreover, music and painting often explore themes from sports activities. The performance of choreographies in certain sports is unimaginable and unfeasible without musical accompaniment, while sports photography holds an irreplaceable place in the media, with frequent exhibitions of such photographs (Ignjatovic et al., 2009).

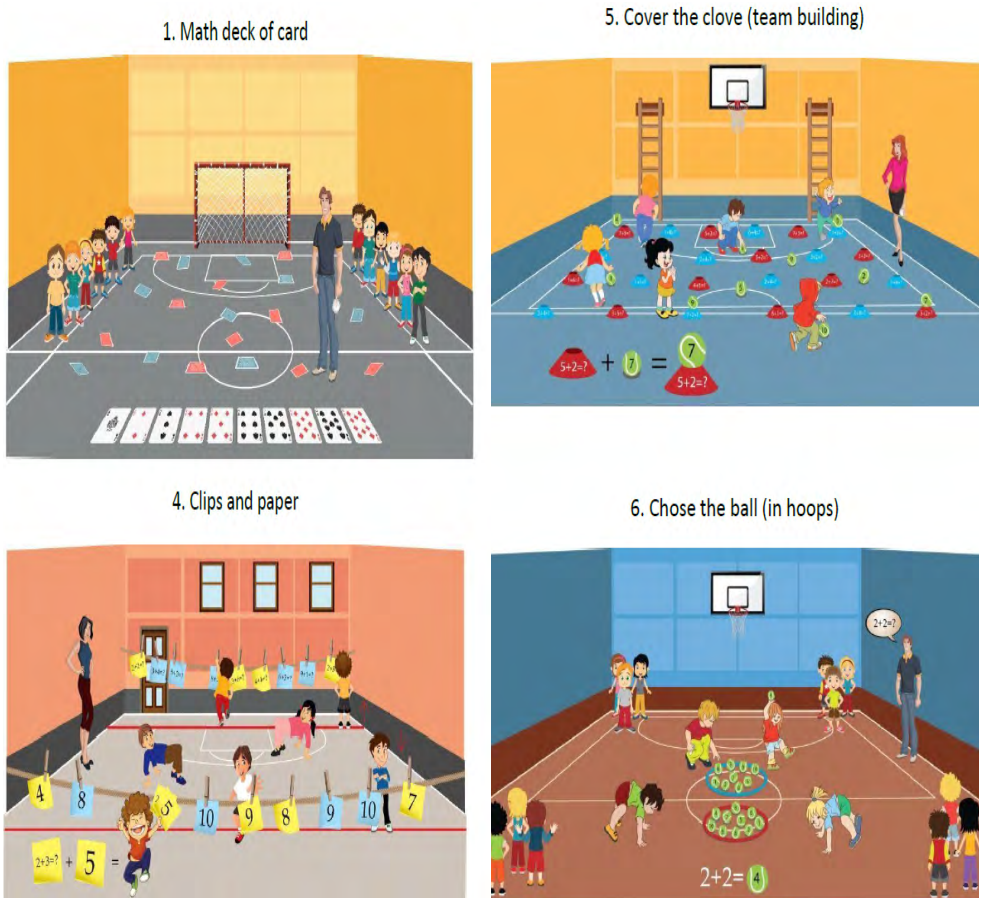
INTEGRATION OF MATHEMATICS IN PHYSICAL EDUCATION

Finally, most of the work on the topic was given on interdisciplinary approach to mathematics and physical education. By integrating mathematics into physical education at the elementary level, educators can create a more dynamic and inclusive learning environment. This approach not only enhances children's mathematical skills but also promotes physical health, teamwork, and problem-solving abilities. It demonstrates the versatility and fun of mathematics, encouraging students to appreciate and enjoy the subject.

The authors of this study have recently conducted research on this topic. They analyzed and highlighted the significance, standing, and practical implementation of logical-mathematical games within an integrated teaching framework for physical education. The process for selecting pertinent studies involved searching through electronic databases to identify those incorporating an integrative approach in this research area. Out of 51 publications reviewed, only 9 published in the last two decades fulfilled the criteria of this study. The findings underscore a clear necessity for more comprehensive research in this field. This need stems not only from the limited number of existing studies but also from the importance of exploring how this integrative teaching method in physical education impacts the motor skills and abilities of younger students (Miloradovic, et al., 2024). The examination of the literature reveals a substantial volume of literature on the use of integrative methods in teaching physical education in conjunction with traditional "classroom" subjects. While the utilization of logic-mathematical games has been shown to positively influence student performance, there is a notable gap in research specifically focused on the application of these games within an integrative approach to physical

education. This is particularly evident for younger school-aged children and in studies evaluating the impact on motor skills and abilities following experimental programs. The findings from the reviewed studies highlight the necessity for more extensive research across a broader age range, encompassing students from primary through to secondary school, to gain a deeper understanding of these methods' effectiveness (Miloradovic, et al., 2024).

The prevailing body of research primarily emphasizes theoretical approaches, with a lesser concentration on empirical experimentation in the field. Additionally, there is a noticeable deficiency in standardized and comprehensive materials pertaining to this subject area. This indicates a gap in practical, experiment-based research and a need for more elaborately developed resources and guidelines to support the integrative approach of incorporating logic-mathematical games in physical education, particularly for younger students. In this regard, the previously mentioned PEMath guidebook is under preparation.



Picture 2. PEMath gudebook, Ignjatovic, under preparation.

ENHANCING ARITHMETIC AND MEASUREMENT IN PHYSICAL EDUCATION FOR FIRST GRADERS: INSIGHTS FROM PEMATH

Using *PEMath* as a guideline, elementary school teachers can create a vibrant learning environment where first graders enjoy the dual benefits of physical activity and foundational arithmetic skill development. This approach not only enhances their mathematical abilities but also promotes physical health, coordination, and cognitive development.

A whole new universe of learning opens up for young kids in the creative and dynamic world of *PEMath*, a manual that skillfully integrates math with physical education. With the help of this creative method, the gym becomes a dynamic learning environment where math and exercise combine to create a joyful tango between health and knowledge.

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Interactive learning is further enhanced through the use of props like numbered cones, mats, or stepping stones. A "number path" sprawls across the floor, inviting students to leap from one number to the next, adding and subtracting as they go, transforming each step into a numeral adventure. The excitement peaks during relay races, ingeniously adapted to include arithmetic challenges. Before dashing across the room, each child pauses to solve a math problem, their physical sprint preceded by a mental leap, effectively integrating calculation with cardiovascular activity.

CONCLUSION

In conclusion, the exploration of integrating physical education with elements of STEAM – Science, Technology, Engineering, Arts, and Mathematics – presents a revolutionary approach in the realm of education. It goes beyond conventional teaching techniques by combining academic rigor with physical activity to create a comprehensive learning environment. Initiatives such as *PEMath* are

prime examples of this integration; they make learning both multifaceted and captivating by fusing logical-mathematical games and exercises with physical instruction. This method fosters students' intellectual, artistic, and analytical abilities in addition to addressing the requirement for physical health and fitness. Nevertheless, the literature now in publication indicates a deficiency in useful, experiment-based research, particularly for younger pupils, despite the apparent advantages. This emphasizes the need for more thorough research and resources to certify and standardize these integrative techniques.

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