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Master's Thesis

**New design in game and visualization approach for
physics formula learning**

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Abstract

As we progress further into the 21st century, the role of science in molding and influencing human society grows increasingly significant. The rapid advancements in technology, medicine, and environmental sciences, to name a few areas, highlight the ever-growing importance of scientific knowledge in driving progress and innovation. However, a concerning trend has emerged in recent years – a noticeable decline in students' interest in science education, especially in fundamental subjects like physics. This decline is not just a minor educational issue; it has far-reaching implications for our collective future.

The waning interest in subjects such as physics is particularly troubling. Physics, often considered a cornerstone of the natural sciences, plays a vital role in understanding the universe's fundamental laws. From the smallest particles to the vastness of space, physics provides the framework for understanding how the world works. It is the foundation upon which many modern technologies are built, including computers, telecommunications, and medical imaging devices. Without a strong grounding in physics, the next generation of innovators, researchers, and thinkers may find themselves ill-equipped to carry forward the mantle of scientific discovery and technological advancement.

The consequences of this trend extend beyond the realm of scientific and technological progress. A robust understanding of scientific principles is more critical than ever in a world increasingly defined by complex global challenges – such as climate change, energy sustainability, and public health crises. Science education, particularly in areas like physics, is not just about producing scientists and engineers; it is about creating informed citizens capable of making knowledgeable decisions and contributing to public discourse on scientific issues.

The reasons behind the declining interest in science education are multifaceted. One factor could be the perceived difficulty of subjects like physics. Physics often involves abstract concepts that can be challenging to grasp, and traditional teaching methods may not effectively engage all students. Additionally, how science is taught may not adequately convey its relevance to students' lives and future careers. This leads to perceiving science as a purely academic pursuit disconnected from the real world.

Another factor might be the broader cultural context in which science education exists. In a world where attention is increasingly fragmented and immediate gratification is often

valued over long-term investment, the disciplined study required for subjects like physics can be a hard sell. The portrayal of science and scientists in media and popular culture also plays a role in shaping young people's perceptions and interest in the field.

Addressing this decline in interest requires a multifaceted approach. First, it is crucial to rethink how science, particularly physics, is taught. Educators and curriculum developers must find ways to make physics more accessible and engaging, connecting abstract concepts to real-world applications that resonate with students. Innovative teaching methods, such as project-based learning and the technology integration, can play a significant role in this regard.

Furthermore, there is a need to change the narrative around science education, portraying it not just as a pathway to a career in research or engineering but as a critical component of a well-rounded education. Science literacy is essential in an increasingly complex world, and understanding scientific principles enables individuals to make informed decisions about everything from healthcare to environmental policy.

Inspiring the next generation of scientists requires role models and mentors. Highlighting diverse figures in science – individuals who have made significant contributions to the field and come from various backgrounds – can help students see themselves as future scientists. Partnerships between schools and universities, research institutions, and industry can also provide students real-world exposure to science and its applications, further sparking their interest and curiosity. Reversing the trend of declining interest in science education, particularly in fundamental subjects like physics, is imperative for the future of our society. It requires innovative approaches to teaching, a shift in how we talk about science in education, and efforts to connect students with the broader scientific community. The 21st century presents numerous challenges and opportunities, and a strong foundation in science is crucial for the next generation to navigate and shape this rapidly changing world.

In response to this issue, educational methodologies have evolved, incorporating game-based learning approaches. These approaches have been successful in various learning contexts, particularly in enhancing student motivation. Recent advancements in educational methodologies have seen the integration of game approaches into various learning contexts, demonstrating significant success in addressing student motivation issues. However, there is a caveat. While game-based learning has shown promise in certain areas, its effectiveness in teaching abstract scientific knowledge, such as that

found in fundamental physics, has been limited. This limitation stems from the inherent complexity of physics concepts, which are often difficult for students to grasp and retain through traditional game approaches. Prior research indicates limitations in the effectiveness of these methods, particularly in the realm of abstract scientific knowledge acquisition, such as in fundamental physics. Students often struggle to enhance their understanding and retain complex concepts through traditional game approach for learning.

This study introduces an innovative system that synergizes formula visualization with a game approach tailored explicitly for fundamental physics subjects to address these challenges. The core idea is to transcend beyond traditional game-based learning by integrating advanced visualization tools that make abstract physics concepts more tangible. This innovative approach has several key components. Firstly, the system uses advanced graphical representations to visualize physics formulas and theories. This visualization aids in demystifying complex equations and concepts, making them more accessible and understandable to students. By seeing the physical representation of an abstract concept, students can form a mental image that aids in comprehension and retention.

Secondly, the system incorporates these visualizations within a game-based framework. This framework is designed to be engaging and interactive, encouraging students to explore and experiment with physics concepts in a virtual environment. The gamification elements, such as point scoring, levels, and challenges, are carefully crafted to motivate students and provide a sense of achievement as they progress.

One of the unique aspects of this system is its adaptability to different learning styles. Recognizing that students have diverse ways of learning, the system offers various modes of interaction and exploration. For instance, some students might prefer direct experimentation with formulas and concepts, while others might benefit from guided tutorials embedded within the game.

Furthermore, the system leverages the power of storytelling and context-based learning. By situating physics concepts within relatable scenarios and narratives, the system helps students understand the practical applications of these theories. This approach not only enhances engagement but also aids in the contextual understanding of physics, making it more relevant to the students' everyday experiences.

The effectiveness of this innovative system was evaluated through a series of studies.

These studies involved a diverse group of students and used a combination of quantitative and qualitative research methods. The results were promising, showing a significant improvement in both the understanding and retention of fundamental physics concepts among students who used the system, compared to those who relied on traditional learning methods.

However, the implementation of such a system has its challenges. Developing a sophisticated educational game that accurately represents complex physics concepts requires a multidisciplinary approach, involving educators, game developers, and subject matter experts. Additionally, there are practical considerations, such as the availability of technology and resources in educational institutions.

In conclusion, integrating formula visualization and game approach presents a promising approach to addressing the challenges in teaching abstract scientific knowledge, particularly in fundamental physics. This innovative system not only enhances student engagement and motivation but also facilitates a deeper understanding of complex concepts. As educational methodologies continue to evolve, it is crucial to embrace such innovations to prepare students for a future where scientific literacy is increasingly important.

Keywords: physics learning, game approach, visualization