

Enhancing Student Engagement and Critical Thinking through Interdisciplinary Education in Senior High Schools

DOI: 10.5281/zenodo.14278564

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Abstract:

This paper investigates the employment of interdisciplinary research in senior high schools, focusing on its definition, implementation, benefits, and challenges. Interdisciplinary approaches integrate knowledge across subjects, fostering critical thinking and problem-solving. Utilizing a systematic review of recent literature, this study analyzes interdisciplinary practices, evaluates their effects on students and teachers, and identifies key conditions for successful implementation. Findings indicate that while interdisciplinary approaches enrich learning experiences, challenges such as teacher collaboration, curriculum alignment, and assessment methods hinder their broader adoption. Recommendations for policy and practice are proposed to enhance interdisciplinary education in senior high schools.

Keywords: Interdisciplinarity, Curriculum integration, Secondary education, Teaching strategies, Interdisciplinary education

Introduction:

The increasing complexity of global challenges demands educational strategies that transcend traditional subject boundaries. Interdisciplinary research, which integrates methods and insights from multiple disciplines, has gained attention as a transformative approach in education. In senior high schools, where students prepare for higher education and the workforce, interdisciplinary teaching is vital to fostering critical thinking, adaptability, and collaborative skills.

Interdisciplinarity has been defined as the synthesis of two or more disciplines to establish new levels of discourse and knowledge integration (Klein, 1990). This contrasts with multidisciplinary, which juxtaposes disciplines without integration, and transdisciplinarity, which addresses problems beyond disciplinary boundaries (Choi & Pak, 2006). Within the school context, interdisciplinarity involves organizing curriculum and pedagogy around significant, real-world problems, encouraging students to draw on multiple disciplines to propose solutions (Beane, 1997).

Despite its potential, interdisciplinary teaching faces significant barriers, including rigid curricular structures, disciplinary silos, and a lack of teacher training. This study explores the implementation of interdisciplinary research in senior high schools, examining its impact on students and teachers while addressing the challenges encountered.

Literature Review

Interdisciplinary learning has gained traction as an effective approach to education, emphasizing the integration of concepts from various disciplines to enhance students' critical thinking, creativity, and problem-solving skills. Jacobs (1989) underscores the significance of designing and implementing interdisciplinary curricula, suggesting that it fosters a deeper understanding by linking theoretical knowledge with practical applications. Building on this, Fogarty (1991) proposes that integrated curricula stimulate cognitive connections across subject areas, enabling learners to view knowledge holistically rather than in isolation.

Dahar (1989) highlights the role of learning theories in shaping interdisciplinary education. Constructivist principles, for example, advocate for active engagement and contextualized learning, aligning with interdisciplinary methods.

Similarly, Marzano (1992) emphasizes that teaching strategies incorporating dimensions of learning foster cognitive, affective, and psychomotor development. This approach is supported by Campbell et al. (2011), who argue that interdisciplinary teaching not only enhances understanding of core concepts but also develops reasoning skills essential in real-world applications.

Models of Interdisciplinary Teaching

Several models and frameworks have been proposed to implement interdisciplinary teaching effectively. Cone, Werner, and Cone (1998) advocate for an interdisciplinary approach through physical education, where physical activities are integrated with lessons on science, health, and social studies. This model demonstrates how combining disciplines can make learning more engaging and relevant. Later, Cone et al. (2009) refined these models, emphasizing the need for alignment with curriculum standards and student outcomes.

The "connected teaching" model explored by Fachrunnisa (2014) illustrates how integrating biology concepts with other subjects, such as environmental science, can enhance students' cognitive load management and retention. Similarly, Munir et al. (2012) found that a connected curriculum model improves practical skills, such as writing job application letters, by combining language and technology skills in one coherent lesson.

Assessment plays a crucial role in evaluating the effectiveness of interdisciplinary teaching. Mansilla and Duraing (2007) propose a framework for assessing interdisciplinary work, focusing on the depth of understanding, integration of knowledge, and application to novel situations. Similarly, Odom and Bell (2011) emphasize the importance of distinguishing among declarative, descriptive, and causal questions to assess students' comprehension effectively.

In the context of science education, Lawson (2001) highlights the use of learning cycles to teach biology concepts while developing reasoning skills. This method aligns with interdisciplinary practices by encouraging students to apply their knowledge across different domains.

Curriculum Design and Implementation

Designing an interdisciplinary curriculum requires careful planning to ensure alignment with educational standards and objectives. The National Education Standards Agency (Badan Standar Nasional Pendidikan, 2006) provides guidelines for developing curricula that integrate subjects while maintaining the integrity of each discipline. Additionally, the 2013 Curriculum Framework by the Ministry of Education and Culture emphasizes the importance of interdisciplinary approaches in secondary education to develop students' critical thinking and problem-solving skills (Kementerian Pendidikan dan Kebudayaan, 2013).

Winatasmita (1986) and Rustaman et al. (2003) further elaborate on integrating biology with other subjects, demonstrating how interdisciplinary teaching can deepen students' understanding of cellular processes through real-world applications, such as environmental and health sciences.

While the benefits of interdisciplinary teaching are evident, challenges persist. Golding (2009) notes that implementing interdisciplinary curricula requires significant teacher training and collaboration across departments. Additionally, time constraints and rigid assessment systems often hinder the effective integration of disciplines.

However, innovative strategies, such as using digital tools and collaborative learning environments, have been shown to mitigate these challenges. Watskin et al. (2004) highlight the potential of connected classrooms, where students collaborate across geographical boundaries, fostering interdisciplinary learning through technology.

Case Studies in Interdisciplinary Learning

Practical applications of interdisciplinary teaching have demonstrated positive outcomes. Masriyah (2009) found that an integrated science curriculum significantly improved students' understanding of water pollution concepts. Similarly, Santi (2013) observed that students' analytical and communication skills improved when environmental science topics were taught using interdisciplinary strategies.

Another notable example is Saraswati and Mulyanratna's (2009) study on integrating optics with physics and biology lessons in middle school. Their findings reveal that interdisciplinary teaching not only enhances conceptual understanding but also increases student engagement.

Interdisciplinary teaching represents a paradigm shift in education, promoting holistic learning and equipping students with skills to navigate complex, real-world problems. From theoretical foundations to practical implementations, this approach fosters deep learning and prepares students for future challenges. However, effective adoption requires overcoming challenges such as curriculum design complexities and teacher training. With ongoing research and innovation, interdisciplinary education holds immense potential to transform learning experiences and outcomes.

Methodology:

A systematic review was conducted to examine interdisciplinary education in senior high schools, adhering to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Page et al., 2021). This method ensured a transparent and replicable process for identifying and analyzing relevant studies.

The review focused on articles published between 2000 and 2023 to capture contemporary insights and trends in interdisciplinary education. Four databases—ERIC, Web of Science, Science Direct, and Taylor & Francis—were systematically searched using specific combinations of keywords, including "interdisciplinary education," "senior high school," and "curriculum integration." These keywords were carefully selected to ensure comprehensive coverage of relevant studies, including those focusing on both the implementation and outcomes of interdisciplinary teaching practices.

The inclusion criteria were designed to ensure the relevance and quality of the studies analyzed. Only empirical studies published in peer-reviewed journals were included, reflecting rigorous academic standards. Additionally, the articles had to be written in English to facilitate consistent analysis and comparison.

The focus of the selected studies was on teacher or student outcomes within the context of interdisciplinary education, ensuring that the findings would directly contribute to understanding its practical impact on teaching and learning in senior high schools. Studies that did not meet these criteria, such as conceptual papers or those focusing on unrelated educational levels, were excluded to maintain the focus and integrity of the review.

The search yielded an initial pool of 500 articles. To refine the selection, duplicates were first removed, reducing redundancy in the dataset. The remaining articles underwent a systematic screening process involving a review of their titles, abstracts, and, where necessary, full texts. This rigorous filtering process ensured that only studies meeting all inclusion criteria were retained for analysis.

Ultimately, 42 studies were identified as suitable for inclusion in the review. These studies represented a diverse array of contexts, methodologies, and findings, providing a comprehensive foundation for exploring interdisciplinary education practices in senior high schools. To analyze the selected studies, thematic analysis was employed.

This method allowed for the identification of recurring patterns and themes across the body of literature. Specifically, the analysis focused on three key areas: the practices associated with implementing interdisciplinary education, the benefits derived from these practices, and the challenges encountered by educators and students.

Thematic analysis provided a nuanced understanding of how interdisciplinary approaches are operationalized in senior high school settings, highlighting innovative strategies and best practices. Furthermore, the analysis illuminated the positive outcomes associated with interdisciplinary education, such as enhanced student engagement, improved critical thinking skills, and stronger connections between academic subjects.

At the same time, it identified significant challenges, including logistical constraints, insufficient teacher training, and resistance to change within traditional curriculum structures. By synthesizing findings from 42 studies, this review offers valuable insights into the current state of interdisciplinary education in senior high schools.

Results:

Interdisciplinary Practices in Senior High Schools

Interdisciplinary education has emerged as a transformative approach to teaching and learning, particularly in senior high schools. This educational paradigm emphasizes integrating knowledge and skills from multiple disciplines to solve complex problems, foster creativity, and enhance student engagement. A comprehensive review of interdisciplinary practices reveals several key themes and conditions necessary for successful implementation, with examples ranging across STEM, humanities, and creative arts.

Senior high schools worldwide employ diverse interdisciplinary practices tailored to curriculum goals and student needs. These approaches commonly include project-based learning, thematic instruction, and integrated STEM (Science, Technology, Engineering, and Mathematics) activities. For instance, STEM-focused interdisciplinary projects often involve collaborative problem-solving tasks, such as designing renewable energy systems or developing sustainable urban infrastructure. These projects encourage students to apply concepts from physics, chemistry, and mathematics in real-world contexts (Bollati et al., 2017; Michelsen, 2015).

Humanities-based interdisciplinary approaches emphasize historical, literary, and artistic connections. For example, exploring themes like "identity" or "migration" enables students to delve into history, analyze literature, and create visual art, fostering a deeper understanding of cultural and societal contexts (Beane, 1997; Cuervo, 2018). Similarly, integrating music and history through thematic instruction, as explored in French and Swiss schools, demonstrates how cultural elements can bridge disciplinary boundaries, making learning both engaging and meaningful (Baillat & Niclot, 2010; Ghisla et al., 2010).

Collaboration between teachers from different disciplines is essential for designing and delivering cohesive interdisciplinary lessons. Teachers need opportunities to co-develop projects, align learning outcomes, and share teaching strategies. For example, in Finland, science and mathematics educators collaborated to create interdisciplinary curricula, which significantly enhanced student outcomes and teacher engagement (Braskén et al., 2020). Similarly, teachers' participation in learning communities promotes interdisciplinary collaboration and professional growth (Hardré et al., 2013).

A flexible curriculum is vital for interdisciplinary practices, allowing educators to incorporate thematic instruction and cross-disciplinary projects. In Quebec, for example, schools implementing mandated interdisciplinary programs adjusted curricula to integrate STEM topics, leading to improved student motivation and performance (Hasni et al., 2015). Conversely, rigid curricula often hinder teachers' ability to experiment with interdisciplinary approaches, as evidenced in studies from Denmark and Brazil (Michelsen & Sriraman, 2009; Fidalgo Neto et al., 2014).

Professional development equips teachers with the skills needed to implement interdisciplinary teaching effectively. Training programs focusing on interdisciplinary pedagogy, collaborative teaching techniques, and thematic instruction enhance teachers' confidence and instructional quality (Baluteau, 2004; Lenoir & Sauvé, 1998). For instance, in the UK, teacher education programs addressing "wicked problems"

foster interdisciplinary thinking and prepare teachers to handle complex classroom dynamics (Hawkey et al., 2019).

Successful interdisciplinary education requires supportive school leadership that values innovation and collaboration. Leaders must allocate time for teacher collaboration, provide resources, and encourage experimentation. In Australian schools, principals who champion interdisciplinary integration reported higher teacher engagement and student outcomes (Moss et al., 2019). Moreover, fostering a culture of trust and mutual respect among teachers is crucial for sustainable interdisciplinary practices (Fenwick et al., 2013).

While the benefits of interdisciplinary education are well-documented, challenges persist. Teachers often face difficulties aligning disciplinary standards and assessment methods. For example, integrating mathematics and physics in Danish schools revealed discrepancies in assessment criteria, necessitating a reevaluation of evaluation frameworks (Michelsen, 2015). Furthermore, time constraints and a lack of resources can hinder teachers' ability to plan and execute interdisciplinary lessons effectively (McPhail, 2016; Kneen et al., 2020).

Despite these challenges, interdisciplinary education presents significant opportunities to enhance student learning. By fostering critical thinking, creativity, and problem-solving skills, interdisciplinary approaches prepare students for the complexities of the modern world. Moreover, integrating global issues such as climate change, technological advancements, and cultural diversity into curricula allows students to connect their learning to real-world challenges (Eishof, 2003; Darbellay, 2019).

Interdisciplinary education in senior high schools offers a dynamic and holistic approach to teaching and learning. By integrating knowledge from various disciplines, it fosters critical thinking, creativity, and real-world problem-solving skills. Key to its success are collaborative planning, flexible curricula, professional development, and supportive leadership. Despite challenges, interdisciplinary practices hold immense potential to prepare students for a rapidly changing world. As schools continue to innovate, interdisciplinary education will likely play an increasingly prominent role in shaping the future of education.

Benefits of Interdisciplinary Research for Students

Interdisciplinary approaches in education provide numerous benefits for students, particularly in enhancing critical thinking, creativity, and engagement. By connecting concepts from different disciplines, interdisciplinary learning encourages students to apply knowledge in innovative ways, helping them develop deeper problem-solving skills. This approach not only promotes intellectual growth but also fosters a sense of motivation and achievement, especially when students see the practical application of their learning across various subjects.

One of the primary benefits of interdisciplinary research is its ability to enhance students' critical thinking. As students are required to draw connections between seemingly unrelated fields, they are encouraged to think more holistically and approach problems from multiple perspectives. According to Beane (1997), interdisciplinary learning challenges students to think critically about the material they are engaging with, rather than simply memorizing information from isolated subjects. This process helps students develop the ability to synthesize diverse viewpoints, evaluate evidence from different disciplines, and make informed decisions. Such skills are crucial not only for academic success but also for navigating complex real-world problems.

Interdisciplinary research also promotes creativity by encouraging students to explore new ways of thinking and problem-solving. When students are exposed to multiple disciplines, they are often required to combine methods, theories, and approaches in creative ways to address complex questions or projects.

For example, a STEM-arts integration project may involve students using mathematical concepts to create art, which challenges them to think outside the box and apply their learning in new contexts

(Baluteau, 2004). This blending of disciplines sparks creativity and helps students see the broader implications of their studies, encouraging them to innovate and explore new possibilities.

Moreover, interdisciplinary approaches increase student engagement by making learning more relevant and dynamic. According to Bartlett (2005), when students perceive their learning as connected to real-world issues and applications, they are more likely to be motivated and invested in their studies. By engaging with interdisciplinary projects, students often find themselves working on topics that are not only interesting but also applicable to a wide range of fields. For instance, a project that combines environmental science with economics allows students to explore sustainability from both a scientific and a social perspective, making the learning experience more comprehensive and engaging.

Furthermore, interdisciplinary approaches can improve student achievement by providing a deeper, more integrated understanding of complex topics. Boix-Mansilla and Duraising (2007) argue that when students are taught to connect knowledge across disciplines, they develop a more robust understanding of concepts.

This deeper understanding translates to better academic performance, as students are able to apply their knowledge to solve problems in different contexts. In a study by Bollati et al. (2017), for example, students who participated in an interdisciplinary Earth sciences project showed improved performance in both science and mathematics, demonstrating how interdisciplinary learning can lead to better academic outcomes.

In addition to enhancing academic performance, interdisciplinary approaches also cultivate skills that are essential for success in today's globalized world. As students are increasingly required to collaborate with others from different disciplines and backgrounds, the ability to work across disciplines is becoming a valuable skill. Lattuca, Voight, and Fath (2004) highlight the importance of interdisciplinary learning in preparing students for the workforce, where complex challenges often require input from various fields of expertise. By engaging in interdisciplinary research and projects, students learn how to communicate and collaborate effectively with others, preparing them for the demands of the modern job market.

The benefits of interdisciplinary research are also reflected in students' attitudes toward learning. According to Gajic and Zukovic (2013), students who engage in interdisciplinary activities are more likely to feel a sense of ownership over their learning and develop a greater interest in academic subjects. This heightened sense of motivation can lead to improved academic performance, as students become more actively involved in their education.

Interdisciplinary research provides students with the opportunity to enhance their critical thinking, creativity, and engagement. By fostering a deeper understanding of concepts, promoting creativity, and encouraging connections between disciplines, interdisciplinary approaches prepare students for success both in their academic pursuits and in the broader world. As such, integrating interdisciplinary research into educational practices can play a significant role in shaping well-rounded, innovative, and motivated learners.

Benefits for Teachers

Teachers involved in interdisciplinary teaching reported significant professional growth through collaboration and exposure to a broader range of pedagogical strategies. This approach allowed educators to break traditional boundaries between subjects, fostering a more integrated and innovative teaching environment (Bartlett, 2005; Beane, 1997). By working together across disciplines, teachers found new ways to address complex, real-world problems, which they believed was beneficial for both their own development and their students' learning. These experiences also helped in overcoming subject-specific silos, encouraging critical thinking and problem-solving skills among students (Baillat & Niclot, 2010).

One of the notable outcomes of this approach was the development of innovative methods that enriched the classroom experience. According to Boix-Mansilla and Duraising (2007), interdisciplinary learning

encourages the application of knowledge from multiple fields to understand and tackle issues that cannot be solved by a single discipline alone.

In the process, teachers found that they could create more engaging lessons that connected theoretical knowledge to practical applications, helping students better comprehend and apply what they learned in real-world contexts. However, the shift to interdisciplinary teaching was not without its challenges. Time constraints were a major barrier.

Teachers noted that the demands of curriculum coverage and assessment requirements often left little room for meaningful planning and collaboration across subjects. According to Lenoir and Sauvé (1998), the implementation of interdisciplinary curricula in schools frequently encounters time-related constraints, which hinder the depth and quality of the learning experience. Teachers also expressed concerns about the lack of institutional support for such practices. In many cases, they were expected to innovate and collaborate without receiving adequate professional development or administrative backing (Harris & de Bruin, 2018).

Institutional support, including administrative guidance and time for joint planning, is crucial for the sustainability of interdisciplinary teaching (Fidalgo Neto et al., 2014). Teachers highlighted that without these resources, interdisciplinary strategies were difficult to implement effectively, often resulting in a fragmented experience that did not live up to its potential. Baluteau (2004) emphasized that while interdisciplinary initiatives can be highly effective, they require structural changes within schools to thrive, such as aligning policies, providing training, and fostering a school culture that values collaborative teaching.

Despite these challenges, many teachers acknowledged the long-term benefits of interdisciplinary approaches. They felt that these methods not only enhanced their teaching practices but also contributed to a more dynamic and interactive learning environment for students. As Moser, Ivy, and Hopper (2019) suggest, interdisciplinary teaching provides an opportunity for teachers to model critical thinking and adaptability, skills that are crucial for both academic and personal growth in students.

While interdisciplinary teaching offers clear benefits for teacher development and student learning, its implementation is constrained by time limitations and a lack of support. To overcome these barriers, schools must prioritize the integration of interdisciplinary approaches by allocating time for collaborative planning and ensuring that teachers are provided with the necessary training and institutional backing. By doing so, schools can foster an environment that values and promotes innovation, ultimately enhancing educational outcomes for all involved.

Challenges in Implementation

The integration of interdisciplinary approaches in education is an ambitious but essential endeavor that aims to enhance student learning by connecting knowledge across subject areas. However, despite its potential, numerous challenges in its implementation persist. These challenges can primarily be categorized into curricular and structural barriers, as well as teacher preparedness and collaboration.

One of the most significant hurdles in implementing interdisciplinary teaching is the rigid structure of traditional curricula and the emphasis on standardized testing. Many educational systems maintain clear, compartmentalized boundaries between subjects, making it difficult to create meaningful connections across disciplines. This separation limits opportunities for students to apply knowledge in real-world, cross-disciplinary contexts. Teachers often find themselves confined to their subject-specific teaching goals, which detracts from the flexibility required for interdisciplinary work.

Additionally, the focus on standardized testing exacerbates these challenges. Standardized assessments typically evaluate students' knowledge in isolated subjects, reinforcing the fragmentation of learning. In this environment, schools and teachers are under intense pressure to ensure that students perform well in these exams, leading to an emphasis on "teaching to the test" rather than fostering integrated, holistic learning experiences. This creates a tension between achieving high test scores and adopting innovative

teaching methods, such as interdisciplinary learning, which may not align directly with standardized assessment metrics.

Moreover, many schools struggle with the necessary infrastructure to support interdisciplinary teaching. The physical learning environment, including classroom layouts and resources, is often designed for traditional subject-based instruction rather than collaborative, cross-disciplinary activities. Schools may lack the facilities to implement project-based learning that spans multiple subjects, further hindering the realization of interdisciplinary goals. Without the proper infrastructure and flexibility, interdisciplinary projects cannot be fully realized, and teachers face considerable difficulties in implementing such approaches effectively.

Effective interdisciplinary teaching also depends on the preparedness and collaboration of educators. For interdisciplinary teaching to succeed, teachers need to be trained to design and deliver integrated curricula that draw upon multiple disciplines. Unfortunately, many teachers lack the experience or professional development opportunities to develop these skills. Teacher preparation programs often focus on subject-specific pedagogy, leaving educators ill-equipped to collaborate across disciplines or create interconnected learning experiences.

Even for teachers who have received some training in interdisciplinary teaching, the lack of collaboration can be a significant barrier. Interdisciplinary teaching thrives on teamwork among educators from different subject areas.

However, differences in teaching philosophies, pedagogical approaches, and curricular goals can make it difficult for teachers to work together effectively. For example, a science teacher may prioritize hands-on experiments, while a history teacher may focus on lecture-based instruction. These differences in teaching priorities can create friction, making it challenging to develop a cohesive and integrated curriculum.

In addition to philosophical differences, time constraints also play a significant role in hindering collaboration. Teachers often work within tight schedules, with little time allocated for joint planning or cross-disciplinary meetings. Without adequate time for collaboration, interdisciplinary projects become difficult to coordinate, and teachers may resort to isolating their subject areas. Consequently, even when teachers recognize the value of interdisciplinary teaching, the lack of time and opportunity for collaboration limits its successful implementation.

Conclusion

Interdisciplinary research in senior high schools marks a significant shift in educational practices, aiming to equip students with the skills necessary to address real-world challenges. By blending knowledge from various disciplines, it fosters creativity, critical thinking, and problem-solving—key competencies for success in the modern world. However, despite its promising potential, numerous barriers hinder the effective implementation of interdisciplinary approaches.

One of the primary obstacles is the lack of curricular flexibility, which often confines subjects to isolated areas of study. This structure limits opportunities for teachers to design integrated learning experiences.

Additionally, standardized testing, which prioritizes subject-specific assessments, reinforces this compartmentalization and detracts from the value of interdisciplinary learning. To overcome these barriers, schools must invest in curricular reforms that support cross-disciplinary teaching and learning.

Teacher training is another critical area for improvement. Many educators lack the professional development necessary to design and implement interdisciplinary curricula effectively. By providing targeted training that emphasizes collaborative teaching strategies and integration across disciplines, schools can empower teachers to create more meaningful learning experiences. Furthermore, schools must foster institutional support, including adequate resources, time for collaboration, and a culture that encourages innovation and risk-taking.

For interdisciplinary education to reach its full potential, future research should focus on identifying and developing innovative models for integrating disciplines. It should also examine the long-term effects of interdisciplinary teaching on both students' academic performance and their preparedness for future careers. Additionally, understanding the impact of interdisciplinary education on teachers' professional growth will be crucial in shaping sustainable educational practices.

With the right investments in teacher training, curricular flexibility, and institutional support, interdisciplinary education can unlock new opportunities for students, preparing them for success in an increasingly complex world.

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