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Teaching Science through Ballet: A Cross-Disciplinary Approach

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Abstract

Science education often faces the challenge of making material relevant and accessible to students from diverse cultural backgrounds. This paper explores innovative approaches to teaching scientific concepts through the integration of ballet as an art form and cultural expression, supplemented by modern technologies such as Artificial Intelligence (AI), Virtual Reality (VR), and Augmented Reality (AR).
Ballet performances are used to illustrate concepts from physics (gravity, balance, force), biology (human anatomy and physiology), and chemistry (materials and stage design). These concepts are further enriched with AI tools that enable motion analysis, force prediction, and personalized learning, as well as VR/AR applications that immerse students in interactive, three-dimensional ballet worlds, providing new perspectives for understanding scientific principles.
The study includes the development and implementation of interdisciplinary teaching modules that combine practical and theoretical activities related to ballet, with VR and AR used for scene simulations and AI as a motivator for exploration and creativity. Additionally, the research examines the historical and cultural dimensions of ballet performances, highlighting how they can be localized and contextualized in science education.
Preliminary results from the implementation show increased student engagement with science, improved understanding of abstract concepts, and enhanced creative thinking. The use of AI, VR, and AR not only complements the experience but also inspires students to explore contemporary scientific and technological issues, paving the way for their future in education. This research opens new perspectives for integrating art and science, emphasizing the role of cultural context and modern technologies in enriching the teaching and learning process.

Keywords: *Ballet, Science Education, Interdisciplinary Learning, Student Engagement*

1. Introduction

In modern education, teachers face the challenge of making scientific concepts understandable, relevant, and engaging for students. This is especially true for abstract topics, such as physics, biology, and chemistry, which often appear disconnected from students' everyday lives. The pursuit of innovative teaching methods that integrate science and art has emerged as a necessity for improving the educational process. One such approach is interdisciplinarity, which combines different fields to create a deeper connection between theory and practice. Ballet, as a dynamic form of art involving movement, emotion, and cultural expression, presents a unique opportunity to visualize scientific principles. This approach can enhance student motivation and offer new perspectives for understanding science. The research sets two key objectives: to increase student engagement by introducing art and dance into the learning process, and to improve understanding of scientific concepts by connecting science with real and practical examples from the arts. This study analyzes the effects of the interdisciplinary approach across various scientific disciplines. Particular attention is given to how innovative technologies, such as Artificial Intelligence (AI), Virtual Reality (VR), and Augmented Reality (AR), can complement this approach, enriching students' experiences. Additionally, the research suggests modules and topics that can be introduced in extracurricular activities to encourage further implementation of such innovative methods in schools. Improvisational dance offers unique research methodologies that not only resonate with scientific practice but also expand its boundaries. By employing collective improvisation, researchers have uncovered new insights into cognitive and creative behaviors as they emerge in real-time. This interdisciplinary approach has proven effective in demonstrating how movement and interaction reveal layers of meaning that often elude traditional methodologies [1]. A significant contribution of these practices is their ability to bridge the divide between the objective world and the subjective lived experiences of participants. Through dance, the false dichotomy between observer and observed is dissolved, enabling participants to co-create the world they inhabit. This participatory method challenges the conventional "god's-eye view" of science, replacing it with a more holistic and inclusive perspective [2]. Our collaborative work highlights the value of learning through immersion and practice. Cross-pollination between disciplines has allowed for the

refinement of shared knowledge frameworks and perspectives. By integrating artistic and pedagogical practices with scientific inquiry, this collaboration fostersthe emergence of new methodologies and paradigms, enriching the understanding of collective sense-making and intersubjectivity [3]. Additionally, recent research underscores the effectiveness of Problem-Based Learning (PBL) within interdisciplinary environments. PBL not only enhances critical thinking and communication but also enables students from diverse fields to collaborate effectively on complex real-world problems. For instance, interdisciplinary projects combining dietetics and electronic engineering have demonstrated how hands-on problem-solving fosters practical skills and real-life applications [4]. These approaches underscore the transformative potential of integrating artistic and scientific perspectives to address societal challenges. Interdisciplinary learning further entails not only the acquisition of knowledge from multiple domains but also the ability to integrate and apply this knowledge in ways that enhance understanding and stimulate creativity, particularly within team settings. Teamwork skills facilitate better communication among group members, allowing for the wide exchange of diverse ideas and perspectives, which is essential in interdisciplinary settings to foster innovative solutions [5]. Moreover, collaborative behaviors are conducive to establishing a culture of trust and collaboration among team members, thus facilitating individual creativity and innovative outcomes in academic and research contexts [6].Motor competence is intrinsically linked to an individual's motor experiences and motivations rather than depending directly on specific sports practice, emphasizing the importance of diverse contexts for development [7]. Research highlights the significant role of motor competence in predicting future sports participation and fostering long-term engagement in physical activities, underlining the need for integrative and inclusive methodologies [8]. Environments rich in movement opportunities and challenges contribute to the enhancement of fundamental motor skills, which are crucial for the acquisition of advanced sports skills and lifelong physical activity [9]. Dance is not specific for any particular body type or cultural group. It's something that all of us can enjoy. Sometimes people conflate "ballet" with "dance." But ballet is just one way people dance, not the only way [10]. Creating a safe environment for people to explore dance encourages people to remain involved in the dance community, allowing them to see beyond physicality to components like creativity, musicality, and coordination [11]. Being critical of traditional works allows us to breathe new life into them, making them more accessible and relatable to this generation while challenging super-problematic narratives [12]. These foundational insights provide the backdrop for this study, which delves into the interplay of movement, perception, and collective creativity within the context of improvisational dance.

2. The Concept of Interdisciplinarity

Interdisciplinarity in primary education refers to an approach that combines different subject areas, ideas and methods in order to solve problems, explore new concepts and develop skills. It involves connecting knowledge from different disciplines, such as mathematics, natural sciences, art, languages, social sciences and others, to create broader and more complete understandings in students. The aim of the interdisciplinary approach is to help students look at problems and topics from multiple perspectives and to develop critical thinking, creativity and problem solving, which helps them in everyday life and in future academic and professional challenges. The interdisciplinary approach to teaching in primary education is considered an important way of educational integration and student development. This approach encourages the integration of different disciplines and connects knowledge from different fields, which allows students to connect theoretical concepts with real-world situations and problems. This leads to a more complete understanding and application of knowledge, as students can see the connection between subjects, rather than studying them separately, which can improve their ability for critical thinking and problem solving. In some education systems, the interdisciplinary approach is supported by national education strategies, which emphasize the importance of creativity, innovation and the all-round development of the learner. However, successfully implementing this approach in practice can be challenging, as it requires collaboration between teachers from different disciplines and a change in traditional teaching methods. Depending on the educational policies and programs of a particular country or region, the interdisciplinary approach can be supported and encouraged through curricula and programs that promote collaboration between different fields and, in practice, direct the teaching process towards the development of skills such as communication, teamwork and problem-solving.

2.1 Connecting Different Disciplines

(Connecting disciplines by similarity or by similar goals)
The approach to science these days takes on other dimensions. Sciences do not always have to be taught classically, that is, the teaching of knowledge does not always have to be frontal, or the teaching/lesson does

not always have to be just read, it can be experienced, purposefully through a specific activity or task or it can be experienced without being aware that one is going through that process. Therefore, when teaching, teachers should plan to teach through meaningful activities through which students will experience what they need to define or, on the other hand, what they have in practice, so that they can explain it to themselves with academic vocabulary. We will show this through two types of connection: connecting scientific disciplines for the purpose of studying the same phenomena and processes from different aspects and connecting a scientific discipline with performing arts for the purpose of correlation and visibility in practice. (*Connecting Scientific Disciplines to Study the Same Phenomena and Processes from Different Aspects).* This topic covers an interdisciplinary approach, where two or more scientific disciplines collaborate to study and understand certain phenomena or processes. A few examples to illustrate what has been said, namely, an interdisciplinary approach can be taken in the study of climate change by combining geography, meteorology and economics to analyze the effects of climate change on the environment and society; another example is possibility to study and research the fields of neurology and psychology to investigate cognitive processes and their impact on behavior; third example is biology and engineering to that can be used by creating biotechnologies to treat diseases. In practice, interdisciplinary research leads to a deeper understanding of complex phenomena and to creative solutions to key problems that are reflected in life. (*Connecting a Scientific Discipline with Performing Arts for Correlation and Visibility in Practice)*
This approach combines science and art to gain a new perspective and create a deeper connection between theory and practice. Here are a few examples: when connecting physics as a science and dance as a performing art, concepts such as gravity and balance can be used to create choreographies that demonstrate science through movement; medicine and theater can be connected by using drama therapy to rehabilitate patients or to train medical professionals in empathetic communication with their patients. It may sound impossible, but it is possible to connect mathematics and music and conduct research on proportions, rhythm and symmetries in musical compositions. Connections such as ecology and art, i.e. staging performances and performances that raise awareness of nature conservation, are increasingly common. These connections create innovative ways to communicate complex ideas to a wider audience and inspire new ways of thinking.

2.2 How Teachers Can Be Prepared for Interdisciplinary Teaching

As already mentioned, interdisciplinary teaching combines knowledge, methods and perspectives from different disciplines to create a deeper understanding of complex topics. The first thing to keep in mind when implementing this type of teaching is the appropriate selection and combination of topics or areas for which we are competent or to ask for help and cooperation from colleagues. So, the thing is to select an appropriate, relevant topic, a topic that corresponds to the school program and is appropriate to the cognitive age of the students. Of course, we should have appropriately set goals for the selected topic. Appropriately set goals mean that the goals correspond to the science / scientific field to which they belong and the goals that are in the school program.
It is best to consider the activity that should concretely address the problem when setting goals for interdisciplinary lessons. The activity should be appropriately structured, and students will be able to learn through an everyday problem for which a solution needs to be developed/designed. After choosing a topic that is interdisciplinary with appropriate goals the plan of integration needs to be done, and that plan would connect the concepts and methods from different disciplines. Example: If you teach ecology, combine biology (ecosystems), geography (climate zones) and economics (sustainable development). Also, you can teach biology by presenting ballet movements and muscle function. You can break down ballet movements to illustrate the scientific principles behind them, focusing on muscle activation, biomechanics, and body mechanics with Step-by-Step Analysis: for each ballet movement (e.g., plié, arabesque, pirouette), you can describe the specific muscles involved and their actions. For example: plié (Bending the knees): As a dancer bends the knees, the quadriceps (front thigh muscles) lengthen, and the hamstrings (back of the thigh) contract to control the descent and ascent of the movement. The calves (gastrocnemius and soleus) help stabilize the ankle joint.
These examples, and others, indicate that it is necessary to apply collaborative teaching, in which teachers who teach different subjects should be involved and they should design and implement lessons. The lessons themselves, on the other hand, can be organized in such a way that they will be implemented with presentations of research by students from different perspectives.
What is particularly important is that interdisciplinarity is appropriately analyzed through active teaching methods, which means: projects, discussions and simulations. To achieve this, students should receive guidance from the teacher on preparing lessons and materials, as well as referring to various learning resources: books, articles, videos and even direct communication, if possible, with experts from different fields. Technology as a tool for research and presentation is understood. Each activity of students should be

valued and evaluated. In this case, the assessment should be separate for each discipline, but also the ability to connect and apply knowledge. Older students can also be encouraged to self-reflection on what they have learned. As a conclusion, we point out what applies to teaching in general, which is flexibility and adaptability, that is, teachers should be open to changes according to the interests and needs of students. Interdisciplinary teaching creates opportunities for students to see how different areas of knowledge are connected and how they can contribute to solving global problems. [13].

3. Methodology

This research is an action research study aimed at examining the effects of an interdisciplinary approach to teaching scientific concepts through ballet. Action research was chosen for its flexibility in testing and adapting innovative teaching strategies in real-world settings. Research questions - The research poses two main questions: How does the interdisciplinary approach integrate ballet and science impact student engagement and motivation? Does and how does this approach improve the understanding of the teaching content covered in the lessons? Participants and contex - Participants: The study includes elementary school students (grades I-VIII) and their teachers. Number of participants: A total of 1,195 students and 40 teachers participated in 195 lessons using the interdisciplinary approach. Context: The research was conducted in four scientific disciplines: Physics and Ballet, Mathematics and Ballet, Natural Sciences and Ballet, Biology and Natural Sciences. Data collection methods- Surveys: Adapted for students and teachers to assess their engagement, motivation, and perception of the teaching approach. Observation: Teachers observed students' reactions and activities during the lessons. Evaluation forms: Completed by teachers for self-evaluation of the activity implementation. Teacher Reflections: Qualitative data collected through open-ended questions in the surveys. Teaching modules - Activity Design: Scenarios combining ballet movements with content were developed: In Physics: Analysis of balance, force, and gravity. In Biology: Exploration of human anatomy through ballet. In Mathematics: Symmetry and geometry (teaching content) through choreography. In Natural Sciences: Illustration of materials and stage design. Incorporating Technologies: Lessons included VR/AR applications for simulating scenes and AI for movement analysis. Data analysis - Quantitative analysis: Surveys were analyzed to determine percentages of engagement, understanding, and motivation. Data were processed using statistical methods to identify trends and results. Qualitative analysis: Teacher reflections were thematically analyzed to identify challenges and successes of the approach. Research limitations Lesson duration: The limited number of lessons may not have allowed for a deeper application of the approach. Technologies: Access to VR/AR devices and AI tools was limited in some schools. Subjectivity: Teachers may have been subjective in their reflections. Ethical aspects: Students and their parents were informed about the research objectives, and participation was voluntary. Data was anonymized and used solely for research purposes.

4. Results

Student engagement and motivation: The data analysis reveals that students demonstrated high levels of engagement and motivation during lessons utilizing the interdisciplinary approach. Engagement: Students in the "Natural Sciences and Ballet" module showed the highest level of interest (91%), while students in the "Physics and Ballet" module exhibited the lowest level (73%). Motivation: The highest percentage of highly motivated students (95%) was observed in the "Natural Sciences and ballet" module.

subject	very interested (%)	very motivated (%)
physics and ballet	73%	79%
mathematics and ballet	82%	80%
natural sciences and ballet	91%	95%
Biology and natural sciences	88%	91%

Table 1. Student engagement and motivation.

Teacher Perception and Motivation: Teacher satisfaction: 93% of teachers expressed a high level of satisfaction with the success of the lessons. Motivation to apply the approach: Teachers were most motivated to use the approach in the "natural sciences and ballet" (100%) and "biology and natural sciences" (98%)

modules. Challenges: Limited access to VR/AR technologies and preparation time were the most commonly cited obstacles.

subject	satisfaction (%)	motivation for application (%)
physics and ballet	89%	85%
mathematics and ballet	91%	88%
natural sciences and ballet	100%	100%
biology and natural sciences	98%	98%

Table 2. Teacher satisfaction and motivation.

Understanding of Scientific Concepts: Students: Students in the “mathematics and ballet" and “biology and natural sciences" modules demonstrated the highest level of complete understanding (85%). Teachers: Teachers highlighted that connecting teaching content with ballet helped clarify abstract topics, particularly in physics and biology.

subject	complete understanding (%)
physics and ballet	71%
mathematics and ballet	85%
natural sciences and ballet	81%
biology and natural sciences	85%

Table 3. Complete understanding of content

Interesting Activities: Teachers and students agreed that the most interesting activities were those involving VR/AR technologies, combined with creative tasks such as choreography creation or stage design. Graph 1. Most interesting activities according to teachers and students (A bar chart showing the percentage share of "VR/AR," "creative tasks," and "theoretical explanations.”). Development of creativity and teamwork Creativity: Students showed significant improvement in creativity, with the highest percentage in the "mathematics and ballet" module (79%).. Teamwork: Teachers observed significant improvements in teamwork, especially in activities involving stage design and movement analysis.

subject	significant development (%)	moderate development (%)
physics and ballet	74%	26%
mathematics and ballet	79%	21%
natural sciences and ballet	78%	22%
biology and natural sciences	50%	50%

Table 4. Development of creativity

Recommendations and Challenges: Students: 95% of students recommended incorporating more VR/AR technologies across all subjects. Teachers: 87% of teachers suggested allocating more preparation time and providing better access to technological resources.

group	more VR/AR (%)	more time (%)	support for teachers (%)
students	95%	-	-
teachers	87%	65%	60%

Table 5. Recommendations for improvement.

Teacher Observations: Teachers who observed the interdisciplinary lessons noted significantly positive reactions and active involvement from students. The students were highly engaged during the lessons, which was reflected in their enthusiasm and interest in the activities. Some of the most notable student remarks include: *"The lessons were amazing, unique, and inspiring. I would love to have more activities like this. Ballet was a fantastic idea!" "The classes using Artificial Intelligence (AI) were particularly appealing because they boosted our confidence and were incredibly helpful for our learning." "Teamwork greatly contributed to better understanding the material and created a pleasant atmosphere."* The observations also showed that incorporating art, along with the use of VR/AR technologies, further enhanced creativity and collaboration among students. Teachers emphasized that this approach allowed students not only to gain a deeper understanding of scientific content but also to develop skills such as confidence, teamwork, and creativity. This methodology sparked interest and motivation among students for further activities that integrate science and art, focusing on practical and interactive experiences.
Teacher Reflections: Teacher reflections, collected through open-ended survey questions, provided valuable qualitative data on the effects of the interdisciplinary approach. Teachers highlighted that this approach not only increased student interest but also improved their understanding of complex subject content. Some of the most notable reflections include: *"The integration of art and science made the lessons much more engaging and interesting for the students. I noticed they were highly motivated and actively participated." "Teamwork was significantly improved. Students demonstrated the ability to collaborate, think creatively, and share ideas." "The use of VR/AR technologies and AI was very helpful. Students could easily visualize abstract concepts, which helped them understand them more deeply." "The lesson scenarios combining ballet movements with subject content were innovative and effective. This is an approach that should be used more frequently."* Some teachers also noted challenges, such as: Limited time for lesson preparation. Limited access to advanced technologies in some schools. Despite these challenges, teachers agreed that the interdisciplinary approach is valuable and meaningful for the educational process. They suggested introducing more activities of this kind and providing greater support for teachers through training and technological infrastructure.

4.1 Conclusion on Results

The results of this study clearly indicate that the interdisciplinary approach integrating science, art, and technology is significant for enhancing the educational process. Through ballet, as a dynamic and expressive art form, students not only understood the teaching content but also engaged in a creative and innovative way, leading to higher levels of motivation and satisfaction.
This methodology confirms the importance of connecting different aspects of human society within the school environment. Ballet, as a cultural and artistic form, allowed students to visualize and relate abstract content from physics, biology, mathematics, and natural sciences to everyday life. Both teachers and students recognized that this approach is not only innovative but also significantly impacts the development of essential life skills such as confidence, teamwork, and creativity.
Additionally, technologies like VR, AR, and AI expanded the learning dimension, enabling interactivity and realistic visualization of complex scientific processes. Students showed greater interest and better understanding of the material when involved in activities that combined theory with practice. Teachers, in turn, noted that this approach increased their motivation and inspired them to continue using similar methodologies.
It is important to emphasize that schools, as central places for education and development, should promote ways to connect science, art, and technology holistically. This approach not only equips students with the knowledge needed for their future professions but also prepares them for active participation in everyday life. Ballet, as part of this approach, opened opportunities for students to think creatively and perceive science and art as integral parts of their personality and society.
As shown by this study, the interdisciplinary approach has the potential to create a school environment where students not only learn but also feel happy and fulfilled. This is essential because schools should not only enhance knowledge but also develop the skills and values necessary for a happy and successful life.

For the future, it is recommended to expand this approach, with an emphasis on greater integration of technologies, development of new modules and activities, and continuous support for teachers. This will ensure that students become competent, creative, and fulfilled individuals, ready to face the challenges of modern society.

5. Discussion

Effectiveness of the Interdisciplinary Approach: The study results demonstrate that the interdisciplinary approach combining science, art, and technology is highly effective in improving student engagement, motivation, and understanding. Activities using VR/AR technologies and creative tasks significantly increased student interest and participation. The highest levels of engagement and motivation were observed in the "Natural Sciences and Ballet" module, indicating that subjects with practical and visual elements are particularly well-suited to this approach.
Differences Between Subjects: Although all subjects showed positive results, there were differences in levels of understanding and creativity. Students in the "Mathematics and Ballet" and "Biology and Natural Sciences" modules achieved the highest levels of complete understanding (85%), likely due to the practical application and visualization of topics through ballet. On the other hand, "Physics and Ballet" showed the lowest percentage of complete understanding (71%), suggesting that additional support is needed for students in more abstract topics, such as force and gravity.
Impact of Technology: A key point of discussion is the impact of VR/AR technologies. Students across all subjects rated this component as the most interesting and helpful for understanding scientific concepts. Technologies not only increased interactivity but also allowed students to visualize complex processes, concepts, and content more clearly, fostering exceptionally high levels of engagement.
Teacher Perceptions: Teachers expressed a high level of satisfaction with the implementation of activities and noted that this approach is practical and feasible in real classrooms. However, they identified several challenges, including limited access to technology, increased preparation time, and the need for additional training.
Development of Creativity and Teamwork: Creativity was significantly improved among students, particularly in activities involving choreography creation or stage design. Teachers also observed improvements in teamwork, a key skill for students in an era of rapidly changing information and its continual supplementation and replacement.
Challenges and Limitations: Despite positive results, the study faced several limitations:
Limited number of lessons: Some teachers expressed the need for more time to integrate all activities.
Access to technology: The lack of VR/AR devices in some schools affected the uniformity of results.
Subjectivity in self-evaluations: Teacher reflections may not always be entirely objective.
Implications for the Future: This approach has the potential for broader application, not only in regular teaching but also in extracurricular activities and supplementary education. The results suggest that technology and creative activities should be central components of any teaching process. Additionally, this approach can be expanded by involving more subjects and adapting activities for different educational levels.

6. Recommendations

For teachers: Integration of technologies: Teachers should be encouraged to use VR/AR technologies to make lessons more interactive and visually engaging. Training should be provided to help them effectively utilize these technologies. Adaptation of activities: Activities should be tailored to the age, interests, and cognitive abilities of students. For example, younger students could focus on hands-on activities, while older students could engage in analytical and theoretical tasks. Time planning: Sufficient time should be allocated for implementing activities, including preparation before lessons. For schools: Investment in infrastructure: Schools should provide access to VR/AR devices, AI tools, and other technologies that support the interdisciplinary approach. Flexible lesson organization: Extracurricular activities and interdisciplinary approaches should be introduced to support the integration of science and art. Support for teachers: Regular training sessions should be organized to help teachers develop skills for working with new approaches and technologies. For students: Promoting creativity: More activities should be included to allow students to create their own ideas, concepts, interpretations, visualizations, and applications of lesson content through dance. Support for individual needs: Additional support should be provided to students who struggle with understanding content presented in this manner. Inclusion of student ideas: Students should have the opportunity to suggest activities they find relevant and interesting. For future research: Continuation of research: Analyze the long-term effects of the interdisciplinary approach on knowledge retention and the development of critical thinking in students. Expansion of the sample: Include more schools and diverse educational contexts to examine the universality of the approach. Integration with other disciplines: Explore how this approach could be applied in other fields, such as history, geography, or even elective subjects. For

educational policies: Support for teaching innovations: Educational policies should support the introduction of interdisciplinary approaches as part of the regular curriculum. Financial support: Provide grants to schools for investing in innovative technologies and teacher training. Inclusion of art in education: Recognize art as a vital component of learning and promote its integration with other subjects.

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