

STEM Education in the context of Physical Education in Bulgaria

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Abstract:

This study explores the possibilities for integrating Science, Technology, Engineering, and Mathematics (STEM) education into physical education within Bulgarian schools. As an innovative educational approach, STEM extends beyond the boundaries of traditional teaching models. By combining science, technology, engineering, and mathematics, this approach offers new opportunities to foster students’ critical thinking, analytical skills, and motivation. Additionally, STEM education supports the development of competencies such as creativity and teamwork. While traditional education primarily prepares students for examinations, innovative education also emphasises preparation for real-life challenges and future professional contexts. **Methods:** The study analyses the pedagogical aspects of the implementation of this innovative approach in physical education classes through sports games, the use of digital technologies, and project-based activities. In the context of modern education, the role of physical education in schools has evolved beyond simple physical training to a multifaceted tool for shaping the overall development of children. Data were collected through surveys and observations in experimental and control groups, assessing motivation, understanding of the relationship between science and sports, as well as the effectiveness of the methods used. **Results:** The results show that the integration of this innovative educational approach leads to increased student engagement and interest, as well as improved awareness of the importance of physical activity and a healthy lifestyle. **Conclusions:** Planning, organising, and conducting Science, Technology, Engineering, and Mathematics (STEM) activities and interdisciplinary lessons in general requires adequate time, additional resources, and substantial support from educational institutions, as well as from the Ministry of Education and Science in the country.

Keywords: physical activity, sport, motivation, education, technologies

Introduction

STEM education as an interdisciplinary paradigm is established as a key model for modern education, aimed at developing critical thinking skills, problem-solving skills, and applying knowledge in real-world situations. In an international context, STEM is seen as a means of bridging the gap between theory and practice, with an emphasis on project-based learning and the use of technology in the classroom. Numerous studies from various scientific fields – including engineering and economics - emphasise that STEM education is at the heart of innovation and progress. Some authors, such as Sulai, M. and Sulai, E. (2021), state that education in the fields of science, technology, engineering, and mathematics is an “engine of national development”. They perceive STEM as a tool that aims to increase not only the standard of living of people but also the economic development of each nation. The two authors consider education in each of the STEM fields a tool for national development. In terms of science, they reveal that one of the goals of science education is to create a more scientifically literate citizenry and to develop a workforce that is responsive to global advances in science and technology (Sulai, M. & Sulai, E., 2021).

Global changes coincide with the arrival of a new generation of learners, which in turn places key demands on education systems. The need for the implementation of innovative approaches, including STEM, is increasing, combining technology, creativity, and practical learning, and leading to the development of the necessary knowledge and skills in adolescents to cope with the challenges of modern life (Galabova, D., 2020). This need is becoming increasingly relevant, as each subsequent generation is distinguished by a number of characteristics compared to the preceding one. For example, children born between 2010 and 2024 belong to the generation called “Alpha” - the first generation born entirely in the twenty-first century (McCrindle, M., 2021). It grows up in this dynamic and developing world, surrounded by technologies that are not just tools or accessories for them but are part of their way of life. According to M. Kaleynska, the “Alpha” generation “is strongly influenced by technology”. Their daily lives are highly dependent on technological devices. This affects not only the social aspects of their lives but also the way they learn, which is why traditional education is losing its influence over them. The education of the “Alpha” generation requires the implementation of modern teaching and learning methods. It is characteristic of this generation that attention span, interest, and engagement are shorter. In this context, M. Kaleynska notes that children “are used to and expect strong stimuli in every

environment of their lives”. Using only traditional methods and means of education is not suitable for retaining their attention during the learning process (Kaleynska, M., 2023).

According to modern research, from 2025 a new generational group will emerge - the “Beta” generation. These are children born after 01 January 2025. Australian demographer M. McCrindle highlights some of the key characteristics that will define this generation. It is assumed that while the “Alpha” generation was born and grew up in a world characterised by the continuous emergence of new technological innovations and devices, as well as the introduction of artificial intelligence (AI), the next generation, “Beta”, will grow and develop “in an era in which artificial intelligence and automation are fully embedded in everyday life - from education and workplaces to healthcare and entertainment” (McCrindle, M., 2025).

The characteristics of these generations require that approaches to upbringing and training change. Representatives of these two generations are, and will be, witnessing increasingly profound digitalisation. Using only traditional methods, approaches, and tools is not sufficient. The technical and social changes we are witnessing today, together with the characteristics accompanying the generational groups “Alpha” and “Beta”, predetermine the approaches, methods, and means of teaching to be up to date. As M. Aleksieva states, “learning and education are becoming more dependent on situations” (Aleksieva, M., 2015).

The modern educational paradigm worldwide strives for the full development of the personal potential of learners. The general goal is to provide high-quality, inclusive, and value-oriented education. With the introduction of STEM into education, it is expected that it will improve to a degree that meets the requirements of the new generation and the needs of modern society.

The integration of the STEM approach is an expression of the desire to incorporate technologies, innovation, and interdisciplinary thinking in education, through which the new generation is prepared for the realities of the twenty-first century. In this context, education today has an extremely important mission – to form and develop the skills in each subsequent generation necessary for a full life, professional realisation, and active participation in the dynamic social and technological environment (Dimitrova, D. S., & Penkova, 2025). Against the backdrop of transforming educational needs and the entry of new generations of learners, STEM is being established as a strategic response to the challenges of the twenty-first century. Therefore, the main trends in its development should be outlined, both in the global and Bulgarian contexts.

The UNESCO report states that STEM education strives to develop and provide innovative solutions to global problems, especially those directly related to the Sustainable Development Goals by 2030, which are strategic guidelines that contribute to the prosperity of people and the planet, as well as to universal peace among all societies (UNESCO, 2019, p. 3). STEM education in Bulgaria is developing rapidly, and interest in it is growing. The need for personnel with acquired STEM skills in the sectors of science, green environmental technologies, information technology, and engineering is also increasing. In this sense, V. Tsvetanova, M. Terziyski, and M. Mladenova point out that “promoting the interest, skills, and careers of young Bulgarians in science, engineering, and technology is a response to global trends for change and the adaptation of education and vocational training” (Tsvetanova, V., Terziyski, M., & Mladenova, M., 2023). Moreover, recently there has been increasing active participation of students in various forums where they present their developments as a result of their STEM training. In addition, publication activity is also increasing, with good practices and achieved results in this area being shared and described. Therefore, STEM education is emerging as a key element, as it goes beyond the framework of traditional education. It encourages the active participation of all stakeholders in the learning process.

Students’ interests and motivation are stimulated, and a number of opportunities are provided for sharing and promoting the results of training, not only within scientific forums but also through the publication of good practices and achieved results in specialised scientific journals, most often by active STEM teachers (English, L., 2016).

In support of these processes, in 2015 the first specialised journal for science and education in the field of STEM was published in Bulgaria - STEM in Bulgaria, Europe and the World. It describes similar good practices by teachers and other specialists, as well as scientific achievements and innovations in the areas covered by the STEM abbreviation. In 2018, Bulgaria joined the European STEM Coalition, which is a network of national STEM platforms and organisations whose role is to monitor the implementation of national strategies in this direction. This network covers the entire European Union (European Commission, 2025). Its aim is to improve STEM education in the Member States by shaping policies and practices to promote “economic growth, opportunities, and well-being for all”.

Bulgarian context and challenges

Bulgarian pedagogical literature emphasises that STEM is not just a set of disciplines but an integrative approach that stimulates creativity and analytical thinking (Todorova, M., 2021). In Bulgaria, in recent years, STEM centres have been established and scientific research has been published focusing on innovations in education. The *STEM Education, Innovation and Knowledge Journal* (EduTechFlag) is the first specialised publication that systematises good practices and theoretical models (Miteva-Belcheva, I., & Zhelyazkova, M., 2022). The European Union finances a number of projects in the Member States, including Bulgaria, with the aim of promoting STEM education. Some of these investments are aimed at transforming the educational infrastructure, others at enhancing teaching capacity, and still others at stimulating students’ motivation to study

science, technology, engineering, and mathematics. These investments are of great importance. As L. Popova points out, “One of the main tasks of a modern school is to create a favourable educational environment that enhances interest and motivates students’ desire to learn. If motivation characterises the process in which the student chooses the direction of their behaviour and activity, then it also characterises the actions of the teacher, which are aimed at the adolescent so that they can choose behaviour that meets the goals of education” (Popova, L., 2024).

Modern research in Bulgaria shows that physical education has the potential to become a field for the integration of innovations and technologies. Ilieva, I. (2023), notes that physical education is an “integrative field, the development of which is a continuous process”, which opens up opportunities for the inclusion of STEM elements – measurement of physical activity, data analysis, and the use of digital tools.

However, challenges remain - a lack of sufficiently trained teachers, limited resources, and the uneven distribution of technologies between schools (Center of Excellence in Education, 2023). It is also important to note the need for a scientifically based analysis of the theoretical and methodological foundations of physical education and sport as a structural factor in increasing the effectiveness of pedagogical interaction (Logan, W., et al., 2018). In addition to the fundamental statements regarding the methodological foundations of physical education and sport, modern pedagogical trends arising from current concepts for training adolescents through sports preparatory activities must also be taken into account (Lee, D., & Schmidt, A., 2025).

The theoretical framework shows that STEM and physical education have a natural intersection: both develop teamwork skills, critical thinking, and the practical application of knowledge. The inclusion of STEM in sports games not only modernises physical education but also turns it into a field for interdisciplinary learning that meets modern educational standards. The concept of “blended learning”, popularised by Horn, B., and Staker, H. (2015), offers a model for combining face-to-face activity and digital support. In physical education, this means integrating video analysis (Ryde, C., & Pearce, G., 2017), wearables, and interactive applications.

Materials & methods

The study analyses the pedagogical aspects of implementing innovative learning in physical education classes through the use of digital technologies and project-based activities. *The main objective* of this study is to outline the actual opinions of current teachers and students regarding the integration of STEM in Bulgarian education.

The tasks include:

To review specialised sources related to STEM as an educational paradigm in both international and national contexts.

To identify the challenges facing teachers in implementing STEM methods.

To present the results of an empirical study based on a survey among teachers and students and to conduct a comparative analysis of their opinions.

As part of the study, a survey was conducted among current teachers and students. Below is a short fragment of the results, illustrating some of the respondents’ opinions on essential issues regarding STEM in education.

The survey among teachers and students was conducted online via the Google Forms platform. A total of 31 current teachers from different schools in the country and 134 students aged 14 - 15 from the cities of Veliko Tarnovo and Gorna Oryahovitsa participated. Two groups were formed - experimental and control. The control group followed a traditional physical education programme, while the experimental group followed a specialised programme involving wearable devices and structured observation. Quantitative data show that students participating in STEM-integrated physical education lessons demonstrate higher motivation and engagement compared to the control group. This confirms the hypothesis that the inclusion of technology and scientific metrics in sports games increases interest in physical activity. Qualitative data (quotes from students and teachers) complement the findings, emphasising the connection between science and sport and indicating specific benefits - better understanding of physiological processes and greater enjoyment of the activities.

Instruments: Surveys, short interviews, and device-generated data.

Physical Education as an Integrative Field - Traditional Goals and New Technologies

Research Emphasis:

Integrating STEM and physical education.

Using digital devices (smart bracelets, applications) to track activity.

Project-based learning: students develop their own mini-projects related to health and sport.

Pedagogical aspects:

How physical education teachers can be trained to use STEM methods.

Impact on student motivation and interest.

Opportunities and challenges for schools – funding, equipment, and staff training.

The role of the National STEM Center and teacher programmes.

The connection between STEM and Physical Education

Physical education is traditionally associated with the development of motor skills, discipline, and social competences. The inclusion of STEM can add the measurement of technological literacy and scientific thinking

to these activities. The STEM approach encourages experimentation, critical thinking, and the practical application of knowledge. In the context of physical education, this may involve the use of technologies to measure physical activity, as well as the development of projects related to a healthy lifestyle.

Modern educational policies emphasise interdisciplinary learning and the formation of key competences through the integration of scientific and practical activities. The STEM approach is seen as a means of developing analytical thinking, problem-solving, and research skills.

The integration of STEM into sports games allows students to understand the connection between movement and science (Wright, M., & Bell, J., 2018). For example, in basketball, the trajectory of the ball can be analysed through geometry and physics; in football, speed and pulse can be measured through technology; in volleyball, jump height can be examined through engineering principles. Thus, sport becomes a laboratory for experimentation, where students not only train but also explore. Miteva-Belcheva, I., and Zhelyazkova, M. (2022) emphasise that STEM in the early stages of learning is especially effective when it is associated with practical activities and game elements.

Results

The majority of the surveyed teachers (51%) indicated that they work in a secondary school and are well versed in STEM. Of these, 42% believe that STEM can be integrated into physical education classes.

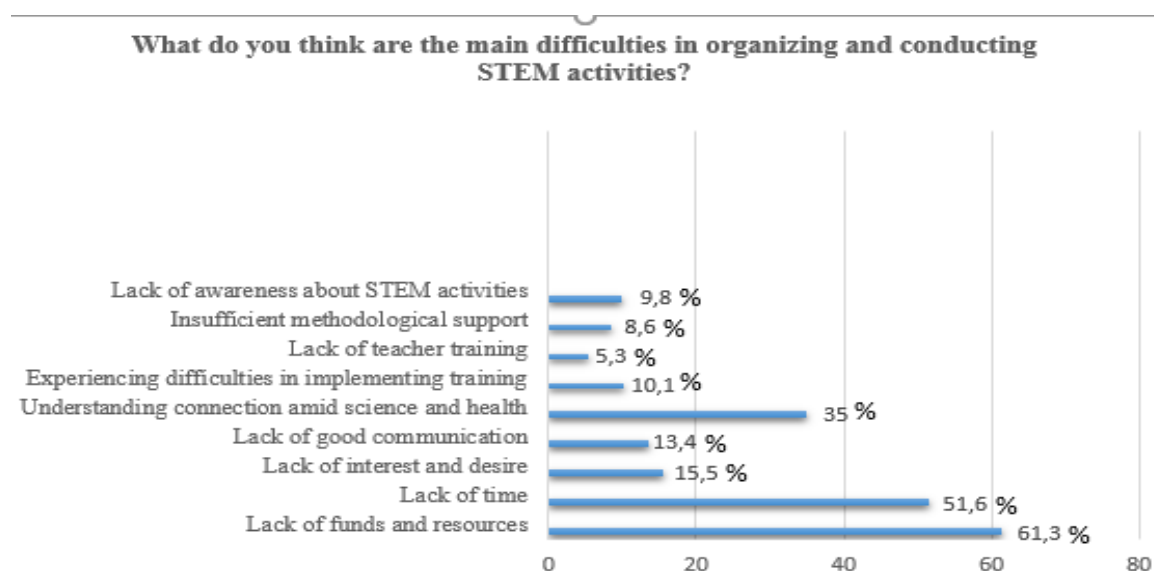


Figure 1. Responses of current teachers

Figure 1 clearly shows that only 5.3% believe that the main difficulties in implementing STEM methods in physical education are the lack of training, and 15.5% cite a lack of interest and motivation. When asked what benefits they see from the integration of STEM in sport, 35% believe that it leads to a better understanding of the relationship between science and health. Although a significant proportion of the surveyed teachers and students state that they have good awareness of STEM activities, the results of the study also reveal a number of practical difficulties that, in their opinion, could hinder implementation in the school environment. The most frequently cited difficulties by respondents in both research groups are related to a lack of time (51.6%) and limited resources and insufficient methodological support (61.3%). Quotes from physical education teachers: “Students are more engaged when we use applications to measure heart rate and speed.”; “The main challenge is the lack of sufficient resources and training in methods.”; “The use of technology in physical education classes has increased students’ interest.”

Regardless of the outlined difficulties, the results of the survey reveal attitudes oriented towards the future development and improvement of STEM in education. In this context, one of the final questions in the survey is: “What do you think is the future of STEM education in Bulgaria?” This question aims to explore respondents’ opinions about the future prospects of STEM in the Bulgarian educational context. The analysis seeks common themes in the respondents’ answers. For greater clarity, the opinions of both groups - current teachers and students - are presented in Table 1.

As can be seen from Table 1, the respondents’ opinions outline a predominantly positive attitude towards the future of STEM education in Bulgaria. Despite the difficulties mentioned, the participants in the study associate this approach with student motivation, the development of key skills, and the needs of the labour market.

Table 1. General Opinions of Respondents

Respondent group	General attitudes	Specific emphases
Acting teachers	STEM has a future because children themselves will realize that they need practical skills, not dry theory.	STEM approach and education will have a future when curricula change
Students	More and more teachers need to get involved in this way of teaching because this is the future.	Investments in staff, methodology, and equal access are needed to make STEM a sustainable part of the education system

The specific emphases vary according to the professional experience and the role of the respondents in the education system; nevertheless, common expectations for wider implementation, institutional support, and the need for further qualification stand out. Some respondents express scepticism related to organisational challenges, which emphasises the need for targeted efforts towards the sustainable development of better organised STEM practices.

All results are visualised in the following figures, which clearly show the distribution of responses and their proportions according to percentage distribution

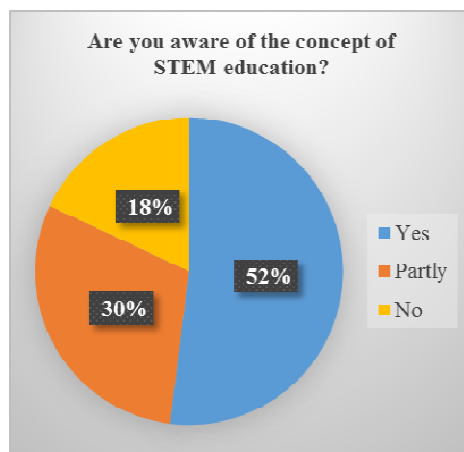


Figure 2. Student Responses to the Concept of STEM Education

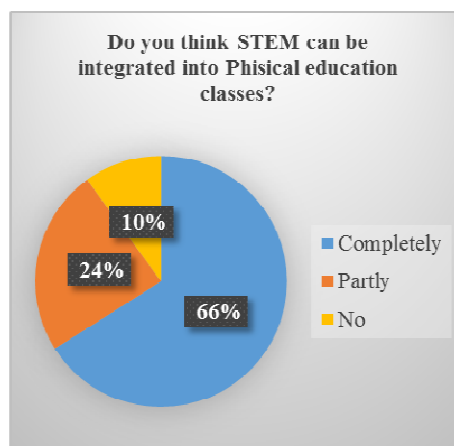


Figure 3. Student Responses to the Possibility of Integrating STEM into Physical Education

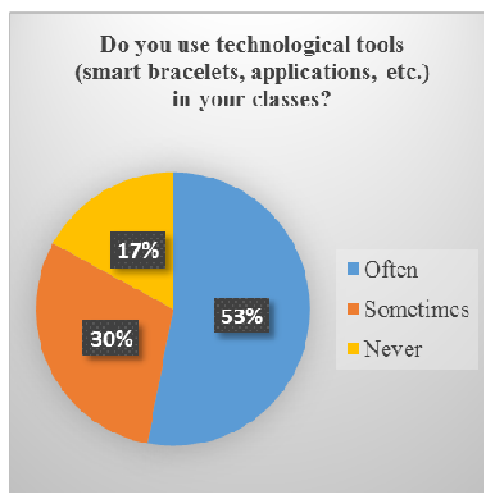


Figure 4. Student Responses Regarding Technological Tools

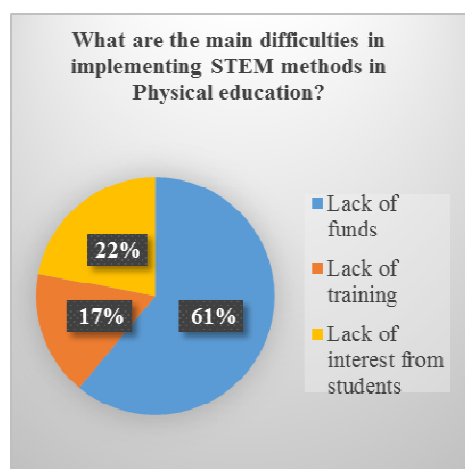


Figure 5. Student Responses Regarding the Difficulties in Implementing STEM

In Figure 4, when asked whether they use technological tools in physical education classes, 53% of students answered that they often use them, 30% stated that they sometimes use them, and 17% reported that they never use them.

Among the students in Figure 5, the overwhelming majority (61%) declare that the main difficulties in implementing STEM are a lack of funds and resources; 17% state that there is a lack of training, while 22% indicate that they have no interest in STEM methods in physical education.

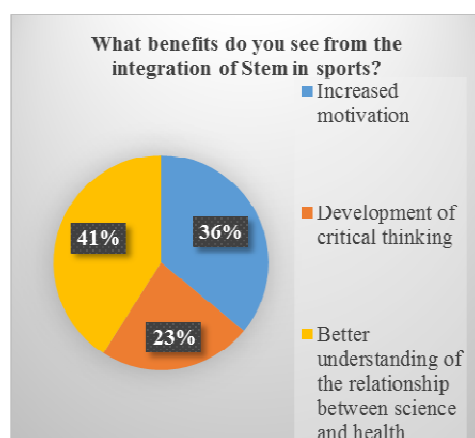


Figure 6. Student Responses on the Benefits of STEM Integration

Regarding the benefits that students see from STEM integration (Figure 6), 41% report a better understanding of the connections between science and health, 36% state that they associate STEM integration with increased motivation, and 23% believe that STEM contributes to the development of critical thinking.

The following thematic highlights emerge from this study:

How can more teachers be motivated to engage in STEM initiatives, especially those with longer teaching experience?

What opportunities exist for integrating STEM into curricula in a way that meets the needs of the labour market?

What risks and difficulties are observed in the organisation of STEM lessons, and how can they be overcome?

What are the prospects for cooperation between schools and universities in the context of STEM education?

As can be seen from Table 2, the results show higher average motivation in the STEM group ($M = 4.3$, $SD = 0.6$, $n = 66$) compared to the control group ($M = 3.6$, $SD = 0.8$, $n = 68$).

Table 2. Mean Motivation Values (Scale 1–5)

Group	Mean	Standard Deviation	Number Of Participants
STEM group	4.3	0.6	66
Control group	3.6	0.8	68

The boxplot is illustrative, as it is based on summary statistics. It is constructed using distributions that correspond to the mean value, the standard deviation, the number of participants, and the 1 - 5 scale.

The scale ranges from 1 to 5, consistent with the measurement instrument, and is visualised using a bar chart.

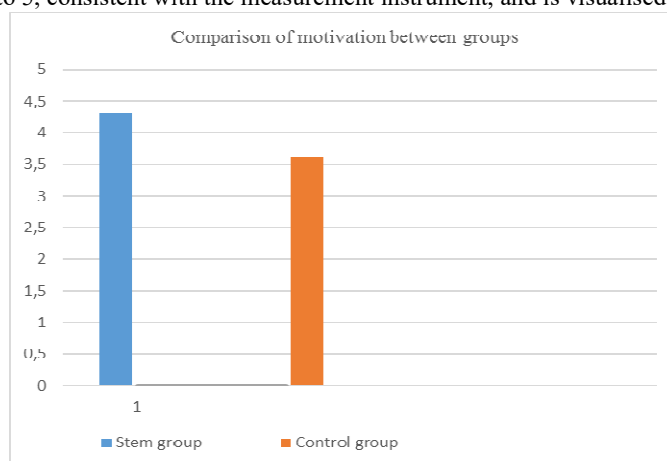


Figure 7. Comparison of Motivation between the STEM Group and the Control Group

In Figure 7, it is evident that the STEM group has a higher mean motivation ($M = 4.3$), while the control group has a lower mean motivation ($M = 3.6$).

In Table 3, different criteria for evaluating STEM sports lessons can be observed.

Table 3. Criteria for Evaluating STEM Sports Lessons

Criterion	Excellent (5)	Very Good (4)	Good (3)	Satisfactory (2)	Poor (1)
Participation and Engagement	Active participation throughout the lesson, enthusiasm and initiative	Participates actively, but with minor hesitations	Participates but not always motivated	Partial participation, passivity	Lack of participation
Data Accuracy	All measurements and records are accurate and complete	Minor inaccuracies, but data is usable	Some errors, requires correction	Data are incomplete or inaccurate	Lack of data
Analysis and Interpretation	Excellent analysis, clear conclusions, connection to STEM concepts	Good analysis, logical conclusions	Basic analysis, partly related to STEM concepts	Limited analysis, interpretation difficulties	Lack of analysis
Teamwork	Excellent collaboration, role allocation, respect	Good collaboration, minor difficulties	Participates in team but weak interaction	Limited cooperation	Lack of teamwork
Creativity and Innovation	Proposes new ideas, uses technology in an original way	Good ideas, uses available resources	Limited creativity	Minimal creativity	Lack of ideas

Discussion

In the context of the outlined theoretical foundations, positive trends, and the opinions of the respondents, a number of questions arise that can serve as a basis for future research and professional discussions aimed at the sustainable development of STEM education in Bulgaria.

Possible research questions:

What are the attitudes of physical education teachers towards integrating STEM methods into their lessons?

Does the STEM approach influence students' motivation to participate actively in sports activities?

What technologies and digital tools are currently used in physical education classes in Bulgaria?

What are the main challenges for teachers in implementing STEM in this field?

Does STEM education improve students' understanding of the relationship between science, health, and physical activity?

The results are in line with the findings of Todorova, S. (2023), who emphasises that STEM stimulates critical thinking and the application of knowledge in real-world situations. They are also supported by Ilieva (2023), who views physical education as an integrative field open to innovation and technology. The observations in the present study also confirm the thesis of Miteva-Belcheva and Zhelyazkova (2022) that STEM is particularly effective when combined with practical activities and game elements.

Teacher training: Targeted training of physical education teachers to work with STEM methods is needed.

Resources: Providing access to portable devices, applications, and digital tools.

Integration: Incorporating STEM elements into sports games as part of the curriculum.

Sustainability: Developing national programmes for STEM in physical education, supported by scientific publications and good practices.

Closing remarks: The discussion shows that STEM integration in physical education not only increases student motivation but also creates new opportunities for interdisciplinary learning. This represents a step towards modernising the education system in Bulgaria and building competences that meet the needs of modern society.

Recommendations: Teacher training, access to technologies, and sustainable modules.

Conclusion

Modern society is faced with challenges that require individuals to be knowledgeable, capable, and skilled in dealing with different situations (Petrova, 2024). That is why Marcheva-Yoshovska points out that "it is an eloquent fact that education is a prerequisite for the economic and spiritual progress of our society" (Marcheva-Yoshovska & Nunev, 2025).

The present study demonstrates that the integration of STEM approaches into physical education has significant potential for the modernisation of the educational process in Bulgarian schools. Quantitative results show higher motivation and engagement among students participating in STEM lessons, while qualitative data highlight the connection between science and sport and increased awareness of the importance of physical activity. Clear directions are needed regarding the applicability of STEM in physical education and the opportunities for national expansion. The field of physical education and sport is integrative, and its development is a continuous process. The shared opinions outline the need for targeted support, methodological improvement, and the promotion of good practices to ensure the sustainable implementation of STEM in the Bulgarian education system. The comparison with the scientific literature confirms that STEM is not just a set of disciplines but an integrative model that stimulates critical thinking, creativity, and the practical application of knowledge (Peev, 2023).

The inclusion of STEM in sports games turns physical education into a field for experimentation and interdisciplinary learning that meets modern educational standards. Despite the positive results, the study also outlines challenges - limited resources, the need for targeted teacher training, and the uneven distribution of technologies. This suggests the need for strategic support at the national level, including the development of STEM programmes in physical education that ensure sustainability and equal access.

In conclusion, STEM integration in physical education not only increases students' motivation and interest but also contributes to the development of key competences necessary for successful participation in modern society.

Conflicts of interest

The author declares no conflicts of interest.

The author declares that no generative AI or AI-assisted technologies were used in the writing, editing, or preparation of this manuscript.

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