

Assistive Technology and Applied Mathematics Foundations for Supporting Students with Intellectual and Developmental Disabilities in STEM Higher Education: A Literature Review

Javier Cevallos_Culqui

Universidad Técnica de Cotopaxi, Cotopaxi, Ecuador

HOW TO CITE:

Javier Cevallos_Culqui (2026). Assistive Technology and Applied Mathematics Foundations for Supporting Students with Intellectual and Developmental Disabilities in STEM Higher Education: A Literature Review. International Journal of Special Education, 41(22s), 1679-1684

COPYRIGHT STATEMENT:

Copyright: © 2026 Authors.
Open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).

ABSTRACT:

Students with intellectual and developmental disabilities (IDD) remain underrepresented in postsecondary STEM programs, and assistive technologies rarely address their mathematics learning from an engineering or applied-mathematics perspective. This review synthesizes 45 sources on assistive technology, adaptive algorithms, Universal Design for Learning (UDL), and evidence-based mathematics instruction for students with IDD. Following an integrative review methodology, sources retrieved from Scopus, Web of Science, IEEE Xplore, ERIC, PubMed, and Google Scholar were organized into six themes: postsecondary access, UDL in mathematics, evidence-based/technology-supported interventions, AI-driven adaptive learning, low-cost IoT devices, and computational thinking/robotics. Special-education instructional science for this population is comparatively mature, while engineering-grounded, postsecondary-specific tools remain scarce. Interdisciplinary collaboration between special education and engineering is recommended.

Keywords: assistive technology, intellectual disability, applied mathematics, STEM higher education, Universal Design for Learning.

1. Introduction

Access to higher education has expanded for students with intellectual and developmental disabilities (IDD) since the Higher Education Opportunity Act of 2008 formally recognized inclusive postsecondary education (IPSE) (Becht et al., 2020; Grigal et al., 2012), and recent Think College data confirm continued but uneven growth in these programs (Grigal et al., 2024). Even so, students with IDD remain concentrated outside STEM tracks (Ariza & Hernández, 2025), and people with disabilities overall make up only about 3% of the U.S. STEM workforce (National Center for Science and Engineering Statistics, 2023). The pattern is global: fewer than 2% of

Ecuadorians with disabilities had accessed higher education historically, and institutional implementation of inclusion policy still lags at the postsecondary level (Aguilera Zamora, 2022; Clavijo Castillo & Bautista-Cerro, 2020; Ocampo, 2018), consistent with WHO/World Bank (2011) estimates that over a billion people worldwide live with a disability.

Assistive technology (AT) improves engagement and participation for students with disabilities in higher education (McNicholl et al., 2021), yet most AT research targets sensory or physical impairments rather than the mathematical-reasoning demands specific to IDD (Dumitru et al., 2025). Meanwhile, special education has

validated evidence-based mathematics strategies for this population — concrete-representational-abstract sequencing, schema-based instruction, UDL (Root et al., 2020; Spooner et al., 2019) — largely at the K-12 level. This review synthesizes both literatures to identify where engineering and applied-mathematics collaboration could translate validated pedagogy into adaptive postsecondary STEM tools.

2. Methodology

Design. This is a narrative literature review with a scoping orientation, following the integrative review approach of Whitemore and Knafl (2005) and reporting practices consistent with PRISMA 2020 (Page et al., 2021), chosen to accommodate the heterogeneous designs (single-case, quasi-experimental, systematic review, policy report) relevant to this topic.

Search strategy and sources. Scopus, Web of Science, IEEE Xplore, ERIC, PubMed, and Google Scholar were searched combining disability terms (intellectual disability, developmental disability, autism), context terms (higher education, postsecondary, STEM, mathematics), and technology terms (assistive technology, adaptive learning, artificial intelligence, Internet of Things, Universal Design for Learning, computational thinking).

Selection criteria. Peer-reviewed sources (or major governmental/intergovernmental reports) addressing IDD populations and a technology-based intervention or instructional framework relevant to mathematics, STEM, or postsecondary access were included, prioritizing the last 10–15 years while retaining foundational earlier studies. Sources unrelated to IDD or to mathematics/STEM/postsecondary access were excluded unless providing essential policy context.

Data extraction and synthesis. Forty-five sources were retained and organized inductively into six themes via thematic synthesis; given design heterogeneity, findings are synthesized narratively rather than meta-analytically.

3. Results

3.1 Access and academic outcomes. A review of 43 studies (1987–2017) found fewer than half confirmed genuine inclusive participation for students with intellectual disability (Becht et al., 2020); national program data show continued but uneven growth (Grigal et al., 2012, 2024), and academic enabling behaviors — engagement, study skills — remain central to success (McLendon et al., 2023). Ecuadorian studies confirm the same structural pattern regionally (Aguilera Zamora, 2022; Clavijo Castillo & Bautista-Cerro, 2020; Ocampo, 2018).

3.2 UDL applied to mathematics. UDL-based intervention produced functional gains in mathematics problem solving for students with extensive support needs (Root et al., 2020). A review of 17 postsecondary UDL studies found 15 effective (Seok et al., 2018), but a dedicated STEM-focused review found UDL still substantially underused in college STEM courses (Schreffler et al., 2019). Longitudinal work found prior knowledge, not IQ, predicted mathematical progress (Schnepel et al., 2020), a systematic review found generally positive but heterogeneous intervention evidence (Schnepel & Aunio, 2021), and instructional setting was linked to progress independent of diagnosis (Schnepel et al., 2022).

3.3 Evidence-based, technology-supported interventions. Explicit instruction, task analysis, and CRA sequencing underpin mathematics instruction for moderate/severe developmental disabilities (Spooner et al., 2019). Schema-based instruction with concrete/virtual manipulatives (Root et al., 2017) and personal-finance word problems (Root, Saunders, et al., 2017) produced gains, later extended through virtual-representational-abstract frameworks (Root et al., 2021), technology-embedded data-analysis instruction (Root et al., 2019), and augmented reality (Root et al., 2022) — a clear trajectory toward technology-mediated delivery. Related dyscalculia work offers adjacent applied-mathematics foundations (Calderón Delgado et al., 2019; Jadhav et al., 2025; Kaufmann, 2008).

3.4 AI-driven adaptive learning. A review of 27 AI-assistive-technology studies found personalized learning benefits alongside a shortage of research on cognitive/neurodevelopmental disabilities specifically (Dumitru et al., 2025). Algorithmic tools built for visual disabilities — real-time arithmetic validation (Ali, Khusro, & Algamdi, 2025), structural navigation of expressions (Ali, Khusro, & Alahmadi, 2024), and an integrated solver (Ali et al., 2025) — illustrate transferable architectures, though not yet validated with IDD populations.

3.5 Embedded and low-cost IoT devices. Wireless/IoT assistive technologies improve engagement but adoption is constrained by cost, infrastructure, and training gaps (Bright, 2021), corroborated by broader AT-adoption barriers (McNicholl et al., 2021). This literature rarely addresses mathematics instruction specifically, leaving a clear gap for mathematics-focused, low-cost embedded design.

3.6 Computational thinking, robotics, and coding. A review of 263 screened studies (2013–2024) found STEM interventions for disability concentrated in the U.S. and in autism/learning-disability populations, with intellectual disability underrepresented (Ariza & Hernández, 2025); a meta-analysis of 40 studies confirmed strong STEM-learning effects while showing disability subtype moderates outcomes (Da et al., 2025). Robotics improved social/communication skills in autism (Alghamdi et al., 2023), and systematic science instruction produced gains for ID/autism (Apanasionok et al., 2019; Knight et al., 2020). UDL-grounded programming instruction (Kim et al., 2024, 2025) and explicit computational-thinking strategies (Israel et al., 2015; Kert et al., 2022; Yildiz & Çengel, 2022) show this is an accessible, evidence-supported STEM entry point.

4. Discussion

Across all six themes, special-education instructional science for teaching mathematics and computational thinking to students with IDD is comparatively mature, while engineering

translation of that science into adaptive, low-cost postsecondary tools lags behind (Ariza & Hernández, 2025; Dumitru et al., 2025; Root et al., 2020). The manipulatives-to-VR-to-AR progression documented within special education itself (Root et al., 2017, 2021, 2022) shows the field moving toward technology-mediated delivery, but largely using off-the-shelf consumer tools rather than purpose-built engineering solutions. Adjacent algorithmic architectures developed for visual disability (Ali et al., 2024, 2025) and IoT frameworks (Bright, 2021) are transferable but unvalidated for IDD, and rarely target mathematics specifically.

This represents a clear opportunity for engineering and applied-mathematics researchers, particularly in resource-limited settings such as Ecuador (Aguilera Zamora, 2022; Ocampo, 2018), to co-design low-cost, mathematics-specific tools with special educators, using computational thinking and robotics (Israel et al., 2015; Kim et al., 2024, 2025) as an evidence-supported bridge into STEM. Structural barriers to access mean technology alone cannot resolve underrepresentation (Becht et al., 2020; National Center for Science and Engineering Statistics, 2023); any technical contribution must complement, not replace, institutional inclusion efforts. Limitations include this review's narrative (non-systematic) methodology, predominance of U.S./English-language sources, and the scarcity of studies isolating postsecondary STEM mathematics as a distinct IDD outcome.

5. Conclusion

Students with IDD remain underrepresented in STEM higher education, in the United States and in Ecuador alike, and available assistive technologies rarely embed the applied-mathematics and engineering principles that could make them more effective and affordable. Special education has established which strategies work; engineering has established the technical tools to deliver them adaptively. The missing element is deliberate collaboration between the two fields. Future work should prioritize co-designed, low-cost technologies validated directly

with students with IDD pursuing STEM, building on the promising foundation of computational-thinking and robotics interventions.

6. Author Declaration

The author confirm that this manuscript reflects original work, has not been previously published, and is not under consideration elsewhere. The author declare no conflicts of interest.

References

- Aguilera Zamora, W. E. (2022). Educación superior en Ecuador con relación a la inclusión de personas con discapacidad. *Revista Scientific*, 7(24), 375–387. <https://doi.org/10.29394/Scientific.issn.1679-1684.2022.7.24.20.1679-1684>
- Alghamdi, M., Alhakbani, N., & Al-Nafjan, A. (2023). Assessing the potential of robotics technology for enhancing educational outcomes for children with autism spectrum disorder. *Behavioral Sciences*, 13(7), 598. <https://doi.org/10.3390/bs13070598>
- Ali, A., Khusro, S., & Alahmadi, T. J. (2024). Accessible interactive learning of mathematical expressions for school students with visual disabilities. *PeerJ Computer Science*, 10, e2599. <https://doi.org/10.7717/peerj-cs.2599>
- Ali, A., Khusro, S., & Algamdi, S. A. (2025). Accessible interactive learning of missing-digit arithmetic problems for students with visual disabilities. *Scientific Reports*, 15, Article 17804. <https://doi.org/10.1038/s41679-1684-01679-1684>
- Ali, A., Khusro, S., Alam, F., Khan, I., & Algamdi, S. A. (2025). AIME-solve: Accessible interactive mathematical expressions solver for optimized learning and visual empowerment. *SoftwareX*, 30, Article 102143.
- Apanasionok, M. M., Hastings, R. P., Grindle, C. F., Watkins, R. C., & Paris, A. (2019). Teaching science skills and knowledge to students with developmental disabilities: A systematic review. *Journal of Research in Science Teaching*, 56(7), 847–880. <https://doi.org/10.1002/tea.21531>
- Ariza, J. Á., & Hernández, C. (2025). A systematic literature review of research-based interventions and strategies for students with disabilities in STEM and STEAM education. *International Journal of Science and Mathematics Education*, 23, 2863–2893. <https://doi.org/10.1007/s11679-1684-10544-z>
- Becht, K., Blades, C., Agarwal, R., & Burke, S. (2020). Academic access and progress for students with intellectual disability in inclusive postsecondary education: A systematic review of research. *Inclusion*, 8(2), 90–104. <https://doi.org/10.1352/1679-1684-8.2.90>
- Bright, D. (2021). An integrative review of the potential of wireless assistive technologies and internet of things (IoT) to improve accessibility to education for students with disabilities. *Assistive Technology*, 34(6), 653–660. <https://doi.org/10.1080/10400435.2021.1956639>
- Calderón Delgado, M. A., Zamora Delgado, R. I., Palma Palma, R., & Moya, M. E. (2019). Dyscalculia and pedagogical intervention. *International Research Journal of Management, IT & Social Sciences*, 6(5), 95–100. <https://doi.org/10.21744/irjmis.v6n5.710>
- CAST. (2018). Universal Design for Learning guidelines (Version 2.2). CAST.
- Clavijo Castillo, R. G., & Bautista-Cerro, M. J. (2020). La educación inclusiva. *Análisis y reflexiones en la educación superior ecuatoriana*. *Alteridad*, 15(1), 113–124. <https://doi.org/10.17163/alt.v15n1.2020.09>
- Da, F., Ma, Y., Ma, M., Mao, J., Weng, Z., Yang, C., & Wang, T. (2025). Effects of STEM learning on students with autism spectrum disorder and students with intellectual disability: A systematic review and meta-analysis. *Humanities and Social Sciences Communications*, 12(1), 1–15. <https://doi.org/10.1057/s41679-1684-05292-y>
- Dumitru, C., Abdulsahib, G. M., Khalaf, O. I., & Bennour, A. (2025). Integrating artificial intelligence in supporting students with disabilities in higher education: An integrative review. *Technology and Disability*, 38(1), 3–24. <https://doi.org/10.1177/10554181251355428>
- Ehsan, H., Rispoli, M., Lory, C., & Gregori, E. (2018). A systematic review of STEM instruction with students with autism spectrum disorders. *Review Journal of Autism and Developmental Disorders*, 5, 1–22. <https://doi.org/10.1007/s41679-1684-1679-1684>

-
- Grigal, M., Hart, D., & Weir, C. (2012). A survey of postsecondary education programs for students with intellectual disabilities in the United States. *Journal of Policy and Practice in Intellectual Disabilities*, 9(4), 223–233. <https://doi.org/10.1111/jppi.12012>
- Grigal, M., Hart, D., Papay, C., Bukaty, C., Choiseul-Praslin, B., & Pound, S. (2024). Annual report of the Cohort 3 TPSID model demonstration projects (Year 3, 2022–2023). Think College, University of Massachusetts Boston, Institute for Community Inclusion.
- Israel, M., Wherefel, Q. M., Pearson, J., Shehab, S., & Tapia, T. (2015). Empowering K–12 students with disabilities to learn computational thinking and computer programming. *TEACHING Exceptional Children*, 48(1), 45–53.
- Jadhav, D., Chettri, S. K., Tripathy, A. K., & Saikia, M. J. (2025). A technology-driven assistive learning tool and framework for personalized dyscalculia interventions. *European Journal of Investigation in Health, Psychology and Education*, 15(5), Article 85. <https://doi.org/10.3390/ejihpe15050085>
- Kaufmann, L. (2008). Dyscalculia and intervention tools: A review of current practice and research. *Journal of Learning Disabilities*, 41(6), 516–528. <https://doi.org/10.1177/0022219408317485>
- Kert, S. B., Yeni, S., & Erkoç, M. F. (2022). Enhancing computational thinking skills of students with disabilities. *Instructional Science*, 50(4), 625–651.
- Kim, M., Kim, J., & Lee, W. (2024). Enhancing computational thinking in students with autism spectrum disorder and intellectual disabilities: A robot programming approach. *International Journal of Developmental Disabilities*. Advance online publication.
- Kim, M., Kim, J., & Lee, W. (2025). Intellectual disabilities and programming: Improving computational thinking-based problem solving. *Education and Information Technologies*, 30(9), 1–41. <https://doi.org/10.1007/s11679-1684-11679-1684>
- Knight, V. F., Wood, L., McKissick, B. R., & Kuntz, E. M. (2020). Teaching science content and practices to students with intellectual disability and autism. *Remedial and Special Education*, 41(6), 327–340. <https://doi.org/10.1177/0741932519843998>
- McLendon, K., Roach, A., & Crimmins, D. (2023). A literature review of academic enabling behaviors of students with an intellectual disability in inclusive postsecondary education programs. *Journal of Inclusive Postsecondary Education*, 5(1). <https://doi.org/10.13021/jipe.2023.3282>
- McNicholl, A., Casey, H., Desmond, D., & Gallagher, P. (2021). The impact of assistive technology use for students with disabilities in higher education: A systematic review. *Disability and Rehabilitation: Assistive Technology*, 16(2), 130–143. <https://doi.org/10.1080/17483107.2019.1642395>
- National Center for Science and Engineering Statistics. (2023). Diversity and STEM: Women, minorities, and persons with disabilities in science and engineering 2023 (NSF 1679-1684). National Science Foundation.
- Ocampo, J. C. (2018). Discapacidad, inclusión y educación superior en Ecuador: El caso de la Universidad Católica de Santiago de Guayaquil. *Revista Latinoamericana de Educación Inclusiva*, 12(2), 97–114. <https://doi.org/10.4067/S1679-16842018000200097>
- Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., McGuinness, L. A., Stewart, L. A., Thomas, J., Tricco, A. C., Welch, V. A., Whiting, P., & Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*, 372, Article n71. <https://doi.org/10.1136/bmj.n71>
- Root, J. R., Browder, D. M., Saunders, A. F., & Lo, Y. (2017). Schema-based instruction with concrete and virtual manipulatives to teach problem solving to students with autism. *Remedial and Special Education*, 38(1), 42–52. <https://doi.org/10.1177/0741932516643592>
- Root, J. R., Cox, S. K., Davis, K., & Gonzales, S. (2022). Using augmented reality and modified schema-based instruction to teach problem solving to students with autism. *Remedial and Special Education*, 43(5), 301–313. <https://doi.org/10.1177/07419325211054209>
- Root, J. R., Cox, S. K., Gilley, D., & Wade, T. (2021). Using a virtual-representational-abstract integrated framework to teach multiplicative problem solving to middle school students with developmental disabilities. *Journal of Autism and Developmental Disorders*, 51(1), 2284–2296. <https://doi.org/10.1007/s11679-1684-01679-1684>
-

-
- Root, J. R., Cox, S. K., & Gonzales, S. (2019). Using modified schema-based instruction with technology-based supports to teach data analysis. *Research and Practice for Persons with Severe Disabilities*, 44(1), 53–68. <https://doi.org/10.1177/1540796919833915>
- Root, J. R., Cox, S. K., Saunders, A., & Gilley, D. (2020). Applying the universal design for learning framework to mathematics instruction for learners with extensive support needs. *Remedial and Special Education*, 41(4), 194–206. <https://doi.org/10.1177/0741932519887235>
- Root, J., Saunders, A., Spooner, F., & Brosh, C. (2017). Teaching personal finance mathematical problem solving to individuals with moderate intellectual disability. *Career Development and Transition for Exceptional Individuals*, 40(1), 5–14.
- Schnepel, S., & Aunio, P. (2021). A systematic review of mathematics interventions for primary school students with intellectual disabilities. *European Journal of Special Needs Education*, 37(4), 663–678. <https://doi.org/10.1080/08856257.2021.1943268>
- Schnepel, S., Dessemontet, R. S., & Moser Opitz, E. (2022). The impact of inclusive education on the mathematical progress of pupils with intellectual disabilities. *International Journal of Inclusive Education*, 28(13), 2815–2829. <https://doi.org/10.1080/13603116.2022.2132425>
- Schnepel, S., Moser Opitz, E., Krähenmann, H., & Sermier Dessemontet, R. (2020). The mathematical progress of students with an intellectual disability in inclusive classrooms: Results of a longitudinal study. *Mathematics Education Research Journal*, 32(1), 103–119. <https://doi.org/10.1007/s11679-1684-00295-w>
- Schreffler, J., Vasquez, E., III, Chini, J., & James, W. (2019). Universal Design for Learning in postsecondary STEM education for students with disabilities: A systematic literature review. *International Journal of STEM Education*, 6(1), Article 8. <https://doi.org/10.1186/s41679-1684-1679-1684>
- Seok, S., DaCosta, B., & Hodges, R. (2018). A systematic review of empirically based universal design for learning: Implementation and effectiveness of universal design in education for students with and without disabilities at the postsecondary level. *Open Journal of Social Sciences*, 6(5), 171–189. <https://doi.org/10.4236/jss.2018.65015>
- Spooner, F., Root, J., Saunders, A., & Browder, D. (2019). An updated evidence-based practice review on teaching mathematics to students with moderate and severe developmental disabilities. *Remedial and Special Education*, 40(3), 150–165. <https://doi.org/10.1177/0741932517751055>
- United Nations. (2006). *Convention on the Rights of Persons with Disabilities*. United Nations.
- Whittemore, R., & Knafl, K. (2005). The integrative review: Updated methodology. *Journal of Advanced Nursing*, 52(5), 546–553. <https://doi.org/10.1111/j.1679-1684.2005.03621.x>
- World Health Organization & World Bank. (2011). *World report on disability*. World Health Organization.
- Yildiz, E. P., & Çengel, M. (2022). An experimental study in determining basic robotic coding skills of pre-school students with intellectual disabilities. *International Journal of Interactive Mobile Technologies*, 16(23), 85–102.
-