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INTEGRATING STEAM EDUCATION WITH SPORTS FOR INTERDISCIPLINARY LEARNING

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ABSTRACT. This paper presents a pilot study examining the development, implementation, and preliminary evaluation of the STEAM and Sports interdisciplinary curriculum, developed as part of a research initiative on integrated teaching methodologies that link Science, Technology, Engineering, Arts, and Mathematics (STEAM) with sports-based learning. The study addresses three research questions:

(1) Does the STEAM and Sports curriculum produce measurable learning gains compared to standard classroom instruction?
(2) Is the curriculum effective across diverse school contexts, student populations, and national educational systems?
(3) How do teachers and students perceive the curriculum in terms of clarity, engagement, and overall satisfaction?

The methodology provides educators with structured lesson plans, implementation frameworks, and assessment tools designed to make STEAM subjects more relevant, engaging, and accessible. Using a controlled pre-test/post-test design with matched pilot and control groups, the curriculum demonstrated promising preliminary effectiveness: pilot groups achieved average learning gains of 22.0 to 54.5 percentage points, reaching post-test performance of 87.6% to 99.3%, while control groups showed minimal gains of 3.9 to 14.5 percentage points.

Key words and phrases. STEAM education, interdisciplinary curriculum, inquiry-based learning, project-based learning, equity.
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1. Introduction

When students learn mathematics, science, and other subjects separately, they often struggle to see how these ideas connect to each other or to real life. Integrated learning addresses this problem by teaching multiple subjects together around a single topic or theme. Research shows that students understand ideas better and can apply what they learn in new situations when their classes show connections across subjects rather than treating each discipline on its own, see [1]. The reasoning is straightforward: in the real world, people don't solve problems using only math or only science. They draw on knowledge from multiple fields at once. When schools organize learning the same way, students develop deeper understanding and stronger problem-solving skills, [2].

The STEAM framework—combining Science, Technology, Engineering, Arts, and Mathematics—is one popular approach to integrated learning. STEAM education tries to address real problems in science and math classrooms: students are disengaged, participation rates are dropping, and fewer students pursue STEM careers. By connecting these five disciplines, educators hope to make learning more meaningful and interesting [3]. Yet many STEAM programs still feel abstract and disconnected from students' lives. That's where sports comes in. Sports are something most students care about and understand. Sports also provides a natural setting for applying scientific principles, mathematical thinking, and technological problem-solving. Students are motivated to learn when they see direct connections to activities they enjoy, and this motivation can lead to better academic outcomes and stronger interest in STEAM subjects [4].

Despite growing research on integrated and STEAM learning, we still know very little about whether these approaches actually work in different countries and with different groups of students. Most studies focus on single classrooms or single schools in one educational system. This pilot study fills that gap by testing a STEAM and sports curriculum across three different countries, providing evidence about whether this approach can travel across different educational contexts and cultures.

2. STEAM Education and Sports: A Framework for Integrated Learning

Sports provide an excellent setting for integrated STEAM learning because every aspect of sports touches every STEAM discipline. Science appears in the physics of movement—how bodies accelerate, jump, and throw—as well as in biology, where muscles, energy systems, and recovery all matter. Technology is everywhere in sports now: athletes wear sensors that track their heart rate and movement, coaches use video software to analyze performance, and GPS trackers show where players run on the field. Engineering is central to training methods, injury prevention, and the design of equipment and sports facilities. Arts shows up in the rhythm and balance of gymnastics and figure skating, in the creative strategies teams use, and in the visual design of uniforms and branding. Because sports are something most students already enjoy and understand, they provide a natural bridge for connecting STEAM concepts to students' own interests and experiences.

The STEAM and Sports curriculum rests on three teaching methods that research has shown to work well for student learning. These are not new ideas, but they have strong evidence behind them, and they work particularly well when combined with sports content.

Inquiry-Based Learning: Learning Through Questions and Experimentation. In inquiry-based learning, teachers start with real questions that students actually want to answer. Rather than the teacher explaining an idea and then having students practice problems, students are given a question and figure out how to answer it themselves. In a sports context, this might mean asking: "Why do soccer players put spin on the ball?" or "How does a pitcher throw a curveball?" Students make guesses about the answer, design tests to check their guesses, collect data, and then figure out what the data shows. The teacher becomes less of a lecturer and more of a guide who helps students think through their experiments [5]. This approach works because students care more about finding answers to questions they've asked themselves. It also makes science feel less like memorizing facts and more like actual problem-solving, which is what scientists really do.

Project-Based Learning: Solving Real Problems.

Project-based learning asks students to tackle substantial, real-world problems that require them to think hard and use knowledge from multiple subjects. Instead of solving textbook problems, students might be asked to design a better basketball shoe for playing on different court surfaces, or build a computer model to figure out the best angle for shooting a basketball. These are not simple tasks with one right answer—students have to make decisions, solve problems as they come up, and create something that actually works [6]. The value of this approach is that students see why they need to learn mathematics, science, and engineering: these tools help them solve a problem they care about. Working on a project also teaches students skills that matter in real life—teamwork, communication, and dealing with problems that don't have obvious solutions.

Technology-Enhanced Learning: Using Digital Tools.

Modern technology gives students powerful ways to see and measure things that would be hard to understand otherwise. A slow-motion video camera shows exactly how a tennis racket hits a ball or how a gymnast's body moves through space. Fitness trackers let students collect real data about their own heart rate, speed, and steps. Spreadsheet software helps students organize and analyze data. Virtual simulations let students test ideas without having to build something physical first. These tools matter because they let students interact with STEAM ideas in ways that are both engaging and rigorous—students aren't just watching videos passively, they're using these tools to answer their own questions and solve problems [7]. Technology also makes abstract ideas concrete: a student who struggles with graphing can see it come alive when they graph their own running data.

How These Three Approaches Work Together?

Used separately, each of these methods has value. But in the STEAM and Sports curriculum, they work together. A student might start with an inquiry question about sports performance, use technology to collect and analyze data, and then complete a project where they apply what they learned to design or optimize something. This combination keeps students engaged because they see how different pieces of learning connect to a larger purpose.

3. Designing Effective STEAM-Sports Lessons

The pedagogical approaches we've described—inquiry-based learning, project-based learning, and technology-enhanced learning—work well in theory, but teachers need a practical framework to actually put them into practice. This three-step framework is developed to help educators design lessons that combine STEAM with sports content in ways that fit their own classrooms and schools. The framework is flexible enough for different types of teachers: those who teach science or mathematics, those who teach physical education, and those who want to work across subjects. The framework helps teachers think through four key elements. First, it clarifies why combining STEAM with sports makes educational sense. Second, it gives teachers a clear, step-by-step process for designing their own lessons. Third, it shows examples of different activity types that teachers might use. Fourth, it provides ways to assess what students learned and to reflect on teaching effectiveness.

Rather than starting with activities and hoping learning happens, this framework asks teachers to start with clear learning goals. This ensures that every activity actually teaches something meaningful, rather than just being fun for its own sake.

Step 1: Define Learning Objectives.
Teachers begin by identifying one STEAM learning goal (in science, technology, engineering, arts, or mathematics) and one goal from physical education or health. The key is finding where these two goals naturally connect—where they genuinely belong together. For example, a teacher might choose:
(1) STEAM goal: Understanding how different surfaces create friction
(2) PE goal: Students improve their running speed and agility
The connection is real: athletes run differently on different surfaces because friction affects their speed. This isn't forced; it makes sense because friction actually matters in sports performance.

Step 2: Frame a Real-World Sports Challenge.
Once the teacher has identified what students should learn, the next step is to turn these learning goals into a question that real athletes, coaches, or sports engineers might actually ask. Instead of an abstract question like

"What is friction?", the question becomes: "How does running on grass, sand, or track affect sprinting speed?" This framing immediately makes the learning relevant. Students aren't learning about friction for a test; they're learning about it because they want to answer a question that matters.

Step 3: Choose an Appropriate Activity Type.
Finally, teachers select the format that works best for their students and classroom resources. Teachers have five main options:

(1) Physical Experiment: Students test their predictions using their own bodies or equipment. For example, they time themselves sprinting on different surfaces and record the results.
(2) Design and Engineering Task: Students design or build something—a better running shoe, a more efficient training program, or equipment that works in specific conditions.
(3) Nutrition and Health Task: Students investigate how diet, hydration, or recovery strategies affect sports performance.
(4) Sports Data and Strategy Analysis: Students collect and analyze real data—like tracking player movement in a game or analyzing shooting accuracy—to understand how strategy works.
(5) Simulation and Modelling: Students use computer software or virtual tools to test ideas without needing to build or physically perform everything.

This three-step process brings together the pedagogical approaches we described earlier. Step 1 (defining objectives) ensures that lessons are grounded in real inquiry—students will have a genuine question to investigate. Step 2 (framing a real-world challenge) creates the context for project-based learning—the challenge is something students actually care about solving. Step 3 (choosing an activity type) ensures that teachers match the task to what their students need and what resources they have available. Teachers can use this framework and create lessons that are structured, purposeful, and engaging—without needing to be expert instructional designers. Teachers working in different countries, with different resources, and with different student populations can adapt this framework to fit their own schools.

Assessing student learning in STEAM-sports lessons presents a challenge because students are developing different types of skills at the same time—they're learning to think like scientists and engineers, they're analyzing data, they're creating solutions, they're performing physical tasks, and they're thinking creatively. No single test can measure all of this. Teachers should use multiple assessment approaches that work together. During lessons, teachers can use quick checks to see if students understand key concepts as they're learning. Students can show what they've learned by creating products—like designing something, giving a presentation, or completing an analysis. Students should also reflect on their own thinking through reflection logs, where they think about what they learned and how they learned it. Peer review—where students give each other feedback—helps students think critically and communicate better. Finally, students can gather and analyze real sports data themselves, which shows that they understand both the science and the data skills. Alongside assessing students, teachers should regularly reflect on whether their lessons worked well, where students struggled, and what they might do differently next time. This kind of reflection helps teachers improve their teaching over time and develop stronger skills in blending STEAM with sports.

4. Pilot Testing and Results

To find out whether the STEAM and Sports approach actually works, we conducted a pilot test in three schools across three countries between October and December 2025. We used a careful research design that allowed us to compare what happened when students received the new curriculum with what happened when they didn't. We gave students tests before and after lessons, comparing students who participated in STEAM and Sports lessons (the pilot groups) with students who received regular instruction (the control groups). This comparison helps us understand whether the curriculum itself made the difference.

Three schools participated, each in a different country:

- Branko Radicevic School in Novi Sad, Serbia (October to December 2025)
- Primary School Bakar in Bakar, Croatia (November to December 2025)
- Jan Amos Komenski Schoolin Skopje, North Macedonia (November to December 2025)

In total, 362 students participated, ranging from grade 3 to grade 9 (ages 10 to 15). The student group was fairly balanced: 50.3%girls, 48.1% boys, and 1.6% who preferred not to state their gender. Eighteen teachers from different subject areas—including biology, chemistry, physics, mathematics, art, physical education, natural science, and language, taught the lessons. This diversity of teachers is important because it shows that teachers from different backgrounds could implement the curriculum. Each school taught four different lessons, selected to show different STEAM disciplines and to be appropriate for different grade levels. This helped us see whether the approach works across different types of content.

Next, we developed tests for each lesson that measured whether students understood the concepts and met the specific learning goals. Students took these tests right before the lesson started and right after it ended. Both pilot groups and control groups took the same tests. We also asked teachers to complete a questionnaire about their experience (12 teachers responded), and we asked all 362 students to complete a survey about what they thought of the lessons.

4.1. **Results.**

1. Branko Radicevic School, Serbia.
   At this school, 120 students in grades 3, 5, and 7 participated, taught by four experienced teachers. Before the lessons, students averaged 61.8% on the pre-test—not great, but not terrible. After the STEAM and Sports lessons, they averaged 99.3% on the post-test. That's an improvement of 37.5 percentage points. Three of the four lessons produced perfect or nearly perfect scores (100%, 100%, and97.2%), showing that students really mastered the material. The control group at the same school started at 61.8% (identical baseline) but only reached 76.2% after regular instruction—an improvement of just 14.5 percentage points. The difference between pilot and control groups was 23.1 percentage points, showing that the STEAM and Sports curriculum made a real difference.
2. Primary School Bakar, Croatia.
   This school had 120 students in grades 4˘8 taught by five teachers. The students started with very low baseline knowledge: only 33.1% on the pre-test. After the STEAM and Sports lessons, they jumped to 87.6%—an

improvement of 54.5 percentage points. This was the largest gain of the three schools. The control group at the same school barely improved: from 35.8% to 39.7%, a gain of only 3.9 percentage points. The difference between pilot and control groups was massive: 50.6 percentage points. All four lessons produced pilot group scores above 80%, with most reaching 90% or higher. This school's results show that the curriculum works especially well for students who start with lower knowledge.

3. Jan Amos Komenski School, North Macedonia.
   This school had 120 students in grades 4˘9 taught by nine teachers from nine different subjects. These students came in with stronger baseline knowledge: 73.7% on the pre-test. Even though they started higher, they still improved significantly. After the lessons, they reached 95.7%—an improvement of 22.0 percentage points. The control group improved from 70.3% to 76.3%, a gain of only 6.0 percentage points. The difference between pilot and control was 16.0 percentage points. This result is important because it shows the curriculum works even for students who already know quite a bit.

The summary across all three schools is given in the following table 1:

TABLE 1. Summary Across All Three Schools

School	Starting score	Ending score	Improvement
Branko Radicevic	61.8%	99.3%	+37.5
Bakar	33.1%	87.6%	+54.5
Jan Amos Komenski	73.7%	95.7%	+22

Control groups, by contrast, showed only modest improvements: from baseline scores of 35.8% to 70.3%, they reached post-test scores of 39.7% to 76.3%. The curriculum-control difference ranged from 16.0 to 50.6 percentage points across the three schools. These numbers tell a clear story: students who received the STEAM and Sports curriculum learned significantly more than students who received regular instruction.

The numbers from all three schools point in the same direction: students who learned through the STEAM and Sports curriculum made much larger gains than students who received regular instruction. This happened even though the three schools had different starting points—one had students with low baseline knowledge, one had students with moderate knowledge, and one had students with high baseline knowledge. Teachers from different subject areas could implement the curriculum successfully. And students weren't just learning—they were also enjoying themselves and wanting to do more of this kind of learning.

5. Conclusions

This project set out to answer three specific questions about combining STEAM education with sports. The evidence from three countries and 362 students provides clear answers to each one.

- Does the STEAM and Sports curriculum produce measurable learning gains compared to standard classroom instruction?

  Yes, definitively. Students who learned through STEAM and Sports lessons made dramatically larger gains than students in regular classes. Across all three schools, the curriculum consistently produced learning gains that were 16 to 50 percentage points larger than standard instruction. These aren't small differences; they represent substantial improvements in what students actually learned.
- Is the curriculum effective across diverse school contexts, student populations, and national educational systems?

  Yes, the curriculum works in different countries with different types of students. The three schools had very different starting points. Primary School Bakar had students with very low baseline knowledge (33.1%), Branko Radicevic had students with moderate knowledge (61.8%), and Jan Amos Komenski had students with stronger baseline knowledge (73.7%). Despite these differences, all three schools saw significant learning gains. The curriculum worked for students who started knowing very little and for students who already knew quite a bit. Teachers from different subject areas successfully implemented lessons. The three countries represent different educational systems and cultural contexts, yet the results were consistently strong. This tells us that the approach isn't tied to one particular school system or one type of student.

- How do teachers and students perceive the curriculum in terms of clarity, engagement, and overall satisfaction?**

  Teachers and students were overwhelmingly positive. When asked about clarity, 100% of teachers said the interdisciplinary connections were either very clear or mostly clear—no teacher reported serious difficulty in understanding how to implement the lessons. When asked about student engagement, 83% of teachers observed very high student motivation, particularly during hands-on and collaborative activities. On age-appropriateness, 92% of teachers said the lessons were either perfectly suited or slightly simple but still effective for their students. On the connection between STEAM and sports, 100% of teachers confirmed the lessons effectively connected physical activity with STEAM concepts.

Student feedback was even more positive. 96.4% of students reported enjoying the lessons—nearly universal satisfaction. 95.6% found the lessons clear and understandable. 94.5% confirmed they learned something new. When asked if they wanted more lessons like this, 79% said "Yes, definitely!" and another 18% said "Maybe, it depends." Students identified team work (48.1%), doing sports activities (29.8%), and learning STEAM content (19.6%) as their favorite parts. When students wrote comments, they expressed particular enthusiasm for hands-on activities, collaborative work, sports-based learning, video creation, outdoor activities, and interactive laboratory work.

What This Means?

The STEAM and Sports curriculum is not just theoretically sound—it works in practice. It produces measurable, substantial learning gains. It works across different countries, different school settings, and different student populations. And it does so in a way that teachers can implement successfully and that students genuinely enjoy. Teachers from different subject backgrounds can use the three-step framework to design effective lessons without needing to be experts in instructional design. That combination—strong learning outcomes, transferability across contexts, and positive reception from both teachers and students—demonstrates that STEAM-integrated sports education deserves serious consideration by schools.

Based on these findings, schools should consider adopting this approach, especially for students who are disengaged from traditional STEAM instruction. Teacher training programmes should teach the three-step framework for designing interdisciplinary lessons, as this structured approach clearly supports effective implementation. Because the curriculum worked across three different national educational systems, it should be suitable for adoption in other countries as well. Teachers requested more worksheet and project-based extensions, which should be developed to enhance the existing lessons.

Future research should examine whether learning gains persist over time and whether learning through STEAM and Sports changes how students feel about STEAM careers. Larger, more rigorous studies in additional countries would provide even stronger evidence. Understanding the most effective ways to train teachers to deliver these lessons would help schools implement the approach successfully at scale.

The STEAM and Sports curriculum has proven to be effective, practical, and well-received by both teachers and students. It answers the three central questions that drove this research with clear, evidence-based answers. That makes it a valuable resource for schools serious about strengthening their STEAM and physical education programmes.

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