



A Critical Examination of STEM (Science, Technology, Engineering and Mathematics) Approach in Education for Students with Disabilities

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Abstract: Students with Disabilities often face significant barriers in accessing quality education, particularly in STEM disciplines. Effective strategies, research and practice gaps are highlighted in this systematic review, which examines the current state of STEM education for students with disabilities. Selected studies on the relationship between disability and STEM education were systematically reviewed and compiled in accordance with PRISMA guidelines. The analysis focused on five key themes: career development and guidance, evidence-based practices, inclusive teaching and teacher support, tailored curricula and assistive technologies, and addressing gaps in existing research and practices. The results highlight the importance of career-oriented counselling, team-based teacher support, and customised approaches in promoting STEM education for students with disabilities. To ensure educational equity, educators should continually adapt and improve their methods, providing all students with equal opportunities to succeed. However, the impact of STEM education on post-secondary outcomes for students with disabilities and develop additional evidence-based strategies to facilitate their STEM learning and the present study is limited to selected studies and Western-centric focus.

Index Terms: STEM education, students with disabilities, inclusive education, PRISMA

1. Introduction

The term Science, Mathematics, Engineering, and Technology (SMET) first appeared in 1993 at one of the programmes of the National Science Foundation (NSF) to improve the quality of the USA's SMET education (Mohr-Schroeder, Cavalcanti, & Blyman, 2015). The word 'STEM' is now widely utilised in the education sector and increasing popularity by the day. STEM combines all four distinct disciplines to build the abilities required for designing processes through creativity, developing technology, and identifying needs-based practical solutions. In an increasingly competitive world, education has long been a driving force for economic well-being, with a direct impact on national economic progress.

The impact of education has been affected with many other factors also like differences in cognitive skills, health and cultural believes. (Hanushek, et al., 2008). Latest reports confirm that innovation, creativity, problem solving attitude, critical thinking and profusion of new technologies have become the key to success for the future economy and jobs (Rothwell, 2013; Scientist, 2014). The value of Science, Technology, Engineering, and Mathematics (STEM) education has increased in recent years, prompted by the mounting need for a technologically literate workforce (National Science Foundation, 2019). Nevertheless, students with disabilities have long been confronted by substantial obstacles to quality STEM education (Koretz et al., 2016). Under the Individuals with Disabilities Education Act (IDEA), Students with Disabilities (SWD) are guaranteed a Free and Appropriate Public Education (FAPE) in the Least Restrictive Environment (LRE) (IDEA, 2004). This notwithstanding, studies have shown that students with disabilities are underrepresented in STEM education and have inferior academic performance (Wagner et al., 2012). This has brought more emphasis on STEM education being modified to ensure the various needs of students with disabilities are addressed (UNESCO, 2015). This involves the integration of Universal Design for Learning (UDL) principles, assistive technology, and evidence-based teaching methods (Rose & Meyer, 2002).

1.1. Scope and Significance

The scope of this review includes adopted curriculum and pedagogy strategies, assistive technology integration, inclusive classroom settings, career development and support and teacher training and attitudes. Importantly, this review identifies best practices for making STEM education appropriate for different needs, emphasizes the necessity of assistive technology integration, sets areas of research and practice, guides teacher preparation programs, and to the development of STEM education frameworks and policies. By bridging research gaps in adapted curriculum, assistive technology, inclusive classroom settings, and professional development, this review will guide future research directions such as measuring long-term impacts of STEM education on career results, developing and evaluating STEM education systems, and researching influence of teacher training programs on STEM education practices. These Challenges need an appropriate comprehension of the intricate interactions within STEM education, disability, and inclusive practices.

STEM education is important for students with disabilities. This systematic review combines ten studies to determine best practices, challenges, and future directions for research. The researcher thereby reviewed on a principal question, what effective strategies and supports can be used to improve STEM special education for individuals with disabilities, encouraging academic achievement, vocational development, and for equal access to STEM opportunities? What could be the implication of the study in further enhancing the need for an integrated strategy to STEM education, to meet the specific needs of students with disabilities and promoting equal access to STEM opportunities.

2. Methodology

Researcher conducted an in-depth analysis of studies focusing on STEM education for students with disabilities. This method was chosen in order to ensure a thorough analysis of the current state of STEM education for students with disabilities. By examining the current literature, the present study aspired to provide insightful recommendations and suggestions for research and practice in this significant topic. Implications for policymakers and educators were further explored to inform more education in STEM among students with disabilities. Instead of focussing solely on evaluating measured quantitative effects, it was crucial to be able to compare these various articles and methods (such as quantitative, qualitative) to find common themes with well-established research methodology. Let us now elucidate the methodology employed in the review.

2.1. Search Strategy

The PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses), method was used to conduct a systematic and transparent review, with a clear process for identifying and selecting studies, as shown in Figure 1. The thorough review of the literature across various databases such as ERIC, PubMed, PsycINFO, Scopus, and Web of Science was performed. Search terms specifically targeting studies in STEM education among students with disabilities were applied. Finding the journals was the initial step, after which the articles from these journals were looked over and selected. The search process was systematically analyzed using predefined inclusion and exclusion criteria to ensure the relevant research articles were included in the review.

The three steps composed in the special PRISMA method follows the below mentioned sequence: (1) Identification: Evidence was located using databases; (2) Screening: Evidence was obtained, files were screened for eligibility, and full-text documents were assessed for eligibility; (3) Included: Number of studies included in the review.

2.2. Inclusion criteria for studies

Peer-reviewed literature that appeared from year 2016 to year 2024 on STEM education among students with disabilities was subject to this systematic review. All the studies qualified as focusing on any of these topics: assistive technologies and adapted curriculum, inclusive teaching and support for instructors, career preparation and guidance, evidence-based approaches, or eliminating gaps between research and practice. The review highlights at quantitative, qualitative, and mixed-method studies adopting approaches with the involvement of students with disabilities in STEM study environments. The research aims to give an overall summary of the current status of research in this area. Further, the research will discuss findings to identify best practices and scope for future work. Through an examination of a range of research methods, the review aims to offer insights into effective methods of providing inclusive STEM education for students with disabilities.

2.3. Exclusion criteria for studies

Based on the understanding of the purpose of the study certain norms are include as exclusion criteria. Thus, this review does not consider non-peer-reviewed articles like editorials, opinion articles, or book chapters. Those studies that did not target STEM education or students with disabilities, or those that were published prior to year 2016 or after year 2024, are excluded. Excluded are publications that are not in English, research that does not present empirical data (e.g., theoretical or conceptual papers), dissertations, theses, and unpublished manuscripts.

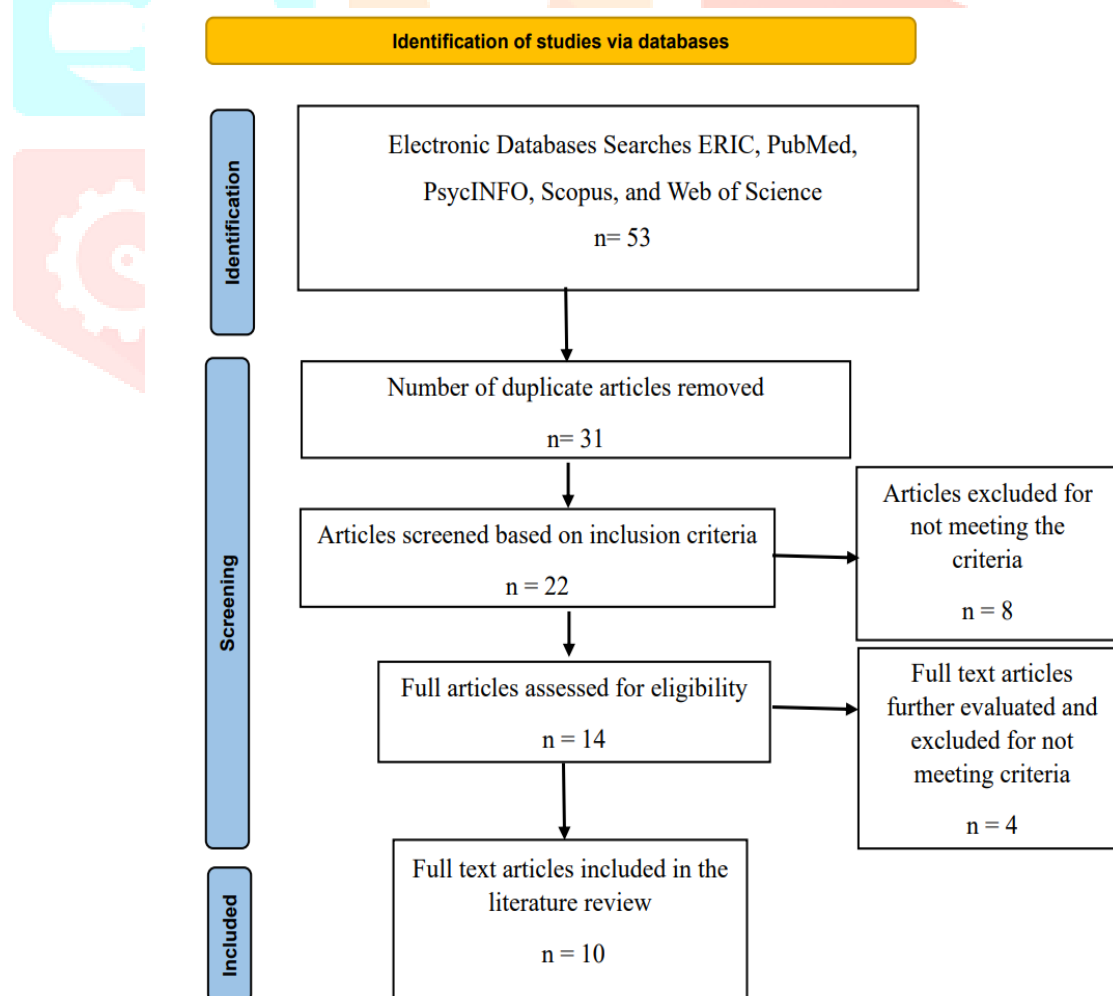


Figure 1: PRISMA Diagram for the Search of Research Literature and Selection of Articles for review

Studies that concentrate largely on general education students or teachers, or on evaluations or measurements without instructional treatments, are also excluded. The inclusion criteria for this review are specifically constructed to be of high rigour and applicability in the final set of studies chosen. By restricting the scope to peer-reviewed journals for some time frame and field of research, the aim is to provide a comprehensive and up-to-date overview of what research on the subject of STEM education in disabled students is currently concerned with.

2.4. Key themes of the literature reviews

The Literature review strongly supports some of the key themes mentioned in the study. To begin with, adapted curriculum and assistive technology prove to be important factors in facilitating accessibility and learning engagement. Secondly, inclusive instruction and teacher support are vital in fostering student motivation, self-efficacy, and engagement. Thirdly, career development and guidance are essential for students with disabilities to navigate STEM fields successfully. Fourth, evidence-based interventions, including video modelling and embedded simultaneous prompting procedures, show promise in teaching STEM material. Lastly, closing research and practice gaps is essential to inform inclusive STEM education policies and frameworks that ensure equal opportunities for students with disabilities. These connected themes highlight the need for a multi-faceted strategy to advance inclusive STEM education and improve academic and career success for students with disabilities.

3. Results

A synopsis of the ten publications considered in this literature review is presented in Table 1. Table 1 summarises the studies published in journals from year 2016 to year 2024, utilising qualitative, quantitative, or combined methodologies. By the examination of these articles, researcher generated findings represented as qualitative themes, which also served as responses to the primary question outlined earlier in the introduction that framed this review. The study of selected literature yielded five emergent themes for the review question: 1. Adapted Curriculum and Assistive Technology 2. Inclusive Instruction and Teacher Support 3. Career Development and Guidance 4. Evidence-Based Practices and, 5. Addressing Gaps in Research and Practice.

Table 1: Summary of articles (n = 10) selected for qualitative literature review

Authors	Journal	Sample	Methodology	Disability	Findings	Recommendations
Bernard L. Dillard. May (2024)	Journal of Special Education Technology	120 students	Survey, interviews	physical, cognitive, sensory	curriculum, assistive technology essential	Teacher training, inclusive classrooms
Locke, S., Rodrigues, J., & Mirielli, L.G. (2023)	Exceptional Children	80 students, 20 role models	Quasi-experimental design	Learning disabilities, ADHD	Positive impact on motivation, self-efficacy	Integrate role models into STEM education
Ayverdi, L., Avcu, Y.E. (2023)	Journal of Intellectual Disability Research	30 students	Single-subject design	Mild intellectual disability	Improved engagement, skills with adapted instruction	Adapted instruction
Yamamoto, S., Alverson, C.Y., McCoid-Goudy, L., Castle, H., & Burr, J. (2022)	Review of Educational Research	Not applicable	Systematic review	LD, ADHD, autism, physical disabilities	Gaps in research, practice identified	Need more research in future

Kuntz, E. M., Carter, E. W., Cassady, K., & Knight, V. F. (2022)	Journal of Teacher Education	10 classroom s, 20 teachers	Observational study	Autism, intellectual disability	Variability in teacher support, student engagement	Teacher training, coaching needed
Wright, J. C., Knight, V. F., & Barton, E. (2020)	Journal of Autism and Developmental Disorders	40 students	Experimental design	Autism, intellectual disability	Improved skills, engagement with video modelling	Video modelling as supplementary tool
Hwang, J., & Taylor, J. C. (2016)	Journal of Special Education	Not applicable	Conceptual framework	physical, cognitive, sensory	Adapted curriculum, inclusive instruction	Development and need of more research in future
Chun, J., Kim, J., Lee, M., & Richard, C. (2024)	Career Development and Transition for Exceptional Individuals	100 students, 20 educators	Mixed-methods survey	Learning disabilities, autism, physical disabilities	Gaps in career guidance, support identified	Targeted interventions, resources needed
Heinrich, S., Collins, B. C., Knight, V., & Spriggs, A. D. (2016).	Journal of Behavioral Education	20 students	Single-subject design	Autism, intellectual disability	Improved skills, engagement with evidence-based practice	Evidence-based practices are essential
Yamamoto, S., et al (2022)	Journal of Research in Science Teaching	Not applicable	Systematic review	LD, ADHD, autism, physical disabilities	Gaps in research, practice identified	Need more research in future in STEM education

3.1. Theme 1: Adapted Curriculum and Assistive Technology

The use of adapted curriculum and assistive technology is a thread that weaves through the literature. (Dillard, 2024), (Ayverdi & Avcu, 2023), and (Hwang & Taylor, 2016) identify the use of modified curriculum and assistive technology to support learning of STEM by students with disabilities. Adapted curriculum allows students to access complex ideas, and assistive technology provides the means for engagement and accessibility. Proper training for teachers and the adoption of an inclusive classroom are the most critical determinants of success for these strategies. By utilizing adapted curriculum alongside assistive technology, teachers can improve students' academic engagement, skill acquisition, and overall inclusion in STEM learning.

3.2. Theme 2: Inclusive Instruction and Teacher Support

Inclusive pedagogy and teacher support are the vital components of STEM education for students with disabilities. The findings of Locke et al. (2023), Kuntz et al. (2022), and Wright et al. (2020) support the effective role of inclusive pedagogical approaches in enhancing students' motivation, self-efficacy, and

engagement. Instruction support availability, role model exposure, and usage of video modeling are the most critical factors required for the improvement of student performance. The differences reflected in teacher support and student participation require higher levels of teacher training and mentoring. By giving priority to inclusive pedagogical practices and enhancing instruction support, teachers can make available a supportive learning environment that promotes academic success.

3.3. Theme 3: Career Development and Guidance

Career guidance and development are essential for disabled students seeking careers in STEM. Chun et al. (2024) mentions a shortage of career guidance and assistance, which requires special intervention and assistance. Effective career development interventions should cater to certain challenges that students with disabilities face, including individual support and mentoring. Career development programs are an important investment, and policymakers and educators can enable disabled students to achieve rewarding careers in STEM.

3.4. Theme 4: Evidence-Based Practices

Evidence-based instruction is necessary to teach STEM courses for students with disabilities. Studies by Wright et al. (2020) and Heinrich et al. (2016) illustrate the effectiveness of video modelling and embedded simultaneous prompting interventions. Evidence-based instructional strategies enhance skill development, motivation, and learning gains. Educators should place greatest priority on evidence-based instruction, screening and adapting their instructional strategies on a consistent basis to support the diverse requirements of students with disabilities.

3.5. Theme 5: Addressing Gaps in Research and Practice

They need practice and research to tackle conflict resolution in inclusive development in STEM. Yamamoto et al. (2022) acknowledge that there is profound research and practice gaps that need scholarly research. Policy and researchers need to work together and develop and implement frameworks, policies, and practices that can support the development of inclusive STEM education. Conflict resolution for such areas will help teachers treat students with disabilities equally, hence leading to ultimate academic and career success in the STEM field.

4. Discussion

The researcher reviewed ten relevant literature articles, identifying immediate issues and knowledge gaps. They assessed the contribution to the literature and the implications for education and special education, including research and practice.

4.1. Overall Implications

These articles emphasize the importance of STEM education for disabled children by means of adapted curriculum, assistive technology, inclusive instruction, career skills, and evidence-based practices. These articles prove that disabled students can be enriched with STEM education if they are provided with proper support.

The key elements of STEM education are an adjusted curriculum and assistive technology. Use of adjusted lesson plans, accessible materials, assistive technology devices, and adaptive testing processes enhances the engagement of the learners with complex concepts and thus their academic achievement. For instance, Dillard (2024), Ayverdi and Avcu (2023), and Hwang and Taylor (2016) note the importance of adjusted curricula and assistive technology. Inclusive teaching and supportive teachers also help ensure educational achievement. Mentorship and modeling, teacher development and coaching, differentiated instruction, and positive behavioral interventions and supports build the supportive learning environment that increases engagement, self-efficacy, and motivation for students. Locke et al. (2023), Kuntz et al. (2022), and Wright et al. (2020) emphasize the paramount importance of inclusive pedagogy. Career development and guidance are crucial in helping students with disabilities in the STEM area. Career exploration and assessment, job shadowing and internship, mentorship, and transition planning facilitate post-secondary education and employment. Chun et al., (2024) highlights the importance of specific career interventions.

Evidence-based practices make teaching methods research-based to provide maximum student outcomes. Visual schedules, embedded simultaneous prompting procedures, video modelling, and positive

reinforcement are all effective methods for teaching STEM. Wright et al., (2020) and Heinrich et al., (2016) validate that evidence-based practices work.

There are significant gaps in STEM education, including the development of frameworks, adapted curriculum, teacher training, and career development research. Future research should focus on these areas, including adapted curriculum, assistive technology, teacher training, career development interventions, and evidence-based practices. Academic scholars acknowledge the diversity of opinion and literature on STEM for disabled students, highlighting limitations in conducting research.

5. Conclusion

STEM education is vital for students with disabilities. Through filling the gaps as outlined and through the implementation of adapted curriculum, assistive technology, inclusive instruction, career development, and evidence-based practices, students can be guaranteed academic and career fulfilment.

5.1. Implications for Research and Practice

In trying to move STEM education forward, future studies would seek to examine STEM education models, evaluate the impact of modified curriculum and assistive technologies, identify the effects of interventions on career progression among students with disabilities, and determine evidence-based practices. Closing these gaps will allow us to move STEM education forward and achieve greater academic and career success for students with disabilities.

5.2. Recommendations

Teachers are key actors as change agents in building inclusive STEM education. Teachers need to work with special education professionals to better meet the diverse needs of students, integrate Universal Design for Learning strategies into their curriculum planning, use assistive technology to optimize accessibility, provide scaffolding and support that is needs-specific for individual learners, and develop a growth mindset that emphasizes effort and progress. The adoption of these strategies has immense potential to build an enabling and inclusive learning environment. Policy-makers also endorse inclusive STEM education through investments in curriculum redesign and assistive technology programs, policy implementation for inclusive STEM education and career development, providing instructor coaching and training in inclusive practice, providing career development programs for disabled students, and promoting research in effective practices in inclusive STEM education. All these policy initiatives will render the STEM education system inclusive and equitable.

5.3. Call to Action

By addressing the implications created and implementing the recommended solutions, one can enhance students with disabilities' academic and career achievement, enhance diversity, equity, and inclusion in STEM, and build a more inclusive and supportive learning community. It is important that policymakers, educators, and researchers join hands to develop an inclusive and comprehensive STEM education model that addresses all students. In conclusion, suggestions for teachers are working with special education professionals, application of universal design for learning principles, use of assistive technologies, provision of scaffolding and support, and promotion of a growth mindset. Policymakers need to provide funding for inclusive STEM education programs, develop policies for adapted curricula and assistive technology, provide funding for teacher training and coaching, campaign for career development programs, and encourage research on inclusive STEM education. Through collaboration, teachers, policymakers, and researchers can provide equal access to success in STEM education for students with disabilities.

Conflict of Interest Statement

The authors state that there is no conflict of interest.

Ethics statement

This paper reviewed existing literature and did not involve human or animal subjects in research.

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