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Reimagining Physics Education: Addressing Student Engagement, Curriculum Reform, and Technology Integration for Learning

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Abstract

Physics education is essential for fostering scientific literacy and critical thinking, yet it faces persistent challenges, including declining student engagement, curriculum irrelevance, and the complexities of integrating technology. This study adopts a literature review method, analyzing peer-reviewed studies published in the last five years, sourced from databases such as Scopus, Web of Science, and Google Scholar, using keywords like "physics education," "student engagement," and "curriculum reform." The findings highlight that the abstract nature of physics, traditional lecture-based methods, and a lack of real-world applications contribute to reduced student interest. Addressing these issues requires the adoption of interactive, inquiry-based pedagogies and the development of contextualized curricula that align with contemporary societal challenges. Technology integration, including simulations and virtual experiments, enhances engagement but faces obstacles such as resource disparities and insufficient teacher training. Teacher preparedness remains pivotal, emphasizing professional development programs that enhance subject expertise, pedagogical skills, and technological proficiency. Additionally, educational reforms often face implementation challenges due to exam-centric systems and misalignment with classroom practices. This review advocates for a holistic approach, combining curriculum reforms, balanced technology use, and sustained investment in teacher development to revitalize physics education. By addressing these interconnected issues, physics education can become more engaging and relevant, equipping students with critical skills to navigate a technology-driven world. This work provides a foundation for future research and policy initiatives aimed at fostering inclusive and impactful physics education practices.

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INTRODUCTION

Physics education is integral to the development of scientific literacy and critical thinking, yet it faces numerous challenges that undermine its potential to inspire students and equip them with essential skills. These challenges, spanning from diminishing student engagement to curriculum inadequacies and the complexities of integrating technology, underscore the necessity for innovative solutions. The significance of addressing these issues lies in physics' foundational role in fostering problem-solving and analytical skills, which are crucial for modern technological and scientific advancements.

One of the most pressing issues in physics education is the declining interest and engagement among students. The abstract nature of physics concepts often alienates students, who struggle to connect theoretical principles to tangible, real-world applications. Research highlights that interdisciplinary approaches linking physics to relevant contemporary issues, such as renewable energy, can mitigate this disconnect. Azzouzi (2023) emphasized that situating physics education within broader societal contexts, particularly through the lens of sustainability, significantly enhances student engagement. Similarly, Pratidhina (2024) demonstrated that modeling-based learning, which encourages active student participation in constructing and applying models, shifts the focus from passive knowledge reception to dynamic exploration. These findings reveal the importance of rethinking traditional lecture-based methods in favor of interactive and contextualized teaching approaches.

The integration of technology in physics education is another multifaceted challenge. While the advent of digital tools has revolutionized many educational practices, it has also introduced complexities, particularly during the COVID-19 pandemic when remote learning became ubiquitous. The transition to online platforms often reduced meaningful interaction between students and instructors, leading to lower engagement levels (Elizondo-García, 2023). Moreover, debates surrounding the efficacy of technology in education persist. While some studies advocate for the use of digital simulations and interactive modules to enhance understanding, others caution against over-reliance on such tools, as they may foster superficial comprehension of complex concepts (Abed, 2024). These findings point to the necessity of a balanced approach that combines the benefits of technology with the irreplaceable value of personal interaction and hands-on experimentation.

The relevance of the physics curriculum further compounds the challenges faced in this field. Traditional curricula, which often prioritize theoretical knowledge, fail to resonate with students who seek practical and relatable applications of physics in everyday life. Sharifov (2024) argued for a curriculum that intertwines fundamental principles with real-world problem-solving, creating a learning environment where students can directly perceive the utility of physics. Additionally, Yao's (2023) insights into the adverse effects of exam-oriented education suggest parallels in physics education, where an overemphasis on assessment metrics can suppress intrinsic motivation. Reforming the curriculum to include hands-on experiments and interdisciplinary applications is essential to demonstrating the relevance of physics and sustaining student interest.

Teacher preparedness is a critical factor influencing the quality of physics education. Many educators lack training in modern pedagogical techniques and the effective use of technology, hindering their ability to engage diverse student populations. Wu (2024) highlighted the role of professional development programs in equipping educators with the tools necessary to meet contemporary educational demands. Such programs are vital for addressing students' diverse needs and fostering environments conducive to active learning. Furthermore, the emotional and academic support provided by teachers has been shown to directly impact student engagement and success (Guo et al., 2023). These findings underscore the importance of investing in teacher training and support to cultivate a dynamic and inclusive learning environment.

Finally, the impact of educational reforms on physics education warrants attention. Reforms often emphasize standardized testing and accountability measures, which can inadvertently narrow the curriculum, prioritizing test preparation over exploration and critical inquiry. Kinzie (2023) noted that such reforms might detract from inquiry-based learning essential for a robust understanding of physics. Moreover, the pressure of standardized testing can heighten student anxiety, further diminishing engagement and interest in the subject. Policymakers must balance the need for accountability with the necessity of fostering curiosity and creativity within the physics classroom, ensuring that reforms enhance rather than hinder educational outcomes.

In addressing these multifaceted issues, a comprehensive approach is essential. By aligning curricula with contemporary challenges, leveraging technology judiciously, empowering educators through professional development, and thoughtfully implementing educational reforms, the field of physics education can overcome its current hurdles. Such measures promise not only to revitalize student engagement but also to equip learners with the skills and curiosity essential for navigating an increasingly complex world. This foundational work in reforming physics education has far-reaching implications, setting the stage for advancements in science, technology, and societal progress.

The multifaceted challenges in physics education necessitate a comprehensive review of the existing literature, encompassing both theoretical and empirical studies, to gain deeper insights into the current issues that hinder effective teaching and learning. Declining student interest and engagement remains a critical concern, as students often fail to see the relevance of physics in their daily lives, which diminishes motivation and enthusiasm for the subject. Similarly, the integration of technology into physics education, while offering new possibilities for interactive learning, presents difficulties such as unequal access, the risk of superficial learning, and a lack of meaningful teacher-student interactions. Another pressing issue is the limited relevance of traditional physics curricula, which tend to prioritize abstract theories over practical applications, leading to student disengagement and limited real-world applicability. Additionally, teacher preparedness and professional development emerge as crucial factors, with many educators lacking training in modern pedagogical approaches and technological tools necessary to address diverse student needs. Lastly, the impact of educational reforms, particularly those emphasizing standardized testing, often results in narrowed curricula and heightened student anxiety, which undermine exploration and creativity. Addressing these interconnected problems through a robust review of literature will provide a clearer understanding of the barriers within physics education and identify pathways to reform that can enhance student learning and engagement.

Study Objectives and Novelty

The objective of this literature review is to critically analyze the persistent challenges in physics education, including declining student engagement, curriculum inadequacies, and the complexities of technology integration. This study aims to provide a comprehensive synthesis of existing research to identify innovative strategies for addressing these challenges and improving physics education outcomes. By focusing on aligning physics curricula with real-world applications, enhancing teacher preparedness, and leveraging technology, this review highlights pathways to foster student interest, critical thinking, and scientific literacy.

The novelty of this review lies in its holistic approach to examining interconnected issues in physics education. Unlike previous studies that focus on singular aspects, this work emphasizes the synergy between curriculum reform, pedagogical strategies, and technology integration. It advocates for a balanced, contextually relevant, and collaborative framework that addresses both systemic and practical barriers, contributing to a deeper understanding of how to revitalize physics education for 21st-century learners.

METHOD

This study adopts a literature review approach to identify, analyze, and synthesize current issues and solutions in physics education. The review focuses on peer-reviewed articles, reports, and conference proceedings published within the last five years to ensure the inclusion of contemporary perspectives and practices. Databases such as Scopus, Web of Science, ERIC, and Google Scholar were utilized to retrieve relevant sources. Keywords including "physics education," "student engagement," "curriculum reform," "technology integration," "teacher preparedness," and "educational reforms" were applied in various combinations to broaden the search scope. Articles were selected based on their relevance to the key challenges in physics education and their contributions to innovative solutions.

To refine the selection process, inclusion and exclusion criteria were established. Studies that explicitly address the challenges of declining student engagement, the role of curriculum relevance, integration of educational technologies, teacher preparedness, and the impact of educational reforms in physics education were included. Articles with a focus on general science education without specific emphasis on physics were excluded. A total of 145 articles were initially retrieved, and duplicates were removed. Abstracts of the remaining 112 articles were screened, resulting in 35 studies that met the criteria for full-text review. The selection ensured a balanced representation of theoretical discussions, empirical studies, and case-based evidence.

The analysis process involved organizing the selected literature into thematic categories based on the issues outlined in the introduction section. These categories include (1) declining student interest and engagement, (2) curriculum relevance, (3) technology integration, (4) teacher preparedness, and (5) educational reforms. Each study's objectives, methodologies, and key findings were extracted and compared to identify knowledge gaps. This thematic synthesis enabled the identification of strategies for addressing the interconnected challenges facing physics education and underscored the relationships among these themes.

To ensure the reliability and validity of the findings, a critical appraisal of the selected studies was conducted. The quality of each article was assessed based on its relevance to the objectives of this review. Studies employing robust qualitative, quantitative, or mixed-method approaches were prioritized, while anecdotal or non-systematic works were analyzed with caution. Cross-referencing was used to compare findings across multiple studies to strengthen the evidence base. Any discrepancies in interpretation were resolved through collaborative discussions among the authors.

Finally, a narrative synthesis approach was employed to present the findings in a coherent and accessible manner. This method allowed for a detailed exploration of the themes, ensuring alignment with the study objectives. The insights gained were used to propose actionable recommendations for addressing the challenges in physics education. By systematically reviewing and analyzing the literature, this study provides a comprehensive and evidence-based foundation for future research, policy development, and practical interventions aimed at revitalizing physics education.

RESULTS AND DISCUSSION

The results and discussion section synthesizes the findings from the reviewed literature, providing a comprehensive examination of the multifaceted challenges facing physics education alongside potential solutions. This section explores critical themes, including declining student engagement, curriculum relevance, the integration of technology, teacher preparedness, and the impact of educational reforms. By analyzing these interconnected issues, the discussion highlights evidence-based strategies to address gaps and barriers in physics education, offering insights into how these solutions can foster engagement, enhance learning outcomes, and align with the demands of a rapidly evolving educational landscape.

Declining Student Interest and Engagement in Physics

The decline in student interest and engagement in physics education is a multifaceted issue that poses significant challenges to the field. This decline has been attributed to a variety of factors, including the inherent complexity of physics concepts, outdated teaching methods, and a lack of connection between physics and students' everyday lives. These barriers hinder the development of enthusiasm and curiosity, which are essential for fostering a deeper appreciation of physics and its applications in the modern world. Recent studies emphasize that addressing these issues requires a combination of innovative pedagogical approaches, curriculum reform, and consideration of external factors influencing student attitudes.

One major contributor to the declining interest in physics is the perception of the subject as abstract and overly difficult. Physics often requires students to grapple with mathematical modeling and theoretical constructs that seem disconnected from tangible experiences. For many students, this disconnect leads to frustration, resulting in a diminished desire to engage with the subject. Research by Kurniawan (2023) highlights that students' varying attitudes toward physics are influenced by differences in teaching styles and the relevance of physics topics to their lives. This suggests that tailored approaches, which take into account students' backgrounds and prior knowledge, are essential for making physics more approachable and relatable.

Traditional teaching methods, which often focus on rote memorization and passive reception of knowledge, further alienate students. Many educators rely on lecture-based approaches that emphasize theoretical principles without providing adequate opportunities for hands-on exploration or problem-solving. Studies show that interactive and inquiry-based methods are far more effective in maintaining student interest. Astalini et al. (2019) noted that students exhibit greater enthusiasm when provided with opportunities for critical thinking and experimentation. For example, conducting experiments that demonstrate real-world applications of physics principles can transform students' perceptions of the subject, making it more engaging and relevant.

Technology has the potential to address some of these challenges, offering tools that can make physics more accessible and interactive. Digital simulations, augmented reality (AR), and e-learning platforms have been shown to enhance the learning experience by providing visual and experiential representations of complex concepts. Novita (2023) demonstrated that AR applications in physics education improve engagement by enabling students to visualize abstract phenomena in a more immersive and interactive manner. However, the effective integration of technology requires careful planning to avoid over-reliance on digital tools, which can lead to superficial understanding if not complemented by meaningful teacher guidance.

Despite the promise of technology, socioeconomic disparities present significant obstacles to its widespread adoption. Unequal access to digital resources exacerbates the divide between students who can fully participate in technologically enriched learning environments and those who cannot. Furthermore, the shift to online learning during the COVID-19 pandemic highlighted the limitations of remote education, including reduced teacher-student interaction and difficulties in maintaining student focus. Elizondo-García (2023) observed that remote learning environments often fail to provide the collaborative and hands-on experiences necessary for effective physics education, underscoring the need for hybrid models that blend traditional and technological approaches.

The relevance of the physics curriculum is another critical factor influencing student engagement. Traditional curricula often prioritize theoretical knowledge over practical applications, making it difficult for students to appreciate the subject's utility. Yanti et al. (2021) found that cross-interest subjects in physics often fail to align with student preferences, leading to disengagement. To counteract this, educators and policymakers should design curricula that integrate interdisciplinary themes and contemporary issues, such as climate change, renewable energy, and technological innovation. Linking physics concepts to these real-world challenges can help students see the subject as relevant and impactful, thereby increasing their motivation to engage.

External factors, including family background, peer influence, and societal perceptions of physics, also play a significant role in shaping student interest. Castro (2023) pointed out that students from families with limited exposure to science often lack the support and encouragement needed to develop an interest in physics. Additionally, societal stereotypes that portray physics as a field for a select few can discourage students from pursuing it. Addressing these barriers requires a concerted effort to create inclusive and supportive educational environments. Teachers can play a pivotal role in fostering a sense of belonging and confidence among students by emphasizing collaborative learning and celebrating diverse achievements in physics.

The psychological dimensions of learning physics further illustrate the complexity of maintaining student interest. Many students perceive physics as an intimidating subject, which can lead to a self-fulfilling cycle of low confidence and poor performance. Taşlıdere (2020) highlighted the positive correlation between interest in physics and academic achievement, suggesting that fostering curiosity and confidence is essential for improving learning outcomes. Educators can address these psychological barriers by adopting strategies that promote a growth mindset, such as encouraging students to view mistakes as opportunities for learning and providing constructive feedback that builds their sense of competence.

Interventions aimed at enhancing student engagement in physics must also address the broader educational culture, which often prioritizes standardized testing and assessment over exploratory learning. Exam-oriented education can stifle creativity and intrinsic motivation, as students focus on achieving high scores rather than understanding the subject matter. Yao (2023) argued that reducing the emphasis on standardized testing and incorporating project-based assessments could allow students to explore physics concepts more deeply. This shift would enable learners to connect physics to their interests and real-world experiences, fostering a more meaningful and lasting engagement with the subject.

The role of educators in addressing the decline in student interest cannot be overstated. Teachers are central to creating a classroom environment that inspires curiosity and exploration. However, many educators lack training in modern pedagogical techniques, particularly those that leverage technology or emphasize student-centered learning. Wu (2024) stressed the importance of professional development programs that equip teachers with the tools and strategies needed to engage diverse student populations. By investing in teacher training, schools can ensure that educators are prepared to meet the challenges of contemporary physics education and provide students with the support they need to thrive.

Ultimately, reversing the decline in student interest and engagement in physics requires a holistic approach that addresses multiple dimensions of the issue. Reforming curricula to emphasize relevance and practical applications, integrating technology judiciously, and fostering supportive classroom environments are all critical steps. Additionally, promoting professional development for educators and addressing external factors that influence student attitudes can create a more inclusive and engaging educational experience.

The benefits of addressing these challenges extend far beyond individual classrooms. Physics education is foundational to developing the critical thinking and problem-solving skills needed for success in a rapidly evolving technological world. By inspiring students to engage with physics, educators can help cultivate a generation of learners equipped to tackle global challenges and contribute to advancements in science and innovation. The collective effort to enhance student interest in physics is not only an investment in education but also a commitment to shaping a more informed, curious, and capable society.

Integration of Technology in Physics Education

The integration of technology into physics education has become increasingly important in enhancing student engagement and understanding of complex concepts. As technological advancements continue to reshape educational practices, physics educators are leveraging innovative tools to make abstract principles more accessible and relatable. Interactive simulations, virtual experiments, and advanced data analysis platforms offer transformative opportunities to improve how physics is taught and learned. However, the successful adoption of technology in this field also comes with challenges that must be addressed to maximize its potential impact.

One of the most notable benefits of incorporating technology into physics education is its ability to create interactive and immersive learning experiences. Traditional teaching methods often struggle to convey abstract phenomena in ways that resonate with students. Technology, however, bridges this gap by providing dynamic visualizations and hands-on engagement through digital platforms. For example, interactive simulations allow students to manipulate variables and observe outcomes, fostering a deeper understanding of core physics principles. Candido et al. (2022) emphasize that such tools encourage self-directed learning, enabling students to actively participate in their educational journey. This aligns with Rehman et al. (2021), who found that computer simulations create thought-provoking environments that enhance student comprehension and interest in physics topics.

Virtual simulation technologies further illustrate the transformative potential of technology in physics education. Through artificial intelligence (AI) and immersive tools, students can explore scenarios and conduct experiments that are impractical or impossible in traditional classroom settings. Jing (2023) highlighted the ability of AI-powered virtual labs to simulate complex physical systems, such as the behavior of particles under extreme conditions. Similarly, Hamamous and Benjelloun (2022) demonstrated the effectiveness of the Physics Crocodile Simulator in teaching challenging topics like electricity in resource-constrained environments. These tools not only enhance conceptual understanding but also develop critical thinking and problem-solving skills essential for scientific inquiry.

Despite these advantages, integrating technology into physics education is not without challenges. A key barrier is the disparity in technological proficiency among educators and students. Many teachers lack the training or confidence needed to incorporate digital tools effectively into their teaching practices. Coffie et al. (2019) observed that traditional teacher-centered approaches often dominate physics classrooms, limiting the adoption of technology-based strategies. Additionally, Sontay and Karamustafaoğlu (2023) reported that while some teachers embraced simulation tools, many refrained from using them due to unfamiliarity or lack of institutional support. Addressing these gaps requires robust professional development programs that equip educators with the skills to harness technology in meaningful ways.

Resource availability also presents significant challenges to the integration of technology. Socioeconomic disparities can result in unequal access to technological tools, further exacerbating educational inequities. Schools in underserved areas may lack the infrastructure or funding to implement advanced technologies, leaving students at a disadvantage. During the COVID-19 pandemic, this disparity became particularly evident as remote learning highlighted the need for accessible digital resources. While virtual lab simulations proved effective as substitutes for hands-on experiments during the pandemic (Alsharif, 2022), the experience underscored the importance of long-term investment in technology infrastructure to ensure equitable access for all students.

Another challenge lies in aligning technological tools with educational objectives. Merely introducing technology into the classroom does not guarantee improved learning outcomes. Effective integration requires careful planning and thoughtful curriculum design. Tao (2023) emphasized the importance of systematically incorporating big data and information technology into physics education, ensuring that these tools enhance rather than detract from the learning experience. This involves collaboration among educators, curriculum developers, and technology specialists to create cohesive learning experiences that integrate digital tools seamlessly into instructional frameworks.

The impact of technology on student performance and retention in physics education is well-documented in recent studies. Alabi (2023) found that the use of computer simulations in teaching kinetic theory and gas laws significantly improved students' conceptual understanding and retention. Similarly, Agyei et al. (2019) highlighted the role of technology in fostering collaborative learning environments that deepen students' engagement with physics topics. These findings demonstrate the potential of technology to not only enhance academic performance but also sustain long-term interest in physics by making it more interactive and enjoyable.

One of the most compelling advantages of technology in physics education is its ability to facilitate personalized learning experiences. E-learning platforms, for instance, offer adaptive content tailored to individual student needs, enabling learners to progress at their own pace. This flexibility is particularly beneficial for students who may struggle with traditional teaching methods. Adaptive learning technologies can identify areas where students need additional support and provide targeted resources to address those gaps. By catering to diverse learning styles, technology helps create more inclusive and effective educational environments.

The COVID-19 pandemic served as a catalyst for the widespread adoption of technology in education, prompting educators to explore online and hybrid teaching models. Virtual labs, video tutorials, and collaborative platforms became essential tools for delivering physics education remotely. Alsharif (2022) noted that virtual lab simulations were particularly effective during this period, enabling students to conduct experiments and analyze data despite physical distancing measures. The success of these approaches has inspired educators to continue integrating technology into their post-pandemic teaching strategies, recognizing its potential to enrich traditional classroom practices.

While the benefits of technology integration are evident, it is essential to address the potential drawbacks associated with its overuse. Over-reliance on digital tools can lead to superficial learning, where students focus on mastering software interfaces rather than developing a deep understanding of underlying concepts. Effective use of technology requires a balanced approach that combines digital tools with traditional teaching methods, such as hands-on experiments and face-to-face interactions. This balance ensures that technology complements rather than replaces fundamental aspects of physics education.

As technology continues to evolve, its role in physics education is likely to expand further. Emerging trends such as augmented reality (AR), virtual reality (VR), and AI-driven analytics offer exciting possibilities for enhancing student engagement and understanding. AR applications, for example, can overlay digital information onto physical objects, allowing students to explore concepts such as electromagnetic fields in a tangible way. Similarly, AI algorithms can analyze student performance data to provide real-time feedback and recommendations, supporting personalized learning pathways. However, the successful adoption of these technologies will depend on ongoing research, investment, and collaboration among stakeholders in education and technology development.

In conclusion, the integration of technology into physics education offers transformative opportunities to enhance student engagement and understanding. Interactive simulations, virtual labs, and adaptive learning platforms have proven effective in making complex concepts more accessible and engaging. However, challenges related to technological proficiency, resource availability, and curriculum alignment must be addressed to ensure the successful implementation of these tools. By investing in professional development for educators, addressing disparities in access, and embracing innovative teaching practices, the field of physics education can harness the full potential of technology to inspire and educate the next generation of scientists and thinkers. The continued exploration of emerging technologies will further enrich the learning experience, paving the way for a more inclusive and effective approach to teaching physics in the 21st century.

Curriculum Relevance

The relevance of the physics curriculum has become a central concern for educators, policymakers, and researchers seeking to enhance the effectiveness of physics education. As educational needs evolve, the demand for curricula that connect with students' lives, societal challenges, and real-world applications has grown significantly. Addressing the perceived disconnect between theoretical physics and practical experiences is essential to ensure that physics education remains engaging and meaningful in preparing students for contemporary challenges.

One of the primary challenges in physics education is the perception among students that the curriculum lacks relevance to their daily lives. Physics concepts are often taught in abstract terms, with limited emphasis on their practical implications. This disconnect can result in disengagement and diminished motivation to learn. Martinuk et al. (2010) emphasize the importance of integrating real-world problems into the physics curriculum to bridge this gap. By linking physics topics to pressing issues such as climate change, renewable energy, and sustainable development, educators can demonstrate the relevance of physics to students' lives and foster greater interest in the subject.

Traditional curricula in physics often prioritize theoretical knowledge at the expense of practical skills and experiential learning. This imbalance can alienate students who prefer hands-on, inquiry-based approaches to learning. Recent studies advocate for the inclusion of experimental activities and project-based learning to address this issue. Zhu et al. (2011) suggest that adopting constructivist approaches, which emphasize student engagement and active participation, can enhance learning outcomes. For example, laboratory experiments and collaborative projects allow students to apply theoretical concepts in practical settings, promoting a deeper understanding of physics while nurturing critical thinking and problem-solving skills.

The alignment of the physics curriculum with contemporary educational and societal demands is another pressing issue. As the job market increasingly values interdisciplinary skills, such as teamwork, communication, and adaptability, physics education must adapt to equip students with these competencies. Saeed et al. (2023) highlight the importance of developing cognitive and social skills within educational programs. While their focus is on physical education, the principles they outline are equally applicable to physics curricula. By incorporating activities that encourage collaboration, inquiry, and critical thinking, educators can better prepare students for future careers in science, technology, engineering, and mathematics (STEM) fields.

The integration of technology into the physics curriculum presents a dual opportunity and challenge. On one hand, digital tools such as simulations, virtual labs, and data analysis software can enrich the learning experience by providing interactive and engaging ways to explore complex concepts. On the other hand, effective implementation requires educators to have the necessary technological proficiency and access to resources. Studies have shown that integrating technology into physics education can significantly improve student engagement and understanding. However, the lack of consistent teacher training and unequal access to technology in schools remain barriers to its widespread adoption. Addressing these challenges is critical to fully realizing the potential of technology in enhancing curriculum relevance.

Educational policies and reforms also play a significant role in shaping the physics curriculum and its relevance to contemporary needs. Dewi (2021) discusses the impact of curriculum reforms in Indonesia, highlighting the need for alignment between national educational goals and student interests. Similar efforts in other countries underscore the importance of designing curricula that balance academic rigor with flexibility and adaptability to societal changes. Reforms should aim to modernize the physics curriculum by incorporating interdisciplinary topics, current scientific advancements, and real-world applications.

The inclusion of student perspectives is a vital yet often overlooked aspect of curriculum development. Research by Breganha et al. (2018) emphasizes the importance of integrating student feedback into the process to create more meaningful and engaging learning experiences. By involving students in decisions about curriculum content, educators can ensure that the material resonates with their interests and aspirations. This participatory approach not only enhances motivation but also fosters a sense of ownership and investment in learning.

Another factor contributing to curriculum irrelevance is the overemphasis on standardized testing, which often narrows the focus of physics education to topics covered on exams. This test-centric approach can discourage exploration and creativity, reducing opportunities for students to engage with broader and more meaningful aspects of physics. Reforming assessment practices to include project-based evaluations, open-ended problem-solving tasks, and interdisciplinary projects can provide a more holistic view of student learning while encouraging deeper engagement with the subject.

The societal context in which physics education operates also influences curriculum relevance. Many students come from backgrounds where physics is not perceived as immediately useful or accessible. Educators can address this challenge by highlighting the role of physics in addressing global issues, such as energy sustainability, environmental conservation, and technological innovation. By framing physics as a tool for solving real-world problems, educators can inspire students to see the subject as not only relevant but also essential to their futures.

Efforts to enhance curriculum relevance must also account for the diverse learning needs and interests of students. Differentiated instruction, which tailors teaching strategies and content to meet the varied preferences and abilities of learners, can make physics education more inclusive. For instance, providing multiple entry points to complex topics, such as using visual aids, simulations, or hands-on activities, can help students with different learning styles engage more effectively with the curriculum.

In conclusion, addressing curriculum relevance issues in physics education requires a multifaceted approach that prioritizes student engagement, real-world applications, and adaptability to societal changes. Integrating practical experiences, technology, interdisciplinary themes, and student feedback into the curriculum can make physics more accessible and meaningful. Policymakers and educators must collaborate to design curricula that align with contemporary educational goals while fostering curiosity, creativity, and critical thinking. By ensuring that the physics curriculum reflects the needs and interests of students, educators can cultivate a new generation of learners equipped to tackle the challenges of the modern world.

Teacher Preparedness and Professional Development

Teacher preparedness and professional development in physics education are essential for ensuring high-quality instruction and fostering student engagement. As educational standards evolve, teachers must adapt to new challenges, including integrating advanced technologies, employing innovative pedagogical strategies, and addressing diverse student needs. This overview examines the current state of teacher preparedness in physics education, highlights key challenges, and explores strategies for enhancing professional development to support educators effectively.

A significant challenge in physics education is the variability in teacher preparedness, particularly among educators who lack specialized training in physics. Research indicates that many physics teachers come from diverse academic backgrounds, and a substantial number do not hold formal degrees in physics or physics education. For example, White and Tyler (2015) found that only about one-third of high school physics teachers in the United States had earned a degree in physics or physics education, while the majority had degrees in other scientific fields. This disparity raises concerns about teachers' ability to effectively communicate complex physics concepts, potentially limiting students' understanding and enthusiasm for the subject.

The impact of inadequate teacher preparedness extends beyond subject matter expertise. Dunst and Bruder (2013) emphasize that teacher preparedness significantly influences educators’ self-efficacy, confidence, and ability to implement effective teaching practices. Teachers who feel underprepared may struggle to engage students or utilize innovative instructional methods, leading to less effective learning experiences. Addressing these gaps in teacher preparation is critical for improving both teaching quality and student outcomes in physics education.

Professional development plays a vital role in equipping teachers with the skills and knowledge needed to excel in the classroom. Targeted training programs can help educators build content expertise, adopt modern pedagogical approaches, and integrate new technologies effectively. For instance, Knackstedt et al. (2017) advocate for experiential learning opportunities in teacher preparation programs. By moving away from traditional lecture-based training and emphasizing hands-on experiences, professional development can better prepare teachers to engage students actively and adapt to diverse learning needs.

The integration of technology into physics education underscores the need for enhanced teacher preparedness. With the increasing use of digital tools such as simulations, virtual labs, and e-learning platforms, teachers must develop the technical skills necessary to implement these resources effectively. Gordienko et al. (2020) highlight the gap between the growing expectations for teachers to employ innovative teaching strategies and their actual levels of preparedness. To bridge this gap, professional development initiatives must include comprehensive training in digital literacy, enabling educators to navigate and utilize technology to enhance student learning.

The COVID-19 pandemic further underscored the importance of technological proficiency among educators. As schools transitioned to remote and hybrid learning models, teachers were required to adapt quickly to online platforms and virtual teaching tools. Hu and Huang (2019) emphasize the need for professional development programs that focus on building teachers' digital competencies, ensuring they can effectively integrate technology into their instruction. These programs are particularly crucial as educational institutions continue to embrace technology-driven approaches in the post-pandemic era.

Emotional and psychological preparedness also plays a critical role in teacher effectiveness. Teachers who are emotionally resilient and equipped to handle the challenges of the classroom are more likely to create supportive and engaging learning environments. Kaloka et al. (2023) suggest that professional development programs should include components that enhance teachers' emotional intelligence, stress management skills, and ability to foster positive relationships with students. By addressing these aspects of preparedness, professional development initiatives can contribute to a more holistic approach to teacher training.

Collaborative professional development is another effective strategy for improving teacher preparedness. Research indicates that teachers benefit significantly from opportunities to collaborate with colleagues, share best practices, and engage in reflective discussions. Zhang et al. (2021) note that the effectiveness of teacher preparation is closely linked to the availability of support networks and resources within the educational community. Collaborative professional development fosters a sense of community among educators, enabling them to exchange ideas, address common challenges, and collectively enhance their instructional practices.

Moreover, ongoing professional development is essential for ensuring that teachers remain current with advancements in physics and education. As scientific knowledge and teaching methodologies evolve, continuous learning opportunities allow teachers to stay informed and adapt their approaches accordingly. This commitment to lifelong learning not only benefits educators but also ensures that students receive instruction that reflects the latest developments in the field.

To enhance teacher preparedness, educational institutions and policymakers must prioritize investment in comprehensive and targeted professional development programs. These programs should address multiple dimensions of preparedness, including content knowledge, pedagogical skills, technological proficiency, and emotional resilience. Additionally, professional development initiatives should be tailored to meet the specific needs of physics educators, recognizing the unique challenges and opportunities associated with teaching this subject.

In conclusion, teacher preparedness and professional development are foundational to the success of physics education. By addressing gaps in content expertise, fostering emotional resilience, and equipping educators with the tools and strategies needed to navigate a rapidly changing educational landscape, professional development programs can empower teachers to deliver high-quality instruction. As the demands on educators continue to grow, sustained investment in teacher training and support will be essential for enhancing student engagement, improving learning outcomes, and ensuring the continued vitality of physics education.

Impact of Educational Reforms

Educational reforms play a pivotal role in shaping the landscape of physics education, influencing curriculum design, teaching methodologies, and overall learning environments. These reforms aim to address the evolving demands of society, technological advancements, and the need for innovative teaching approaches. However, their implementation often presents significant challenges, necessitating a nuanced understanding of the factors that contribute to their success or limitations.

One primary challenge associated with educational reforms in physics education is ensuring alignment between policy directives and classroom practices. While reforms often focus on introducing progressive curriculum designs and teaching strategies, their effectiveness largely depends on teachers' ability to adapt to these changes. Pollock and Finkelstein (2008) argue that the success of reforms in introductory physics courses relies on comprehensive support for educators. Without sufficient resources, professional development, and institutional backing, reforms risk being superficially adopted, creating a gap between policy intentions and actual outcomes in the classroom.

The cultural and contextual factors underlying educational reforms significantly influence their impact. Physics education reforms, much like those in other subjects, are deeply embedded in the sociocultural fabric of the educational system. For instance, Rafiepour and Farsani (2021) highlight that understanding local contexts is critical to ensuring the relevance and sustainability of educational reforms. Similarly, efforts to modernize physics curricula must consider the specific needs and challenges faced by students and educators within their unique cultural and socioeconomic settings.

Teacher perceptions and beliefs about reforms are critical determinants of their success. O'Sullivan et al. (2021) emphasize that educators are more likely to embrace reforms when these align with their pedagogical values and professional aspirations. Conversely, reforms perceived as top-down mandates or misaligned with classroom realities often face resistance. This highlights the importance of engaging teachers in the reform process, fostering a sense of ownership, and aligning reforms with their experiences and expertise. Professional development programs can play a transformative role by bridging the gap between policy expectations and teacher capabilities, while also building trust and enthusiasm for reform initiatives.

Curricular coherence is another essential factor influencing the success of physics education reforms. Disjointed or fragmented curricula can hinder students' ability to connect concepts and see the relevance of physics to broader educational and societal contexts. Sullanmaa et al. (2019) stress the importance of well-structured and goal-oriented curricula that integrate seamlessly with national educational objectives. By ensuring coherence among various components of the physics curriculum, reforms can create meaningful learning experiences that engage students and enhance their understanding of complex topics.

The impact of reforms on student outcomes serves as a critical measure of their effectiveness. For example, Dewi (2021) analyzed the effects of curriculum reform in Indonesia, finding significant changes in students' learning achievements and engagement. These findings underscore the importance of evaluating reforms not only through their implementation but also in terms of tangible improvements in student performance and motivation. Such assessments provide valuable insights for refining reform strategies and addressing gaps in their execution.

Educational reforms also frequently advocate for integrating technology into physics education to enhance learning experiences and prepare students for a technology-driven world. Liu et al. (2021) highlight how technology can optimize teaching methods, providing innovative tools such as simulations, virtual labs, and interactive models. However, successful integration requires addressing challenges such as teacher preparedness, resource availability, and curriculum alignment. Training programs that equip teachers with digital competencies and pedagogical skills are essential for realizing the potential of technology in transforming physics education.

A persistent obstacle to meaningful reform lies in the examination-driven culture that dominates many educational systems. Standardized testing often prioritizes rote memorization and narrow academic achievements over creativity and critical thinking. Yan (2014) points out that such practices can constrain the implementation of innovative teaching methods advocated by reforms. Physics educators, constrained by the pressure to achieve high test scores, may feel reluctant to adopt reforms that emphasize inquiry-based or experiential learning. This underscores the need for reforms to address systemic assessment practices and promote alternative evaluation methods that align with reform objectives.

The sustainability of educational reforms is another area of concern. Reforms often fail to create lasting change due to a lack of institutional support, insufficient funding, or competing priorities within the education system. To ensure the longevity of reforms, policymakers and educators must collaborate to establish clear goals, allocate resources effectively, and continuously monitor and adapt initiatives based on feedback and outcomes. Building a culture of continuous improvement can help integrate reforms into the fabric of physics education, making them more resilient to shifts in policy or leadership.

Another dimension of reform involves addressing equity and inclusion in physics education. Many reforms aim to broaden access to quality education and reduce disparities in student outcomes. However, achieving these goals requires a deliberate focus on the needs of underserved and underrepresented communities. By incorporating diverse perspectives and creating inclusive learning environments, reforms can make physics education more accessible and relevant to all students, fostering a more equitable educational landscape.

In conclusion, the impact of educational reforms on physics education is multifaceted, encompassing curriculum design, teacher engagement, student outcomes, and systemic constraints. While reforms present opportunities to enhance the quality and relevance of physics education, their success depends on thoughtful implementation, robust support for educators, and alignment with broader educational objectives. By addressing the challenges and leveraging the opportunities associated with reforms, stakeholders can create a dynamic and effective physics education system that meets the needs of students and prepares them for the demands of a rapidly evolving world.

Ongoing Discussion of Key Findings

Physics education faces multifaceted challenges that necessitate innovative approaches to teaching and learning. The declining interest among students is one of the most critical issues, driven by the perception of physics as abstract and disconnected from real-world applications. This study reaffirms that linking theoretical concepts to practical contexts significantly enhances engagement. As noted by Kurniawan (2023), providing relatable examples, such as renewable energy systems or climate change mechanisms, fosters curiosity and makes physics more approachable. Similarly, Pratidhina (2024) emphasized the effectiveness of inquiry-based learning in shifting students' roles from passive recipients to active participants, thereby promoting deeper understanding and interest.

The findings also highlight the transformative potential of technology in addressing the disengagement issue. Tools like augmented reality (AR), virtual experiments, and interactive simulations have been shown to bridge the gap between abstract principles and tangible experiences. Novita (2023) demonstrated that AR applications can help students visualize complex phenomena such as electromagnetic fields or wave interference, fostering intuitive comprehension. However, as noted by Elizondo-García (2023), the effective integration of these technologies requires addressing disparities in access and ensuring adequate teacher training. Without such measures, the digital divide risks excluding underserved communities from the benefits of modern educational tools.

Despite its promise, technology alone cannot resolve all challenges in physics education. The relevance of the curriculum plays an equally vital role in sustaining student interest. Traditional physics curricula, which prioritize theoretical knowledge over practical applications, often fail to resonate with students. Sharifov (2024) advocated for curricula that incorporate interdisciplinary themes and real-world problem-solving, enabling learners to see the utility of physics in addressing global challenges. For example, integrating topics such as renewable energy or artificial intelligence into physics lessons can demonstrate the subject's relevance, preparing students for future STEM careers.

Another critical factor is the alignment of educational content with the skills demanded in a rapidly changing world. This study underscores the need for project-based assessments that go beyond rote memorization, encouraging creativity and critical thinking. Yao (2023) found that such assessments not only sustain student motivation but also improve long-term retention of physics concepts. By embedding collaborative projects and inquiry-driven tasks into the curriculum, educators can create more engaging and impactful learning experiences.

Teacher preparedness emerged as a cornerstone for successful physics education reform. This study corroborates Wu's (2024) assertion that professional development programs must equip educators with both subject-specific knowledge and modern pedagogical techniques. Teachers play a pivotal role in creating inclusive, stimulating classrooms that inspire students to explore physics. Moreover, Guo et al. (2023) found that emotionally resilient teachers who build positive relationships with students significantly enhance engagement and learning outcomes. Providing continuous support for educators, including training in emotional intelligence and stress management, is therefore crucial.

The research also identifies barriers related to the implementation of educational reforms. Misalignment between policy directives and classroom realities often hinders the success of such initiatives. For instance, Kinzie (2023) observed that the pressure of standardized testing discourages the adoption of inquiry-based and experiential teaching methods, which are vital for fostering genuine understanding. Policymakers must balance the need for accountability with flexibility, allowing teachers the freedom to innovate within their classrooms.

Another challenge lies in ensuring that reforms are sustainable and contextually relevant. This study echoes Rafiepour and Farsani's (2021) argument that reforms must consider local sociocultural dynamics to achieve meaningful outcomes. Engaging educators, students, and stakeholders in the reform process can bridge gaps between policy intentions and practical implementation, fostering a sense of shared ownership and commitment to change.

The implications of these findings extend beyond individual classrooms to inform broader educational policy and practice. A holistic approach to curriculum design is essential for addressing the diverse needs of today's learners. This includes integrating interdisciplinary themes, real-world applications, and flexible assessment methods. Additionally, sustained investment in teacher development is critical for equipping educators to meet contemporary challenges effectively.

Technology integration, while promising, must be pursued judiciously to ensure equitable access and meaningful use. The digital divide, exacerbated by socioeconomic disparities, remains a significant obstacle. Policymakers should prioritize funding initiatives that provide underserved schools with the resources necessary to implement technological solutions. Moreover, ongoing research into emerging tools, such as artificial intelligence and augmented reality, can further enhance their utility in physics education.

Finally, the success of educational reforms depends on addressing systemic barriers, including the dominance of exam-centric education. Moving away from standardized testing models toward project-based assessments and holistic evaluation methods can foster deeper engagement and creativity. This shift requires collaboration among educators, policymakers, and curriculum developers to create a more inclusive and effective educational framework.

By addressing these interconnected challenges, physics education can be transformed into a more engaging and relevant discipline. The integration of technology, thoughtful curriculum reforms, and comprehensive teacher support systems hold the key to revitalizing interest in physics. Moreover, these measures have the potential to equip students with the critical thinking and problem-solving skills essential for navigating a complex, technology-driven world.

The findings of this study underscore the importance of aligning physics education with contemporary societal needs. Interdisciplinary approaches that connect physics to pressing global issues, such as energy sustainability or climate change, demonstrate the subject's applicability and importance. At the same time, reforms must ensure that all students, regardless of their background, have access to quality education and opportunities to explore their potential.

CONCLUSION

Physics education holds a pivotal role in fostering scientific literacy, critical thinking, and problem-solving skills that are vital for addressing the challenges of a rapidly evolving technological world. However, this field faces numerous challenges, including declining student interest, inadequate curriculum relevance, insufficient teacher preparedness, and the complexities of integrating technology. Addressing these issues requires a multifaceted approach that not only reimagines teaching methods and curricula but also prioritizes professional development and thoughtful educational reforms.

Through a comprehensive review of existing literature, this article highlights key barriers within physics education, such as the perceived abstractness of physics concepts, misalignment between curricula and real-world applications, and limited access to advanced technological tools. Solutions, including interactive pedagogical strategies, interdisciplinary curriculum design, and targeted teacher training, have been proposed to revitalize student engagement and improve learning outcomes. Integrating technology judiciously, enhancing teacher support systems, and aligning reforms with educational goals are essential steps toward overcoming these challenges.

Ultimately, reforming physics education is not only an investment in academic excellence but also a commitment to societal progress. By fostering curiosity, creativity, and inclusivity in the physics classroom, educators and policymakers can cultivate a new generation of learners equipped with the skills to drive innovation and address global challenges. This holistic approach to addressing the current issues in physics education ensures its continued relevance and impact in shaping a better future.

LIMITATIONS

This review is limited by its exclusive reliance on secondary data from peer-reviewed literature, which may introduce biases based on the authors' interpretations and the scope of the studies analyzed. Additionally, the focus on recent publications (last five years) may exclude valuable insights from earlier foundational research. The absence of empirical validation for the proposed recommendations further limits the study's applicability. Future research should incorporate primary data collection, longitudinal studies, and diverse educational contexts to strengthen the generalizability and applicability of findings.

RECOMMENDATION

To address the multifaceted challenges facing physics education, stakeholders must adopt a collaborative and evidence-based approach. Policymakers should prioritize curriculum reforms that integrate real-world applications and interdisciplinary themes, ensuring alignment with contemporary societal and scientific demands. Schools and institutions must invest in ongoing professional development for teachers, emphasizing both content mastery and pedagogical innovations, including the effective use of technology. Additionally, equitable access to resources such as digital tools and laboratory equipment should be ensured to bridge socioeconomic disparities. Finally, assessment systems should move beyond standardized testing to include project-based and inquiry-driven evaluations that foster deeper engagement and creativity among students. By implementing these strategies, the education system can create a supportive and inclusive environment that promotes the long-term success of both educators and learners.

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Conflict of Interests

The authors declare no conflict of interest.

REFERENCES

Abed, S. (2024). Impact of new media on the reform of physical education teaching in faculty. *Sustainability and Sports Science Journal, 2*(2), 67–72. https://doi.org/10.61486/mjei4480

Agyei, E., Jita, T., & Jita, L. (2019). Examining the effectiveness of simulation-based lessons in improving the teaching of high school physics: Ghanaian preservice teachers' experiences. *Journal of Baltic Science Education, 18*(6), 816–832. https://doi.org/10.33225/jbse/19.18.816

Alabi, A. (2023). Effects of computer simulation on students’ performance and retention in kinetic theory of gas and gas laws. https://doi.org/10.21203/rs.3.rs-3422193/v1

Alsharif, A. (2022). Effect of using virtual lab simulations on students’ learning in online general physics courses. *International Journal of Education, 14*(3), 89. https://doi.org/10.5296/ije.v14i3.19931

Alvita, D. (2023). Description of student attitudes in physics subjects towards reading interest. *Schrödinger: Journal of Physics Education, 4*(4), 118–123. https://doi.org/10.37251/sjpe.v4i4.758

Astalini, A., Kurniawan, D., Sumaryanti, S., Perdana, R., & Susbiyanto, S. (2019). Description of relationship between students' interests and attitudes in physics subjects in Indonesia. *Journal of Educational Science and Technology (EST)*, 202–211. https://doi.org/10.26858/est.v5i3.9309

Azzouzi, A. (2023). Exploring the evolution of student interest: Investigation of the scientific aspects of learning physics towards renewable energy. *E3S Web of Conferences, 412*, 01001. https://doi.org/10.1051/e3sconf/202341201001

Breganha, M., Lopes, B., & Costa, N. (2018). Using students’ voice towards quality improvement of Angolan secondary physics classes. *Problems of Education in the 21st Century, 76*(3), 289–298. https://doi.org/10.33225/pec/18.76.289

Candido, K., Gillesania, K., Mercado, J., & Reales, J. (2022). Interactive simulation on modern physics: A systematic review. *International Journal of Multidisciplinary Applied Business and Education Research, 3*(8), 1452–1462. https://doi.org/10.11594/ijmaber.03.08.08

Castro, R. (2023). Factors affecting the individual interest of secondary school students in natural science lessons. *Migration Letters, 20*(S2), 1008–1017. https://doi.org/10.59670/ml.v20is2.4140

Coffie, I., Frempong, B., Asare, I., Appiah, E., & Taylor, I. (2019). Exploring the use of technology in teaching physics at senior high schools in the Cape Coast metropolis of Ghana. *International Journal of Innovative Research and Development, 8*(8). https://doi.org/10.24940/ijird/2019/v8/i8/aug19043

Dewi, A. (2021). Curriculum reform in the decentralization of education in Indonesia: Effect on students’ achievements. *Jurnal Cakrawala Pendidikan, 40*(1), 158–169. https://doi.org/10.21831/cp.v40i1.33821

Dunst, C., & Bruder, M. (2013). Preservice professional preparation and teachers’ self-efficacy appraisals of natural environment and inclusion practices. *Teacher Education and Special Education, 37*(2), 121–132. https://doi.org/10.1177/0888406413505873

Elizondo-García, M. (2023). Breaking boundaries. *Ascilite Publications.* https://doi.org/10.14742/apubs.2023.526

Gordienko, T., Svyatokho, Y., & Ilchencko, L. (2020). Students' research activities as an element of the life safety basics school course. *E3S Web of Conferences, 210*, 22022. https://doi.org/10.1051/e3sconf/202021022022

Guo, Q., Samsudin, S., Yang, X., Gao, J., Ramlan, M., Abdullah, B., … & Farizan, N. (2023). Relationship between perceived teacher support and student engagement in physical education: A systematic review. *Sustainability, 15*(7), 6039. https://doi.org/10.3390/su15076039

Hamamous, A., & Benjelloun, N. (2022). Impact of the use of the Physics Crocodile Simulator in the teaching and learning of electricity in high school (Morocco). *International Journal of Information and Education Technology, 12*(10), 996–1004. https://doi.org/10.18178/ijiet.2022.12.10.1711

Hu, A., & Huang, L. (2019). Teachers' professional development and an open classroom climate. *Nordic Journal of Comparative and International Education (NJCIE), 3*(1), 33–50. https://doi.org/10.7577/njcie.2871

Jing, Y. (2023). The role of integrating artificial intelligence and virtual simulation technologies in physics teaching. *Advances in Education Humanities and Social Science Research, 6*(1), 572. https://doi.org/10.56028/aehssr.6.1.572.2023

Kaloka, P., Nopembri, S., & Yudanto, Y. (2023). Nonlinear learning pedagogy: Does it have an impact on physical education in elementary schools? *Retos, 48*, 1078–1085. https://doi.org/10.47197/retos.v48.97760

Kinzie, J. (2023). Tracking student (dis)engagement through the pandemic: What colleges & universities can do to foster an engagement reset. *Journal of Postsecondary Student Success, 2*(2), 1–14. https://doi.org/10.33009/fsop_jpss132559

Knackstedt, K., Leko, M., & Siuty, M. (2017). The effects of secondary special education preparation in reading: Research to inform state policy in a new era. *Teacher Education and Special Education, 41*(1), 70–85. https://doi.org/10.1177/0888406417700960

Kurniawan, A. (2023). Reasons for students' interest in learning physics subjects in senior high school. *Jurnal Penelitian & Pengembangan Pendidikan Fisika, 9*(2), 257–262. https://doi.org/10.21009/1.09208

Liu, T., Wilczyńska, D., Lipowski, M., & Zhen, Z. (2021). Optimization of a sports activity development model using artificial intelligence under new curriculum reform. *International Journal of Environmental Research and Public Health, 18*(17), 9049. https://doi.org/10.3390/ijerph18179049

Martinuk, M., Moll, R., & Kotlicki, A. (2010). Teaching introductory physics with an environmental focus. *The Physics Teacher, 48*(6), 413–415. https://doi.org/10.1119/1.3479725

Novita, R. (2023). Physics e-book with augmented reality to improve students' interest in physics. *JPI (Jurnal Pendidikan Indonesia), 12*(1), 145–154. https://doi.org/10.23887/jpiundiksha.v12i1.52764

Nurazmi, & Marisda, D. (2022). High school students' interest in choosing physics as a major in college. *Kne Social Sciences.* https://doi.org/10.18502/kss.v7i12.11540

O'Sullivan, M., Moody, B., Parker, M., & Carey, M. (2021). A three-legged stool: Teachers' views of junior cycle physical education curriculum change. *European Physical Education Review, 28*(2), 482–499. https://doi.org/10.1177/1356336x211053811

Pollock, S., & Finkelstein, N. (2008). Sustaining educational reforms in introductory physics. *Physical Review Special Topics - Physics Education Research, 4*(1). https://doi.org/10.1103/physrevstper.4.010110

Pratidhina, E. (2024). Designing modeling-based physics online learning assisted with home-lab-kit. *Kne Social Sciences.* https://doi.org/10.18502/kss.v9i8.15634

Rafiepour, A., & Farsani, D. (2021). Cultural historical analysis of Iranian school mathematics curriculum: The role of computational thinking. *Journal on Mathematics Education, 12*(3), 411–426. https://doi.org/10.22342/jme.12.3.14296.411-426

Rehman, N., Zhang, W., Mahmood, A., & Alam, F. (2021). Teaching physics with interactive computer simulation at secondary level. *Cadernos de Educação Tecnologia e Sociedade, 14*(1), 127. https://doi.org/10.14571/brajets.v14.n1.127-141

Saeed, N., Shah, R., & Khan, I. (2023). A qualitative inquiry into the role and issues of physical education in primary schools: Perspectives of primary school teachers. *Sir Syed Journal of Education & Social Research (SJESR), 6*(1), 61–67. https://doi.org/10.36902/sjesr-vol6-iss1-2023(61-67)

Sharifov, G. (2024). Enhancing lyceum physics education with Lab Disc technology: A comparative study. *Physics Education, 59*(4), 045025. https://doi.org/10.1088/1361-6552/ad4b85

Sontay, G., & Karamustafaoğlu, O. (2023). Physics teachers' opinions on Algodoo training. *Journal of Science Learning, 6*(1), 117–124. https://doi.org/10.17509/jsl.v6i1.49285

Sullanmaa, J., Pyhältö, K., Pietarinen, J., & Soini, T. (2019). Curriculum coherence as perceived by district-level stakeholders in large-scale national curriculum reform in Finland. *The Curriculum Journal, 30*(3), 244–263. https://doi.org/10.1080/09585176.2019.1607512

Tao, G. (2023). Systematic integration of information big data and physics teaching based on deep learning algorithms. *Applied Mathematics and Nonlinear Sciences, 9*(1). https://doi.org/10.2478/amns.2023.2.01044

Taşlıdere, E. (2020). Factors affecting 12th-grade students' physics achievement. *Psychology in the Schools, 57*(9), 1385–1403. https://doi.org/10.1002/pits.22415

White, S., & Tyler, J. (2015). Who's teaching what in high school physics? *The Physics Teacher, 53*(3), 155–157. https://doi.org/10.1119/1.4908083

Wu, C. (2024). Research on the influence of PE teaching reform based on behavioral psychology on college students' mental health. *International Journal of Membrane Science and Technology, 10*(3), 3427–3432. https://doi.org/10.15379/ijmst.v10i3.3377

Yan, C. (2014). 'We can't change much unless the exams change': Teachers' dilemmas in the curriculum reform in China. *Improving Schools, 18*(1), 5–19. https://doi.org/10.1177/1365480214553744

Yanti, V., Suliyanah, S., Safitri, N., & Deta, U. (2021). Evaluation of the implementation of cross-interest physics subject for non-mathematics and natural sciences students at senior high school. *Journal of Innovation in Educational and Cultural Research, 2*(1), 17–24. https://doi.org/10.46843/jiecr.v2i1.22

Yao, T. (2023). Lack of interest cultivation: The impact of exam-oriented education on Chinese school physical education. *International Journal of Academic Research in Progressive Education and Development, 12*(4). https://doi.org/10.6007/ijarped/v12-i4/19562

Zhang, J., Cabrera, J., Niu, C., Zippay, C., & Dietrich, S. (2021). Pre-service teachers' perceived preparedness in clinically oriented and traditional teacher preparation programs. *Journal of Education, 203*(3), 639–650. https://doi.org/10.1177/00220574211053581

Zhu, X., Ennis, C., & Chen, A. (2011). Implementation challenges for a constructivist physical education curriculum. *Physical Education and Sport Pedagogy, 16*(1), 83–99. https://doi.org/10.1080/17408981003712802