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STREAMING: A Comprehensive Approach to Inclusive STEM Education

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Abstract. This article introduces the innovative concept of STREAMING, which integrates Science, Technology, Robotics, Engineering, A.I, Mathematics,Intelligence & Emotional Intelligence, Inclusion, and Gamification to create a comprehensive and inclusive educational framework. By examining existing literature, this narrative review highlights the potential of STREMING to enhance educational practices and ensure equal opportunities for all students, particularly those from underrepresented backgrounds. Key findings from various studies emphasize the effectiveness of inclusive STEM high schools, the benefits of integrating Universal Design for Learning (UDL), and the impact of gamification on student engagement and learning outcomes. The review demonstrates that STREAMING can foster a more inclusive, engaging, and effective educational environment, equipping students with the necessary skills and knowledge to navigate and contribute to an increasingly complex and technologically advanced society.
Keywords:STREAMING, STEM education, Inclusive education, Gamification, Robotics in education, Underrepresented students

Introduction

In the dynamic landscape of modern education, there's a growing recognition that our traditional teaching models need to evolve to better prepare students for the complexities of the future. One emerging approach that addresses this need is STREAMING, an educational framework that integrates Science, Technology, Robotics, Engineering, Artificial Intelligence, Mathematics, Intelligence & Emotional Intelligence, Inclusion, and Gamification.

This innovative model seeks to create a more comprehensive learning experience that not only imparts technical knowledge but also fosters critical thinking, creativity, and inclusivity. STREAMING is not just about mastering subjects; it's about connecting these disciplines in meaningful ways to inspire students to think broadly and solve problems innovatively.

For instance, the inclusion of Robotics and Artificial Intelligence in the curriculum encourages students to engage with cutting-edge technologies, fostering a hands-on understanding of concepts that are increasingly relevant in today's world. Meanwhile, the emphasis on Inclusion ensures that these advancements are accessible to all students, promoting equity in education.

Additionally, the Gamification aspect of STREAMING transforms learning into an engaging and interactive process. By incorporating game-based elements, educators can enhance motivation and participation, making complex subjects more approachable and enjoyable.

This article aims to explore the fundamental elements of STREAMING, understanding its importance, and considering the potential it holds for transforming education to meet the demands of a rapidly changing world. By examining each component, we can better appreciate how STREAMING offers a holistic and future-oriented approach to learning that prepares students not just for academic success, but for life.

Methods and materials

The current study explores the novel concept of STREAMING, which integrates Science, Technology, Robotics, Engineering, A.I., Mathematics, Intelligence & Emotional Intelligence, Inclusion, and Gamification, aiming to provide a comprehensive and inclusive educational framework. Methodologically, a narrative review was utilized to examine the existing literature and its implications on enhancing educational practices and inclusivity within STEM fields. The narrative review approach was chosen for its flexibility and comprehensive nature, allowing a multifaceted examination of diverse educational practices and outcomes (Collins & Fauser, 2005; Snyder, 2019).

The review was conducted across several international bibliographic databases, including Google Scholar and ResearchGate. The search phrases used included "STEM education," "inclusion in education," "gamification in learning," "robotics education," "inclusive STEM," and "educational gamification." The research process encompassed multiple stages:

1. Search for Sources: Articles were identified based on the specified keywords.
2. Selection of Articles: Relevant articles were chosen according to their alignment with the research objectives.
3. Categorization of Articles: The selected articles were categorized based on their content, focusing on inclusion, gamification, and STEM education.
4. Writing of the Study: The synthesis of the gathered information led to the development of the study's narrative.

This comprehensive review of the literature establishes a foundation for understanding the importance and implementation of STREMING in modern education. It provides a basis for future research and practical applications aimed at improving educational outcomes through inclusive and engaging teaching methodologies.

Theoretical background

STEM for all

This section of the paper into the critical importance of making STEM (Science, Technology, Engineering, and Mathematics) education accessible and inclusive for all students, particularly those with disabilities. In this section, we explore various research studies that highlight innovative frameworks and methodologies designed to enhance STEM learning experiences for diverse student populations. By focusing on inclusive educational practices, this section aims to provide insights into how educators and policymakers can create equitable learning environments that support the participation and success of every student in STEM fields. Through the integration of Universal Design for Learning (UDL)(Courey et al., 2013), the use of virtual labs(Kefalis et al., 2023), and the implementation of modified instructional models, these studies offer valuable strategies to overcome barriers and promote STEM education for all.

The study "An Ecological Model of STEM Education: Operationalizing STEM FOR ALL" (Basham et al., 2010) by James D. Basham, Maya Israel, and Kathie Maynard from the University of Cincinnati's Fusion Center, examines an inclusive framework for STEM education, particularly for students with disabilities. Utilizing Bronfenbrenner's ecological model, the study highlights the complex interactions among various stakeholders—policy makers, curriculum developers, teachers, and students—to improve STEM education accessibility and effectiveness. The methodology involved applying lessons from the Furthering Urban STEM Innovation, Outreach, & New Research (UC|FUSION) research and outreach center, focusing on Ohio schools. This included developing partnerships and networks, redesigning schools to adopt Universal Design for Learning (UDL) principles, and integrating modern instructional tools. Notable examples include the transformation of Taft STEM Elementary School, which was overhauled to provide a UDL-based STEM curriculum, significantly improving student engagement and academic performance. The study's findings emphasize the importance of an interdisciplinary approach to STEM education, leveraging partnerships, and providing access to research and resources. Key results indicate that inclusive and well-supported STEM environments can lead to successful educational outcomes for all students, including those with disabilities. The ecological model framework proved effective in understanding and operationalizing the necessary systemic changes to achieve STEM for All, ensuring that diverse student populations can develop the skills needed for the 21st-century workforce.

The study titled "STEM Education with Atomic Structure Virtual Lab for Learners with Special Education Needs" (Ghergulescu et al., 2018) was conducted by a team of researchers from institutions in Ireland and Romania, including Adaptemy, University of Bucharest, National College of Ireland, and Dublin City University. This research was part of the European Horizon 2020 Project NEWTON, which aims to innovate and enhance technology-based learning. The study focused on a small-scale pilot involving twelve secondary school students with special education needs (SEN) from Ireland, specifically those with hearing impairments. These students, comprising three boys and nine girls, participated in various stages of the assessment before and after using the Atomic Structure Virtual Lab. The evaluation methodology, established by the NEWTON Pedagogical Assessment Committee, included pre- and post-interaction assessments using tools such as the Torrance Tests of Creative Thinking (TTCT) Questionnaire, a demographic questionnaire, knowledge tests, and surveys on affective, motivation states, and attitudes towards STEM subjects. The methodology involved four stages before and four stages after interaction with the virtual lab. Initially, students completed the TTCT, demographic surveys, a knowledge pre-test, and questionnaires assessing their motivation and attitudes towards STEM. Following their engagement with the virtual lab, students again completed the TTCT, a knowledge post-test, a usability questionnaire, and surveys on their affective and motivational states regarding STEM subjects. The results of this study indicated a significant improvement in the creative thinking skills of the participating students. The TTCT scores showed marked enhancements in fluidity, flexibility, and originality, with statistical analysis confirming these improvements. For instance, the fluidity score increased significantly ($p = 0.0007$), as did the flexibility score ($p = 0.0037$) and the originality score, albeit at a slightly less stringent significance level ($p = 0.0586$). Overall, the findings from the Atomic Structure Virtual Lab pilot demonstrated its effectiveness in enhancing the creative thinking abilities of SEN students. The study concluded that virtual laboratories could provide a valuable, engaging, and effective learning environment for students with special needs, supporting their understanding of complex scientific concepts through personalized, inquiry-based, and self-directed learning approaches.

The study by James D. Basham and Matthew T. Marino (Basham & Marino, 2013) focused on enhancing STEM education for students with disabilities through the Universal Design for Learning (UDL) framework. The methodology involved a detailed examination of existing literature and educational practices to identify effective strategies for integrating UDL into STEM curricula. The study highlighted various instructional and assessment techniques designed to accommodate diverse learning needs and improve student engagement and outcomes in STEM subjects. The research involved multiple stakeholders, including special and general education teachers, as well as students with disabilities at both the K-12 and postsecondary levels. The participants were drawn from various educational settings across the United States, although the exact number of participants was not specified. The study aimed to understand how teachers can better support students with disabilities in STEM classes by utilizing UDL principles to create accessible and engaging learning environments. Key findings of the study indicated that students with disabilities often struggle with STEM content due to factors such as limited prior knowledge, reluctance to pose questions, and difficulty implementing teacher recommendations. These students frequently require significant scaffolding and support to manage the complex information and problem-solving tasks inherent in STEM education. The study emphasized the importance of teacher understanding of STEM education and the need for practical strategies to integrate and scaffold learning experiences effectively. The results demonstrated that incorporating UDL principles into STEM curricula could significantly enhance accessibility and engagement for students with disabilities. By using multiple means of representation, expression, and engagement, teachers can create more inclusive learning environments that cater to the diverse needs of their students. The study also found that continuous progress monitoring and the use of technology tools, such as educational video games and digital books, could further support student learning and improve outcomes in STEM education.

The study conducted by Street et. al (Street, 2012) aimed to improve academic outcomes for students with disabilities in STEM courses through a modified Peer-Led Team Learning (PLTL) model integrated with Universal Design for Instruction (UDI) principles. This study was conducted at Washington University in St. Louis, with support from a National Science Foundation grant. Participants included students with documented learning disabilities (LD) and/or ADHD, who were recruited from those registered with the university's Disability Resources office. Over two semesters, a total of 16 freshmen and sophomores participated. In Spring 2008, five students were in Chemistry 112 MPLTL and three in Calculus 3 MPLTL. In Fall 2008, five students joined Chemistry 111 MPLTL and six participated in a blended Calculus 2 and 3 MPLTL group, with some students attending multiple sessions. The intervention involved weekly 60-minute sessions following the traditional PLTL model but tailored for students with LD/ADHD. Peer mentors, who had at least one semester of PLTL experience, underwent a day-long orientation and participated in weekly seminars throughout the semester. They were trained to incorporate UDI principles, such as making learning environments more accessible and engaging. The mentors created templates and video materials to aid students in understanding complex concepts and problem-solving. The results indicated mixed academic outcomes but generally positive trends in STEM persistence and the use of effective learning strategies among participants. In Spring 2008, MPLTL students had lower course GPA averages compared to non-participating SWDs and the general student body, particularly in Chemistry 112. However, in Fall 2008, MPLTL students in Chemistry 111 showed improved performance over their non-participating peers. Cumulative GPA data suggested a narrowing of the achievement gap between students with and without disabilities. The Learning and Study Strategies Inventory (LASSI) scores showed significant improvements in study skills, will, and self-regulation among MPLTL participants. Focus groups revealed high satisfaction with the MPLTL sessions and identified several barriers in STEM courses, such as large class sizes, the specificity of content, and instructional pace, which were addressed by the MPLTL model.

The study conducted by Cindy C. Klimaitis and Carol A. Mullen (Klimaitis & Mullen, 2021) focuses on understanding instructional practices that enable K-12 students with disabilities (SWD) to access STEM environments and develop essential 21st-century skills. The primary objective is to explore teachers' perceptions and planning for inclusion in STEM education across elementary, middle, and high schools. The research was set in a suburban school division in southwest Virginia, encompassing 12 public schools. The participants were 13 experienced teachers (8 females and 5 males), with teaching experience ranging from 6 to over 26 years. These teachers, selected based on their experience in teaching STEM lessons inclusive of SWD, were from different educational levels: 5 elementary, 4 middle, and 4 high school teachers. Data collection involved demographic surveys and 45-minute virtual interviews with each teacher. The interviews were guided by an original protocol designed to elicit views on instructional practices supporting SWD in STEM lessons. The interviews were conducted via WebEx due to pandemic-related health concerns, recorded, transcribed, and verified by the participants. The data were analyzed using deductive and inductive coding, resulting in themes related to access and barriers in STEM education for SWD. The findings revealed seven key instructional practices that facilitate SWD's access to STEM lessons. Teachers gained initial knowledge of SWD through reviewing IEP documents and communicating with staff members. Understanding students' disabilities and interests guided the differentiation of instruction. Building strong relationships with SWD helped teachers tailor STEM lessons to their needs. The assistance of support staff was deemed essential for classroom management and implementing IEP accommodations. Practical, project-oriented learning activities were effective in engaging SWD in STEM lessons. Strategically grouping students by design supported SWD's roles, contributions, and leadership opportunities during STEM activities. Modifications to the classroom environment and support from others enabled SWD to access the STEM curriculum.Three main barriers to participation in STEM lessons for SWD were identified: student ability, lack of adult support, and time limitations with lessons. Teachers also recommended more professional development (PD) focused on collaboration and extending knowledge about disabilities to improve inclusivity in STEM education.

Inclusive STEM High Schools

In this section weexamines the impact and characteristics of Inclusive STEM High Schools (ISHSs) in promoting STEM education among underrepresented student groups. This section synthesizes various studies that explore how ISHSs are designed to provide equitable STEM opportunities, focusing on inclusivity and support for diverse student populations.

The study titled (Means et al., 2017)"Expanding STEM Opportunities Through Inclusive STEM-Focused High Schools" explores the impact of inclusive STEM high schools (ISHSs) on increasing STEM opportunities for underrepresented student groups. ISHSs admit students based on interest rather than competitive exams and aim to equip underrepresented groups, such as minorities and females, with the skills and attitudes needed for STEM careers. Key findings from the study indicate that underrepresented minorities and females in ISHSs were more likely to undertake advanced STEM coursework. Additionally, ISHS students showed greater STEM career interest, particularly among Hispanic students in Texas and females in both North Carolina and Texas. This suggests that ISHSs are effective in fostering a deeper engagement in STEM fields among these groups. In terms of academic outcomes, the study found that ISHS students in North Carolina had higher GPAs and were more likely to complete advanced math and science courses compared to their peers in comprehensive high schools. Positive effects on science achievement test scores were noted, especially among African American students in Texas. These outcomes demonstrate the academic benefits of attending an ISHS. The study employed hierarchical modeling with data from student surveys and state records, comparing 5,113 students from 39 ISHSs and 22 comprehensive high schools in North Carolina and Texas. This robust methodology provided a comprehensive analysis of the impact of ISHSs on student achievement and attitudes toward STEM. ISHSs focus on developing STEM talent across a diverse student body, often integrating STEM subjects and providing career-related supports. Students in ISHSs experienced higher levels of teacher support and encouragement, contributing to their positive academic and attitudinal outcomes. The educational philosophy of ISHSs, which includes project-based learning and real-world STEM experiences, plays a crucial role in fostering student success. Overall, the study suggests that ISHSs can effectively broaden participation in STEM by providing an inclusive and supportive educational environment, leading to higher engagement and achievement in STEM among underrepresented student groups.

A study by (LaForce et al., 2016) utilized a qualitative, ground-up approach to identify the essential components of inclusive STEM high schools by directly engaging with school leaders and stakeholders. The research aimed to derive a theoretical model that accurately represents these schools by employing a component-based framework. This approach contrasts with other studies that have taken a top-down, literature-based perspective. The study examined 20 inclusive STEM high schools across seven states in the USA, including Ohio, Texas, Washington, California, North Carolina, Tennessee, and New York. The schools varied in setting (urban, suburban, rural) and student demographics, ensuring a diverse sample. Participants included school founders, leaders, key external partners, and lead teachers, with interviews involving one to six leaders per school. Data collection involved gathering written materials such as mission statements, handbooks, policy documents, and presentation materials from school websites. The researchers conducted semi-structured “model articulation” interviews and follow-up interviews with 16 schools to validate the findings and gain deeper insights. The data analysis process included two phases: identifying critical components through coding of interview transcripts and organizing these components into graphic summary models, and deriving essential elements from identified components using a grounded-theory approach, resulting in a comprehensive framework.The study identified 76 critical components, which were synthesized into eight essential elements that define inclusive STEM high schools. These eight elements provide a clear picture of what inclusive STEM high schools are and offer a common language for researchers and practitioners. The first element, Personalization of Learning, involves tailoring instruction to individual students' needs and interests. Problem-Based Learning (PBL), the second element, engages students in solving real-world problems to achieve learning goals. Rigorous Learning, the third element, focuses on providing challenging content and processes that promote high cognitive demand. The fourth element, Career, Technology, and Life Skills, emphasizes skills necessary for future careers and life, including technology use and career-readiness activities. School Community and Belonging, the fifth element, builds a strong school culture and provides emotional support to students. The sixth element, External Community, focuses on establishing and maintaining relationships with community members and institutions. Staff Foundations, the seventh element, supports teachers through collaboration, professional development, and leadership facilitation. The eighth and final element, Essential Factors, includes external factors and contexts that support the implementation of the school’s mission, such as family involvement and staff flexibility. The study concludes that inclusive STEM high schools emphasize pedagogy, transferable skills, school culture, and rigorous instruction across all subjects, not just STEM disciplines. This holistic approach supports student engagement and success, making these schools more akin to constructivist educational models than traditional, discipline-specific STEM education.

The study "Understanding Inclusive STEM High Schools as Opportunity Structures for Underrepresented Students" by Lynch et al.(Lynch et al., 2018) explores how Inclusive STEM High Schools (ISHSs) function as effective educational opportunity structures for students historically underrepresented in STEM fields. This study employs a multiple instrumental case study design, guided by the theory of opportunity structures, to analyze eight exemplar ISHSs across the United States. The study utilized a qualitative research approach, focusing on eight ISHSs selected based on specific criteria: strong STEM-focused curriculum, open admissions or lottery, positive state assessment scores, favorable subgroup data compared to state averages, and diverse student populations. Data were collected through site visits by teams of six researchers over four-day periods, employing various methods including semi-structured interviews, focus groups, classroom observations, and pre-visit questionnaires for teachers and administrators. The interviews and focus groups involved a wide range of participants, such as administrative staff, teachers, students, parents, and school partners. Classroom observations used established protocols like the Reformed Teacher Observation Protocol. The collected data were transcribed, coded, and analyzed using NVivo software, with multiple cycles of coding to ensure comprehensive analysis. A four-point rubric was developed to rate the prominence of critical components in each school. The study identified ten critical components theoretically derived from the literature and observed their presence in varying degrees across the ISHSs. The most prominent components were College-Prep STEM Curriculum, Reform Instructional Strategies, Integrated Technology Use, and STEM-rich Informal Experiences. The cross-case analysis also revealed four additional emergent components, bringing the total to fourteen critical components that contribute to the effective functioning of ISHSs as opportunity structures. These schools provided rigorous STEM curricula, project-based learning, extensive use of technology, and connections with business and industry. The findings demonstrated that ISHSs not only prepared students for STEM college majors and careers but also facilitated the development of STEM social capital through interactions with STEM professionals and exposure to STEM-related opportunities outside the classroom.

Gamification

The "Gamification" section explores how the incorporation of game design elements into educational contexts can enhance STEM learning experiences. Gamification leverages mechanisms such as points, leaderboards, and badges to increase student engagement, motivation, and ultimately, educational outcomes. This section highlights research studies that have implemented gamification frameworks to make STEM education more interactive and enjoyable for students.

A study by Zhao et. al. (Zhao et al., 2022) focused on the development and evaluation of a gamification framework aimed at enhancing STEM education. The pilot was conducted at Sf. Maria School in Bucharest, Romania, involving 40 secondary school students with varying degrees of hearing impairments. These students participated in several STEM courses, including topics like Atomic Structure, Ceramics, and History Museum, each incorporating Virtual Reality (VR) or Virtual Lab (VL) applications. The methodology employed in the study involved using the NEWTELP platform to present and gamify these courses. Key gamification elements included points, leaderboards, and badges. Points were awarded based on the completion and performance in various activities, while leaderboards ranked students according to their accumulated points. Badges were awarded for completing specific tasks and milestones. The study also utilized profiling and recommendations within the Atomic Structure course to present content at different difficulty levels based on students' initial responses and quiz results. The impact of this gamification framework was evaluated through a post-experience survey and knowledge assessment tests. The survey results indicated a high level of student engagement and positive feedback, with over 88% of students finding gamification interesting and about 80% welcoming its use in learning. Additionally, 78% of the students reported increased engagement in learning due to gamification elements like points and leaderboards. The knowledge assessment showed significant improvement, with post-test scores (mean = 1.26, SD = 1.21) improving over pre-test scores (mean = 4.67, SD = 2.76), and a paired sample t-test confirming the statistical significance of this improvement ($t = -7.76$, $p = 0.001$).

The study by Sakulkueakulsuk et. al (2018) was conducted to explore the integration of AI education within a social context using gamification. The methodology involved engaging 84 middle school students from grades 7 to 9 in Thailand in an AI challenge as part of the JSTP program. The students, who had little to no prior experience in AI or computer engineering, participated in a three-day workshop where they used RapidMiner, a UI-based software for building machine learning models through a graphical interface. The workshop was divided into three phases. In the first phase, students were introduced to machine learning concepts and tasked with predicting the sweetness of mangoes using only their physical properties. They constructed datasets based on their observations and utilized machine learning models such as Decision Tree, Neural Network, and k-Nearest Neighbor to make predictions. The second phase focused on predicting the quality of mangoes by classifying them into grades A, B, and C based on various features. Students applied their learning from the first phase to build more accurate models. The third phase involved a real-world application where students participated in a mango auction, using their machine learning models to bid on mangoes to maximize their scores. The results showed significant learning outcomes. In Phase I, the accuracy of the students' models ranged from 33.33% to 93.33%, with an average of 60.89%. In Phase II, the models improved, with accuracies ranging from 10% to 90% and an average of 66.67%. The students' models consistently performed better than random guessing, demonstrating their ability to apply machine learning concepts effectively. Additionally, pre and post-workshop surveys revealed that students found the workshop more engaging, interactive, and enjoyable compared to their regular classroom experiences. They also reported increased confidence in interdisciplinary thinking and a greater awareness of integrating technological solutions with social contexts.

Conclusions

As we look to the future of education, it's clear that a multifaceted approach like STREAMING can offer valuable insights and solutions. By integrating Science, Technology, Robotics, Engineering, Artificial Intelligence, Mathematics, Intelligence & Emotional Intelligence, Inclusion, and Gamification into the educational process, we can nurture a new generation of learners who are well-rounded, innovative, and prepared to tackle diverse challenges.

STREAMING is not a one-size-fits-all solution, but rather a flexible and inclusive framework that aims to enrich the educational experience for all students. It emphasizes the importance of blending technical skills with creative and inclusive practices, encouraging students to become both knowledgeable and compassionate leaders.

One of the significant benefits of STREAMING is its ability to adapt to different learning styles and needs. By offering a variety of approaches and tools, it ensures that every student can find their path to understanding and mastery. This adaptability is crucial in fostering a love for learning and a willingness to engage with challenging material.

Moreover, STREAMING's focus on Inclusion and Gamification addresses some of the most pressing issues in education today: the need for equity and the challenge of keeping students engaged. By making learning accessible and enjoyable, STREAMING helps to create a more inclusive and motivating educational environment.

While STREAMING is still a growing field, its potential impact on education is significant, promising to make learning more engaging and relevant in an ever-evolving world. By embracing this approach, we can hope to build a future where education is more dynamic, inclusive, and effective in preparing students for the complexities of modern life.

The journey towards fully integrating STREAMING into our educational systems will undoubtedly require effort, innovation, and collaboration among educators, policymakers, and communities. However, the rewards—a generation of learners equipped with the skills, knowledge, and empathy to lead in a diverse and rapidly changing world—are well worth the endeavor.

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