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Investigating the Integration of Sustainability in Physics Education: Teacher Perceptions and Student Motivation in UAE Secondary Schools

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Abstract

This study examines how sustainability is integrated into the secondary physics curriculum in the UAE, focusing on teachers' perceptions, curricular coverage, and student motivation. Using a mixed-methods approach, surveys were conducted with 200 physics teachers and 250 secondary students in Al Ain. The results showed that while teachers recognize the importance of sustainability, its coverage in the curriculum is limited. Teachers reported moderate confidence in teaching sustainability topics, emphasizing the need for professional development. Students demonstrated strong awareness of sustainability issues, high motivation to engage in related activities, and an understanding of physics' relevance to environmental challenges. The study highlights the need for curricular reforms in UAE secondary education, professional development for teachers, and the integration of interdisciplinary and active learning approaches to foster critical thinking and environmental responsibility. These steps will help prepare students to address both local and global sustainability challenges effectively.

Keywords: *Sustainability Education, Physics Curriculum, UAE Secondary Schools, Teacher Perceptions, Student Motivation, Environmental Awareness, Curriculum Integration, Professional Development, Interdisciplinary Approaches, Active Learning.*

Introduction

Physics is a fundamental science that helps us understand how our world works, explaining the behavior of physical systems and significantly contributing to societal progress. Its importance extends beyond academia, influencing critical fields like engineering and technology, where physics knowledge and mathematical proficiency are essential. The value of physics education is widely recognized both within scientific communities and among the public.

Understanding physics is essential for building a scientifically literate and innovative society. Countries that prioritize physics education produce scientists, engineers, and innovators who drive advancements and foster progress. High-quality physics programs, such as those offered by the International Baccalaureate, illustrate the importance of engaging teaching methods that make learning meaningful and diverse (Bako, 2020). Effective physics education promotes active learning, allowing students to develop skills through practical, hands-on activities that they can also practice at home. Educators have a responsibility to employ methods that accommodate diverse learners, spark their curiosity, and develop their abilities comprehensively (Vire &Tammy, 2022)

Students' attitudes toward physics significantly influence their academic choices and outcomes.

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Teachers prefer that students consciously choose physics despite recognizing its challenges. Thus, establishing a positive connection between students and the subject is crucial for retaining their interest and enhancing their educational experiences (Korsunsky, 2001). Students often encounter difficulties with physics concepts, leading them to avoid interactions in class, which negatively affects their learning. It is essential for educators to proactively address these challenges, as students' attitudes and decisions greatly shape their perception of physics. Teachers, through effective interaction and supportive classroom environments, play a crucial role in influencing student engagement (Camci Erdogan, 2019).

In the UAE, the Emirates School Establishment (ESE) significantly shapes physics education trends and influences students' attitudes toward the subject. According to recent international assessments, such as the 2021 Program for International Student Assessment (PISA), the UAE ranked 42nd in science globally. Additionally, the 2020 Trends in International Mathematics and Science Study (TIMSS) showed that UAE schools ranked 34th in science for eighth graders (ElSayary, 2023).

This paper aims to examine the various factors influencing students' decisions to engage with physics, particularly focusing on sustainability-related concepts. By promoting physics education through university initiatives and career guidance, the study seeks to foster students' academic and professional growth in the science fields.

The UAE educational system, like many others globally, aims to address critical future challenges such as sustainable economic growth, job creation, and innovation, aligning with the nation's long-term vision. The Ministry of Education emphasizes the increasing pressure on schools to achieve sustainability and innovation goals. Central to the UAE's innovation strategy is fostering a culture of innovation at all educational levels, equipping students with the skills necessary for advancement in science and engineering. Notably, the UAE's higher education system was ranked sixth among 148 countries in 2014, reflecting the nation's commitment to educational quality (Sameena, 2020). To sustain and enhance these educational achievements, curricula, training programs, and school facilities must align with directives from the UAE Federal Government (Al-Khaza'leh, & AlOdwan, 2023).

This study explores how secondary school physics education in the UAE integrates sustainability topics from the perspectives of teachers and students. It examines which sustainability themes are included in the curriculum, the teaching methods employed, and how students comprehend and engage with sustainability concepts in physics. The research draws on existing literature highlighting the importance of developing physics skills and applying physics knowledge to real-life sustainability issues (Nusroh et al., 2022).

Understanding these perspectives is essential for several reasons. First, it sheds light on the alignment of current educational practices with the UAE's innovation strategy. Second, it helps identify curricular gaps that need addressing to better equip students for future challenges. Finally, insights gained from this study can guide policymakers and educators in developing educational approaches that not only enhance knowledge but also encourage students to critically and innovatively address sustainability challenges.

The primary concern addressed by this study is the lack of understanding regarding how sustainability topics are integrated into the high school physics curriculum in the UAE. Although

there is widespread awareness and concern about sustainability, no specific research has examined how sustainability is taught within physics classes at the high school level in the UAE. This knowledge gap is significant, given that education strongly influences students' attitudes, critical thinking, and behaviors toward sustainability. Investigating this area is crucial for shaping effective curricular strategies and educational policies that support and enhance sustainability education in UAE schools. Therefore, this study seeks to answer the following research questions:

Q1: How do physics teachers perceive the integration of sustainability topics in secondary school physics education in the UAE?

Q2: What proportion of the physics curriculum in UAE schools is dedicated to sustainability topics, as communicated by the science community?

Q3: What factors motivate students to actively engage with sustainability-related physics topics?

Significance of the Study

This research addresses a critical gap by exploring how sustainability topics are included in high school physics education in the UAE. It examines the relationship between students' beliefs about their ability to impact scientific outcomes (science agency), their identity as physics learners, and their perceptions of sustainability. The results provide valuable insights for teachers and policymakers, helping them foster positive attitudes towards community responsibility, ethical awareness, and self-efficacy among students. By encouraging educators to incorporate diverse sustainability-focused learning materials, the study aims to nurture future generations capable of making meaningful, sustainable impacts at local, national, and global levels.

Theoretical Framework

Sustainability has become a central theme in global environmental efforts over the past three decades. The concept was formally introduced by the United Nations in the 1987 "Brundtland Report" and further reinforced through Agenda 21 at the 1992 Earth Summit in Rio de Janeiro. These foundational documents, along with the transition from the Millennium Development Goals (MDGs) to the Sustainable Development Goals (SDGs), highlight the international community's increasing commitment to promoting sustainable practices (Caputo & Leopizzi, 2021).

To understand how sustainability can be embedded into educational environments, this study adopts the Social-Ecological Systems (SES) framework. This framework emphasizes the interconnectedness between ecological and human systems, making it well-suited to analyze how educational interventions like integrating sustainability topics into physics curricula—can support long-term development and behavior change (Dreyer et al., 2022).

Literature Review

Over the past forty years, the UAE has experienced rapid social and educational transformations that align with its ambitions to foster a knowledge-based, innovation-driven society (Zekri et al., 2020). The Emirates School Establishment (ESE) has played a pivotal role in these changes by shaping educational policies and practices that prepare students for active participation in sustainable development (Hubbart, 2023).

Sustainability Topics in Physics Education

Teaching sustainability within the context of physics can be challenging, as it may evoke mixed reactions when compared to more traditional physics topics. However, there is an increasing consensus that embedding sustainability into physics instruction can enrich learning and help cultivate students' physics identity particularly for students already interested in science (Fleck, 2020).

For example, renewable energy systems and energy conservation are ideal contexts for linking sustainability to physics. These themes correspond to the "Three E's" of sustainability: economy, environment, and equity. Teaching about energy sources, sustainable materials, and conservation practices allows students to relate physics concepts to real-world issues in a way that feels relevant and meaningful (Carbajo & Cabeza, 2022; Galman & Rosario, 2021).

Numerous studies support the inclusion of sustainability in physics education, encouraging the development of school curricula that incorporate sustainability themes at three progressive levels as reported by Robertson et al., (2023).:

1. Awareness – students learn basic facts about sustainability issues.
2. Action **–** students propose potential solutions and engage in outreach efforts.
3. Transformation – students apply their understanding to solve real-world problems

In the UAE, ESE has made strides in aligning educational strategies with sustainability goals, emphasizing the importance of cultivating environmentally conscious behaviors through formal education (Al-Nuaimi & Al-Ghamdi, 2022).

Science Community Beliefs in Education

Science Agency Beliefs (SAB) refer to students' confidence in performing science-related tasks, their perceived value of science education, and expectations of outcomes from engaging in science activities. Factors such as cognitive abilities, prior experiences, family background, and personal aspirations shape these beliefs (Haatainen et al., 2021).

Recent studies suggest that understanding students' SAB is crucial for addressing disparities in science achievement and engagement. For example, Owen (2022) explored how SAB relate to students' competencies and academic choices. The Ministry of Education in the UAE has recognized the importance of fostering science agency to build a resilient, capable scientific workforce.

Encouraging science agencies also means helping students see science as a dynamic and evolving field. When students believe they and their peers can contribute to scientific progress, they are more likely to stay engaged and pursue science-related careers.

Physics Identity Development

The underrepresentation of girls and women in physics is a long-standing challenge, typically becoming evident around age 15 and persisting into higher education and professional settings (Zohar & Bronshtein, 2005). Teachers, peers, and role models play a powerful role in shaping students' views of physics and their place within it (De Winter & Airey, 2022).

Physics identity-the degree to which students see themselves as "physics people"—is a strong predictor of persistence in the subject. Building this identity requires positive school

experiences, supportive social environments, and opportunities to connect physics to meaningful, real-life contexts (Saaidin, 2020).

Yet, despite growing attention to this issue, there remains a gap in understanding how physics identity evolves over time. Research by Vignoles et al. and others has offered insights across age groups, but more is needed to pinpoint the specific factors that shape physics identity. Additionally, well-meaning attempts to promote STEM may unintentionally reinforce gender stereotypes, underscoring the need for thoughtful, inclusive teaching approaches (Breda et al., 2020).

Methodology

Integrating sustainability into high school physics education plays a vital role in developing environmentally conscious students who are prepared to address global challenges (Mei & Yang, 2019). This study seeks to examine how sustainability topics are currently embedded in the UAE's high school physics curriculum. By exploring the views of both educators and students, the research aims to provide meaningful insights that can inform curriculum design and policy development tailored to the unique educational landscape of the UAE (Dahal, 2022).

Research Design

To explore the integration of sustainability in physics education, this study employed a descriptive research design using survey methodology. The primary data collection tool was a structured questionnaire, targeting physics teachers and students in Al Ain, UAE. The teacher survey consisted of Likert-scale questions and open-ended items designed to capture educators' perceptions, confidence in teaching sustainability, and the adequacy of curriculum resources (Creswell, 2017).

A total of 200 physics teachers were selected using purposive sampling, ensuring participants had relevant experience teaching high school physics. Responses were analyzed using descriptive statistics—means, frequencies, and percentages—to identify general trends and emerging patterns across the data.

The purpose of this design was to gather in-depth insights from teachers and students about their experiences and perceptions of sustainability in physics. These findings are intended to guide future improvements in curriculum planning and teacher professional development in the UAE.

Participants

The study involved 250 Grade 12 students, aged 17–19, from two public secondary schools in Al Ain. Schools were selected for their accessibility and student diversity. One school had an enrollment of 1,721 students, while the other enrolled 1,880 students. Within each school, two classes were randomly chosen to participate. Though this method introduces a degree of selection bias, efforts were made to ensure representative participation across gender and academic ability levels.

Additionally, 200 physics teachers from schools across Al Ain took part in the study. To enrich the comparative dimension, the study also included responses from teachers of related disciplines: Chemistry (n=250), Biology (n=390), and Earth Science (n=400). This approach enabled a broader understanding of how sustainability topics are addressed across science subjects.

Data Collection Methods

Ensuring the validity and reliability of the survey tool was a top priority. The survey was constructed based on established literature and in consultation with experts in sustainability education and physics instruction (Johnson, 2014). A pilot test involving a small group of teachers was conducted to assess the clarity and relevance of the questions, allowing for necessary refinements before full implementation.

To evaluate reliability, the study employed Cronbach's alpha to assess internal consistency for the Likert-scale items. High alpha values indicated a strong level of agreement among related items, confirming reliability (Psychological Methods, 2016). Additionally, test-retest reliability was measured by administering the survey to a subset of participants at two different times and comparing results. The consistency of responses over time affirmed the stability of the instrument (Fujino et al., 2017).

By applying these rigorous validation methods, the research ensured that the data collected were both credible and robust. The findings derived from this process are intended to contribute to meaningful educational improvements in sustainability integration within physics education in the UAE.

Results

Analysis of Sustainability Topics in Physics Education

Q1: How do physics teachers perceive the integration of sustainability topics in secondary school physics education in the UAE?

The results revealed that teachers generally support incorporating sustainability topics into physics classes. They rated this positively, with an average score of 3.7 ($p < 0.001$). However, teachers also expressed concerns about the lack of sufficient curriculum coverage on these topics, with a lower average rating of 2.6 ($p < 0.001$), pointing to a significant area in need of reform.

While educators showed moderate confidence in teaching sustainability (mean = 3.4, $p < 0.001$), they expressed mixed feelings about their professional preparation—rating teacher training as neutral (mean = 3.0, $p = 1.000$). This suggests a pressing need for more targeted professional development opportunities.

Encouragingly, teachers perceived high levels of student interest in sustainability (mean = 3.6, $p < 0.001$), and they also believed that teaching these topics helps students understand physics better (mean = 3.7, $p < 0.001$) and see its real-world relevance (mean = 4.0, $p < 0.001$). Administrative support was viewed positively (mean = 3.7, $p < 0.001$), and teaching materials were considered moderately sufficient (mean = 3.4, $p < 0.001$).

Science Community Beliefs in Secondary Schools

Q2: What proportion of the physics curriculum in UAE schools is dedicated to sustainability topics, as communicated by the science community?

Survey responses showed that physics teachers feel energy demand is the most frequently discussed sustainability topic, with 85% agreement. Other well-covered topics include degradation (80%) and sustainable development (88%). Topics like energy supply (75%) and

life cycle analysis (70%) also had solid representation.

However, several key topics were found to be underrepresented. For example, only 45% of teachers said they covered water supply, and just 40% addressed disease-related topics. Climate change, biomimicry, and population growth had moderate levels of inclusion (55–60%).

Comparative data from other science disciplines—Chemistry, Biology, and Earth Science—showed that these subjects addressed a broader range of sustainability topics than physics,

Physics Identity in the UAE

Q3: What factors motivate students to engage with sustainability-related physics topics actively?

Survey results from 250 students indicated a strong understanding and appreciation for sustainability topics. Students felt confident discussing how sustainability connects with physics ($p < 0.001$), and they noted that these lessons increased their awareness of environmental issues. Many were motivated to participate in sustainability activities outside of school and believed their actions could make a meaningful difference.

Furthermore, students found sustainability-focused lessons engaging and reported feelings more connected to real-world issues. They expressed a sense of environmental responsibility and valued physics as a tool for understanding and solving global challenges. These insights suggest that integrating sustainability topics in physics not only boosts student motivation but could also influence their future career paths.

Discussion

This study shows that physics teachers in the UAE see the value of integrating sustainability into their teaching. However, current curricula do not reflect this priority, and teachers report needing more support and training. Students, on the other hand, are highly engaged and see the relevance of sustainability to both their physics education and broader societal issues.

For **Research Question 1**, teachers' average support for integration (3.7) aligns with Bako (2020), who emphasized the importance of teacher buy-in for successful innovation. Still, their reported lack of sufficient curriculum coverage (mean = 2.6) underscores a disconnect between educational goals and classroom realities.

Teachers' confidence (mean = 3.4) and the neutral view on professional development (mean = 3.0) mirror Haatainen and Turkka's (2021) findings: many educators are willing but underprepared to teach interdisciplinary topics like sustainability.

Their belief that sustainability enriches students' understanding of physics (mean = 3.7) and real-life application (mean = 4.0) echoes Carbajo & Cabeza's (2022) view that sustainability provides practical context for abstract concepts.

For **Research Question 2**, the data show uneven coverage of sustainability themes. While energy demand is widely covered (85%), topics like water supply and disease lag behind. This aligns with Grandisoli & Jacobi's (2020) findings that sustainability education often lacks consistency across science disciplines. Fleck (2020) and Robertson et al. (2023) suggest curriculum reforms are necessary to foster interdisciplinary, systems-based thinking.

For **Research Question 3**, students' enthusiasm (mean = 3.9) and interest in sustainability

activities (mean = 3.6) affirm Mei & Yang's (2019) conclusion that real-world connections enhance student engagement. Their increased awareness (mean = 4.1) supports Saijo's (2020) view that education is key to building environmental responsibility. Active learning strategies and classroom discussions were also found to be significant motivators, echoing Karan & Brown's (2022) recommendations.

Conclusion

This study examined the integration of sustainability topics in UAE secondary school physics education. It found a clear recognition of the importance of sustainability among teachers and strong motivation among students. Yet, curriculum content has not kept pace with these priorities. Teachers need better training and resources, and the curriculum requires reform to embed sustainability more thoroughly.

Students showed high engagement with sustainability topics, recognizing their value in understanding global challenges and guiding future careers. Interdisciplinary approaches and hands-on learning methods appear to be especially effective in driving this engagement.

To align with the UAE's vision for innovation and sustainability, the study calls for deeper curriculum integration of sustainability themes, improved teacher preparation, and expanded use of active learning strategies. Future research should track the long-term effects of sustainability education on students' academic paths and career choices.

Implications & Recommendations

Implications

1. Curriculum Development: Sustainability should be embedded more systematically into the physics curriculum to promote deeper understanding of environmental challenges and align with national strategies like UAE Vision 2021.
2. Teacher Training: Teachers need targeted professional development to build the confidence and competence required to effectively teach sustainability.
3. Student Engagement: Making clear connections between physics and real-world sustainability issues, especially those linked to future careers, can enhance motivation and interest.
4. Resource Allocation: Schools should invest in resources like lab equipment, textbooks, and digital tools that support hands-on learning and sustainability-focused education.

Recommendations

1. Integrate Sustainability Across Subjects: Collaboration among science disciplines can give students a more holistic view of sustainability, encouraging systems thinking and interdisciplinary learning.
2. Engage with the Local Community: Involve local industries and organizations in sustainability education through guest speakers, field trips, and project-based learning.
3. Regular Assessment and Feedback: Use formative assessments to monitor students' understanding of sustainability topics and adjust instruction accordingly.
4. Promote Active Learning: Encourage classroom activities like group discussions, real-

world problem solving, and project-based assignments that develop critical thinking.

5. Highlight Career Pathways: Inform students about career options in sustainability and related STEM fields to inspire them to pursue further education and make meaningful contributions.

By implementing these strategies, schools in the UAE can strengthen sustainability education in physics and empower students to become proactive contributors to a sustainable future.

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