STEM Education Notes **3** (2026), no.1, 1–15
ISSN: 2955-1838 (electronic version)
https://doi.org/10.37418/amsj.3.1.1

# FROM MOVEMENT TO LEARNING: AN INTERDISCIPLINARY MODEL LINKING PHYSICAL EDUCATION AND STEAM

Limonka Koceva Lazarova[1] and Nagehan Baykan Afşar

ABSTRACT. This paper presents an interdisciplinary teaching model that links Physical Education with STEAM disciplines through movement-based learning. Physical activity is used as a learning context in which students explore concepts from mathematics, physics, biology, and informatics through practical and experiential activities. Four interdisciplinary modules were implemented, combining physical exercises with data analysis, scientific exploration, and problem-solving tasks. Learning takes place across classroom, gym, and outdoor environments, promoting active participation and collaboration. The model demonstrates that Physical Education can serve as an effective platform for interdisciplinary STEAM learning, supporting both physical development and cognitive competencies while enhancing student engagement and real-life application of knowledge.

## 1. INTRODUCTION

Contemporary education increasingly emphasizes interdisciplinary learning approaches that connect knowledge across subjects and promote meaningful, authentic application. In parallel, STEAM education has gained momentum as a

[1]*corresponding author*
*Key words and phrases.* physical education, STEAM, collaborative learning, interdisciplinary model.
*Submitted:* 15.12.2025; *Accepted:* 21.01.2026; *Published:* 28.01.2026.

framework for integrating science, technology, engineering, arts, and mathematics in ways that strengthen problem-solving, creativity, collaboration, and real-world relevance. Within this landscape, Physical Education (PE) is often treated as separate from "academic" disciplines, despite its strong potential to serve as an experiential learning environment where concepts from mathematics, science, and technology become observable through movement, measurement, and experimentation.

A growing body of research supports the idea that movement and embodied learning can enhance attention, learning engagement, and conceptual understanding. Evidence reports and reviews show consistent links between physical activity and learning-related outcomes such as concentration and attainment, [1]. More recently, education research has consolidated "embodied learning" as a promising approach that intentionally integrates cognition, physical activity, and interaction with the environment, offering a strong theoretical basis for movement-based interdisciplinary teaching, [2].

Within STEM/STEAM contexts, physically active learning has been explored particularly in mathematics. Studies indicate that "active mathematics" lessons-where learners combine mathematical reasoning with physical tasks-can increase physical activity during lessons while maintaining or supporting learning outcomes, [3], [4].

At the broader curriculum level, recent work has also discussed the role of interdisciplinary STEM education and the challenges of implementation, including the need for clearer models and replicable teaching designs, [5].

Several recent studies have explored physically active learning in specific STEAM domains. In mathematics education, movement-based activities involving measurement, data collection, and spatial reasoning have been shown to support conceptual understanding and student motivation, and physically active lessons have been reviewed as interventions that can increase physical activity while maintaining educational outcomes [9, 10], also the embodied-learning synthesis in early mathematics: [11]. Similarly, interdisciplinary links between Physical Education and biology can be supported through learning designs where students observe and interpret bodily/physiological responses to exercise (e.g., real-time heart-rate feedback to support understanding of exertion and motivation: [12]. In physics education, sport and movement contexts provide intuitive examples of motion, forces, balance, and material properties, enabling learners to connect theoretical principles with observable phenomena [13]. Taken together, these findings suggest that Physical Education offers authentic contexts for applying STEAM concepts in meaningful and interdisciplinary ways.

More specifically, interest is increasing in positioning PE as a contributor to STEAM learning, rather than merely a parallel subject. Recent publications argue that PE can support STEAM learning through practical contexts for measurement, experimentation, collaboration, and the application of scientific principles in movement and sport, [6]. At the same time, digital and game-based learning environments have shown promise for developing spatial reasoning and creativity—competencies closely connected to STEM success. For example, studies using Minecraft Education report improvements in spatial thinking and other learning outcomes when integrated into curriculum activities, [7,8].

In response to this gap, the present study introduces an interdisciplinary teaching model that connects Physical Education with mathematics, physics, biology, and informatics through movement-based learning activities. The model provides a structured yet flexible framework that supports real-life problem solving, experiential learning, and interdisciplinary connections. By presenting concrete examples of activities across different learning environments, this paper contributes to ongoing discussions on interdisciplinary education and offers practical insights for educators seeking to implement STEAM-oriented approaches through Physical Education.

## 2. Concept of the Interdisciplinary Model

This interdisciplinary model is based on the idea that Physical Education can function as a learning laboratory where concepts from science, mathematics, technology, and informatics are experienced through movement, measurement, experimentation, and reflection. Rather than positioning PE as a separate or auxiliary subject, the model treats it as an active context for knowledge construction, aligned with contemporary interdisciplinary and embodied learning principles.

The model responds to the need for meaningful learning experiences that connect abstract concepts with real-world situations. By integrating STEAM-related content into PE activities, students engage cognitively and physically, allowing theoretical knowledge to be explored through observable and measurable phenomena such as motion, force, angles, timing, biological responses, and data patterns. To operationalize this approach, the interdisciplinary model is structured around clearly defined thematic links between Physical Education and selected STEAM disciplines. Each link is designed to highlight natural conceptual overlaps, where physical movement and sport-related activities provide authentic contexts for exploring scientific, mathematical, technological, and computational concepts. In this way, disciplinary boundaries are preserved while meaningful connections between subjects are intentionally emphasized.

The model follows a coherent instructional sequence that begins with the introduction of a key STEAM concept and continues with its exploration through physically active tasks. During these tasks, students collect data, observe outcomes, or interact with digital tools, enabling them to connect theoretical knowledge with tangible experience. Reflection and discussion are then used to support conceptual understanding and transfer of learning to other academic or real-life contexts.

Importantly, Physical Education serves not merely as a setting for interdisciplinary activities but as an equal partner in the learning process. Movement, performance, and bodily experience are treated as sources of information that support reasoning, analysis, and problem-solving. Through this integration, students are encouraged to perceive learning as an interconnected process, where physical and cognitive dimensions reinforce one another. Building on this conceptual framework, the interdisciplinary model is implemented through four types of activities, each connecting Physical Education with a specific STEAM discipline: mathematics, physics, biology, and informatics. These activities are designed to reflect authentic links between movement-based experiences and disciplinary concepts, ensuring that learning remains contextualized, experiential, and meaningful.

Each type of activity follows a common pedagogical logic—combining physical engagement, conceptual exploration, and technology-supported analysis—while addressing discipline-specific learning objectives. Together, they form a coherent model that enables students to experience STEAM concepts through bodily action, observation, and reflection.

2.1. **Physical Education and Mathematics.** The interdisciplinary activities integrating Physical Education and Mathematics are designed to demonstrate how mathematical concepts are embedded in sport-related contexts and everyday physical activities. The focus is placed on helping students recognize mathematics as a practical tool for understanding movement, space, performance, and decision-making in sports.

Key mathematical topics addressed within these activities include ratio and proportion and basic geometry, with particular emphasis on angles. These concepts are introduced through real-life examples drawn from sports environments, such as stadium design, audience capacity, scoring systems, and movement trajectories. In addition to ratio, proportion, and basic geometry, the activities incorporate a range of mathematical concepts naturally arising from Physical Education contexts. These include measurement of time, distance, and speed during running and jumping tasks; data collection and basic statistical analysis of performance results such as averages, comparisons, and progress over time; and the representation of movement-related variables using simple tables and graphs. In game-based activities, probability concepts may also be introduced through the analysis of scoring success, decision-making strategies, or outcome frequencies. Through these examples, students experience mathematics as a practical tool for describing, analyzing, and improving physical performance. By working with authentic data and familiar contexts, students are encouraged to perceive mathematics as relevant and meaningful within Physical Education.

The activities are organized through a sequence of collaborative and gamified learning experiences. Students work in mixed teams and participate in workshops, discussions, and problem-solving tasks that combine physical engagement with mathematical reasoning. For example, ratio and proportion are explored through comparative analyses of sports venues, where students calculate capacities, proportions, and simple odds related to sporting events. Geometry concepts are addressed through practical movement tasks, where students examine how angles influence accuracy, efficiency, and strategy in different sports.

Physical activity sessions are complemented by reflective components, including presentations, posters, and group discussions, allowing students to articulate the connections between mathematical theory and physical performance. Gamification elements, such as team challenges and city-based exploration tasks, are incorporated to enhance motivation and engagement while reinforcing learning objectives.

Overall, these activities support the development of mathematical literacy within Physical Education by linking abstract concepts to observable and measurable phenomena in sports. At the same time, they foster collaboration, communication, and critical thinking, contributing to a holistic interdisciplinary learning experience.

Examples of these mathematical applications within Physical Education contexts are illustrated in Figure 1, Figure 2 and Figure 3.

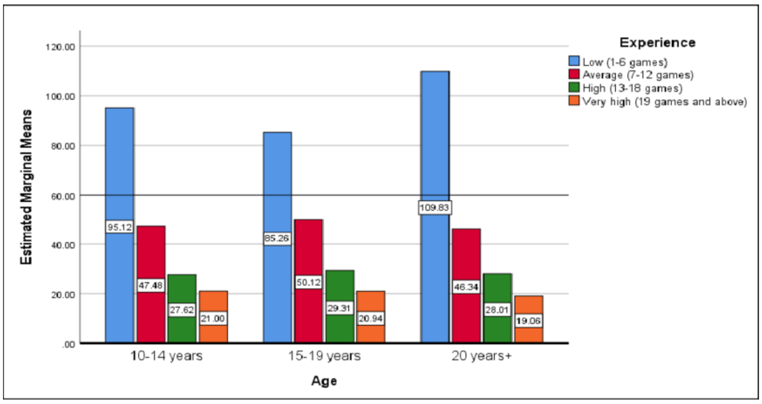


FIGURE 1. Performance data analysis

2.2. **Physical Education and Physics.** The interdisciplinary activities integrating Physical Education and Physics focus on exploring fundamental physical principles through movement and sport-related situations. Physical Education provides an authentic and dynamic environment in which abstract physics concepts become observable, measurable, and directly experienced by students through bodily action. Through physical activities, learners are able to connect theoretical knowledge with real-world movement, supporting meaningful and embodied learning.

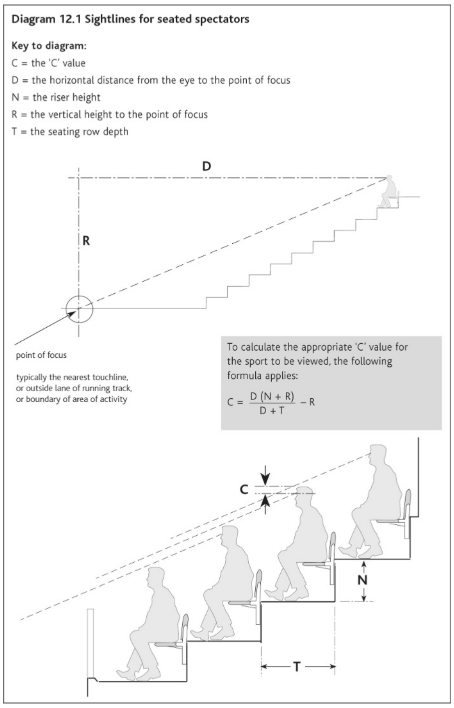


FIGURE 2. Illustration of ratio and proportion concepts in Physical Education through stadium seating capacity and section distribution

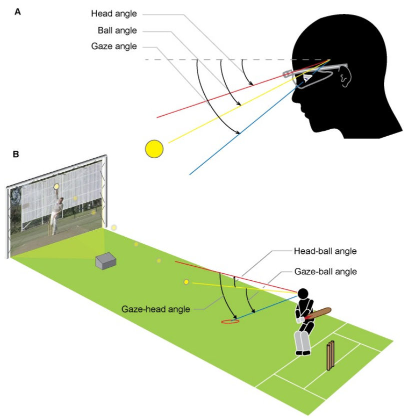


FIGURE 3. Illustration of angle concepts applied in Physical Education through sport-related movement and shooting trajectories..

Key physics concepts addressed within these activities include motion, speed, acceleration, force, balance, energy transfer, and friction. These concepts are introduced through familiar physical activities such as running, jumping, throwing, changes in direction, and interaction with different surfaces. For example, projectile motion is explored through ball trajectories, acceleration and force through sprint starts, and balance through controlled movement tasks. Particular emphasis is placed on frictional force, as it plays a critical role in many sports, influencing speed, control, safety, and performance. In some sport disciplines, reducing friction is essential for increasing speed, while in others, sufficient friction is necessary to ensure stability and effective movement. Example of how material design and tread patterns in sports footwear influence friction and movement control is illustrated in Figure 4 and Figure 5 shows visualization of static, sliding, and rolling friction and their effects on motion and acceleration.

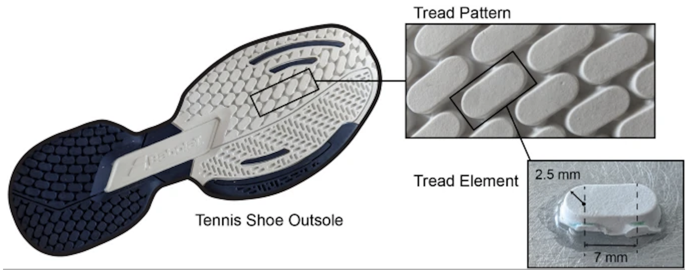


FIGURE 4. Tennis shoe outsole (tread pattern)

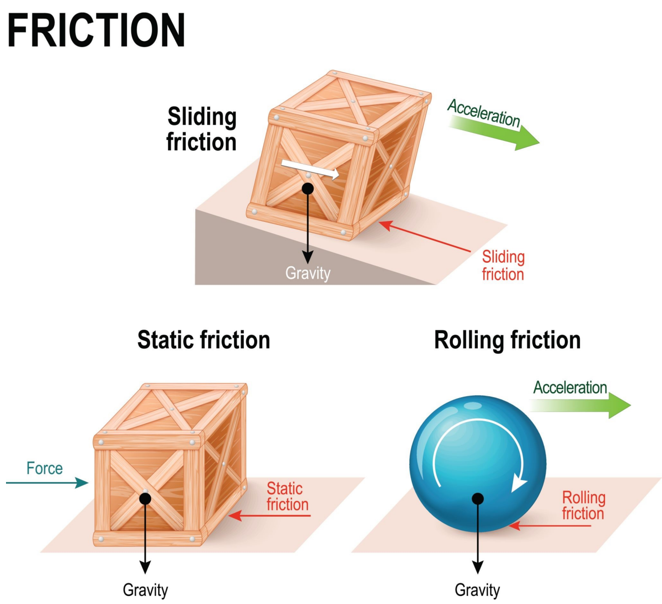


FIGURE 5. Static, sliding, and rolling friction diagram

The activities are structured to combine physical engagement with observation, measurement, and analysis. Students participate in movement-based tasks during which they record data related to time, distance, velocity, or surface interaction, and then interpret these results using basic physics principles. Through guided discussion and simple modeling, learners identify cause-and-effect relationships between applied forces, frictional conditions, and resulting motion.

Collaborative and gamified learning approaches are used to enhance engagement and creativity. Students work in mixed teams to investigate the role of friction and materials in different sports branches, supported by discussions, practical demonstrations, and visual representations such as infographics or short presentations. As part of the learning process, students may design simple physical or digital games illustrating physics concepts, encouraging originality and deeper conceptual understanding.

The activities also include reflective components that connect physics concepts to real-world applications and future opportunities. Students analyze how sports equipment, footwear, and playing surfaces are designed to optimize friction and performance, and they explore potential STEM-related careers in areas such as sports science, materials engineering, and technology development. Overall, the integration of Physical Education and Physics enhances students' understanding of physical laws by situating learning within meaningful physical experiences, while simultaneously promoting scientific reasoning, problem-solving, collaboration, and innovation.

The interdisciplinary activities are designed to support the embodiment of scientific concepts through physically active and gamified learning experiences. Gamification, defined as the use of game elements in non-game educational contexts, is increasingly recognized as an effective pedagogical approach for enhancing student motivation, engagement, and participation in learning. Commonly used game elements include points, badges, levels, leaderboards, challenges, progress indicators, and avatars, which are strategically embedded within the learning activities.

Within this framework, students explore different sports branches and investigate scientific principles—particularly friction—through interactive, collaborative, and game-based tasks. Gamified learning environments allow learners to engage with complex physics concepts in an accessible and enjoyable manner, promoting experimentation, creativity, and discovery. By examining friction as both an advantage and a limitation in sports performance, students develop a deeper understanding of how physics knowledge applies to real-world contexts such as sports technology, materials design, and performance optimization.

In addition to supporting conceptual learning, gamified activities encourage students to adopt active roles in problem-solving and design. Learners are prompted to consider how scientific knowledge can inform innovation and practical solutions, fostering awareness of potential STEM-related and entrepreneurial pathways connected to sports science and engineering.

2.3. **Physical Education and Biology.** On Figure 6 is given integration of biological concepts in Physical Education through body systems exploration, physiological responses to exercise, and digital visualization tools. The figure presents key human body systems and an augmented reality–based anatomical visualization, supporting the understanding of biological structures and their role in movement and physical activity. The interdisciplinary activities integrating

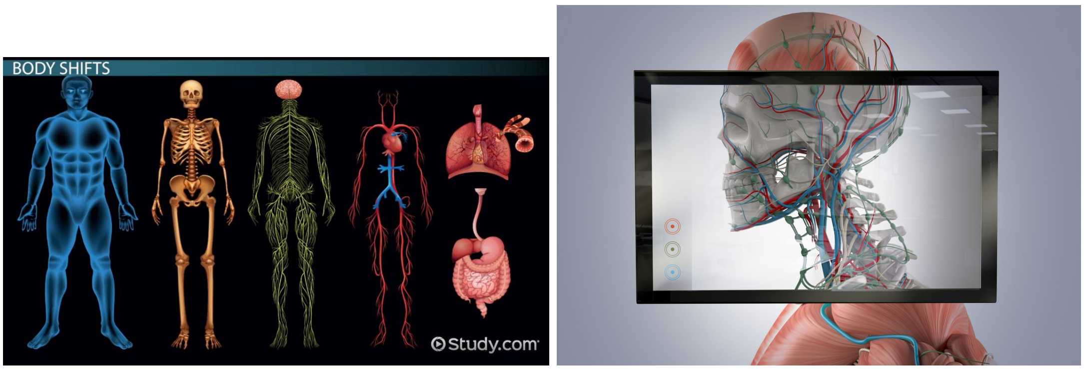


FIGURE 6. Visualization of Human Body Systems through Digital and Augmented Reality Tools.

Physical Education and Biology focus on understanding the human body in movement, emphasizing the relationship between physical activity, physiological processes, and healthy lifestyle habits. Physical Education provides an experiential context in which biological concepts related to anatomy, physiology, and nutrition become observable and meaningful through direct bodily engagement.

Central biological topics addressed within these activities include the structure and function of the human body, cardiovascular and respiratory responses to physical activity, and the role of nutrition in health and performance. Through movement-based tasks, students explore how the body reacts to exercise by measuring indicators such as heart rate and pulse before, during, and after physical activity. These experiences support students' understanding of why movement is essential for bodily function and overall well-being.

The activities combine physical practice with digital and interactive learning tools. Students work in mixed teams to create physical activity diaries, body atlases using interactive applications, and visual representations of body systems. Augmented reality applications are introduced to support the exploration of anatomical structures, allowing learners to visualize organs and systems in three-dimensional and interactive ways. This approach bridges students' familiarity with digital environments and the study of biological processes, enhancing motivation and engagement.

In addition, the interdisciplinary design incorporates creative and gamified elements, such as quizzes, cartoons, and collaborative challenges related to nutrition and healthy lifestyles. By designing visual materials and presenting their work to peers, students develop communication skills while reinforcing their biological knowledge. Nutrition-related activities encourage learners to reflect on daily habits, energy balance, and the long-term effects of dietary choices on health and physical performance.

Overall, these interdisciplinary activities support a holistic approach to learning, addressing cognitive, affective, and psychomotor development simultaneously. By linking biological concepts to physical experience and real-life contexts, the integration of Physical Education and Biology promotes health literacy, active participation, and lifelong awareness of the importance of movement and healthy living.

2.4. **Physical Education and ICT.** The interdisciplinary activities integrating Physical Education and Information and Communication Technologies (ICT) focus on developing computational thinking, digital literacy, and problem-solving skills through physically active and game-based learning environments. By combining movement with coding-related tasks, these activities aim to make abstract ICT concepts accessible, engaging, and meaningful for students.

A central component of this integration is the use of coding through games and movement, including both digital and unplugged approaches. Coding without a computer allows students to understand fundamental concepts such as sequencing, algorithms, instructions, and logical thinking through physical activity stations and team-based challenges. At Figure 7 are presented unplugged coding activities in Physical Education, illustrating algorithmic thinking through movement and sequencing tasks.

FIGURE 7. Unplugged Coding Activities.

These activities support embodied learning by enabling students to experience computational logic through action, collaboration, and decision-making.

Digital environments, particularly Minecraft Education, are used to extend learning by connecting virtual design with physical activity. Students work in mixed teams to design scenarios, movement tracks, and game-based challenges that combine physical tasks with digital planning and execution. Through this process, learners develop creativity, spatial reasoning, and teamwork skills while gaining experience in basic coding and game design principles. At Figure 8 is shown use of Minecraft Education to design and plan movement-based activities, integrating digital creativity with Physical Education.

The interdisciplinary model also emphasizes digital safety and responsible technology use. Workshops on e-safety, information security, and the evaluation of online content are integrated into the activities, helping students develop critical awareness of digital environments. Teachers and students engage in parallel learning sessions, ensuring that safe and effective ICT practices are applied both in the classroom and in daily life.


FIGURE 8. Minecraft Education.

Overall, the integration of Physical Education and ICT promotes 21st-century competencies by linking physical activity with digital skills development. Through gamification, collaborative design, and active participation, students experience learning as an interactive and meaningful process, while teachers gain practical strategies for implementing interdisciplinary, technology-enhanced Physical Education.

## CONCLUSION

This paper presented an interdisciplinary model that positions Physical Education as an active and meaningful context for integrating STEAM disciplines, including mathematics, physics, biology, and information and communication technologies. By treating movement as a source of data, experience, and reflection, the model demonstrates how abstract academic concepts can be transformed into observable and engaging learning experiences.

Across the four interdisciplinary domains, the proposed approach emphasizes embodied learning, gamification, and technology-enhanced instruction. Mathematical reasoning is grounded in measurement, ratios, and data analysis; physics concepts are explored through motion, force, and friction; biological knowledge is developed through the study of body systems, physiological responses, and nutrition; and ICT competencies are fostered through coding, digital design, and safe technology use. In all cases, Physical Education functions not as a supplementary subject but as an equal partner that supports cognitive, affective, and psychomotor development.

The model also highlights the value of student-centered and collaborative learning environments. Through problem-based tasks, creative design activities, and reflective practices, students are encouraged to connect learning with real-life contexts, develop transversal competencies, and increase motivation and engagement. At the same time, the approach provides teachers with practical strategies for interdisciplinary planning and the meaningful use of digital tools in contemporary education.

Overall, the proposed interdisciplinary model contributes to ongoing discussions on STEAM education by illustrating how Physical Education can serve as a powerful platform for holistic and inclusive learning. Future research may focus on systematic evaluation of learning outcomes, long-term impact on students' attitudes toward STEAM subjects, and the adaptability of the model across different educational levels and contexts.

## Acknowledgment

The authors would like to acknowledge the PE–STEAM project for supporting the development and implementation of the interdisciplinary model presented in this study, which integrates Physical Education with STEAM disciplines. The project provided a collaborative framework that enabled innovative, student-centered, and technology-enhanced learning practices across partner institutions.

## References

[1] Youth Sport Trust Research: *Evidence Paper – The Link Between Physical Activity and Attainment in Children and Young People* , March 2022.

[2] P. Faella, S. Digennaro, A. Iannaccone: *Educational Practices in Motion: a Scoping Review of Embodied Learning Approaches in School*, Front. Educ., **10** (2025), https://doi.org/10.3389/feduc.2025.1568744.

[3] R. Liliana, V. Simões, and S. Franco: *"Active Mathematics"- A Classroom-Based Physical Active Learning Intervention in an Elementary School: An Experimental Pilot Study*, Education Sciences, **14**(6) 637 (2024), https://doi.org/10.3390/educsci14060637.

[4] N.S. Wood, S. B. Cooper, K. J. Dring, Karah J. Dring, D. Magistro, R. Boat: *Examining a Teacher-led Physically Active Mathematics Intervention: Teachers' Perceptions of the Facilitators and Barriers to Implementation in UK Primary Schools*, Front. Educ., **10** (2025), https://doi.org/10.3389/feduc.2025.1569479.

[5] M. G. Nugraha, G. Kidman, H. Tan: *Interdisciplinary STEM Education Foundational Concepts: Implementation for Knowledge Creation* , EURASIA Journal of Mathematics, Science and Technology Education, **20**(10) (2024), https://doi.org/10.29333/ejmste/15471.

[6] A M. IGNJATOVIĆ, Ž. M. MARKOVIĆ, B. D. MILORADOVIĆ: *The Role of Physical Education in STEAM Learning* , STEM/ STEAM/ STREAM Approach in Theory and Practice of Contemporary Education, (2025) pp.341–351, DOI: 10.46793/STREAM25.341I.

[7] E. J. SLATTERY, D. BUTLER, K. MARSHALL, M. BARRETT, N. HYLAND, M. O'LEARY, L. P. MCAVINUE: *Effectiveness of a Minecraft Education Intervention for Improving Spatial Thinking in Primary School Children: A Mixed Methods Two-Level Cluster Randomised Trial*, Learning and Instruction, **94** (2024),102003, ISSN 0959-4752, https://doi.org/10.1016/j.learninstruc.2024.102003.

[8] E. J. SLATTERY, P. LEHANE, D. BUTLER, M. O'LEARY, K. MARSHALL: *Assessing the benefits of digital game- based learning with Minecraft in children, adolescents and young adults: A broad systematic review*, Review of Education, (2025), https://doi.org/10.1002/rev3.70035.

[9] E. NORRIS, N. SHELTON, S. DUNSMUIR, O. DUKE-WILLIAMS, E. STAMATAKIS: *Physically Active Lessons as Physical Activity and Educational Interventions: A Systematic Review of Methods and Results*, Preventive Medicine, **72** (2015), pp.116–125, https://doi.org/10.1016/j.ypmed.2014.12.027.

[10] A.J. DALY-SMITH, S. ZWOLINSKY , J. MCKENNA, P.D. TOMPOROWSKI, M.A. DEFEYTER, A. MANLEY: *Systematic Review of Acute Physically Active Learning and Classroom Movement Breaks on Children's Physical Activity, Cognition, Academic Performance and Classroom Behaviour: Understanding Critical Design Features*, BMJ Open Sport Exerc Med., **4**(1) (2018) :e000341. doi: 10.1136/bmjsem-2018-000341. PMID: 29629186; PMCID: PMC5884342.

[11] J. WAY, P. GINNS: *Embodied Learning in Early Mathematics Education: Translating Research into Principles to Inform Teaching*, Education Sciences, **14**(7):696 (2024). https://doi.org/10.3390/educsci14070696

[12] T. STOCKEL, R. GRIMM: *Psychophysiological Benefits of Real-Time Heart Rate Feedback in Physical Education*, Front. Psychol., **12**(2021).

[13] K. VOURLIAS, F. SEROGLOU: *Physics and sports: Let's get out of the classroom!*, AIP Conf. Proc. 1722, 310006 (2016) https://doi.org/10.1063/1.4944316.

DEPARTMENT OF MATHEMATICS AND STATISTICS
FACULTY OF COMPUTER SCIENCE, GOCE DELCEV UNIVERSITY
KRSTE MISIRKOV 10-A, STIP,
NORTH MACEDONIA.
*Email address*: limonka.lazarova@ugd.edu.mk

EDUCATION SCIENCE AND YOUTH ASSOCIATION-DENGE
ULAMIŞ NEIGHBORHOOD, 1419 STREET, NO. 3/2, SEFERIHISAR, İZMIR,
TURKEY.
*Email address*: info@dengegenclik.com