



iJERResearch

International Journal of Education and Research

Vol. 1, Number 2, September - 2026 | Peer-Reviewed Journal

ISSN 2764-9733 | ijerresearch.org

DOI: 10.5281/zenodo.23062116

SCIENCE, TECHNOLOGY, EDUCATION, AND SOCIETY: AN INTEGRATED AND EXPANDED ANALYSIS OF TECHNOLOGICAL INNOVATIONS IN THE TEACHING-LEARNING PROCESS

AUTHOR

Márcia Schiavo: Doctoral candidate in Education Sciences at Universidad de la Integración de las Américas (UNIDA), Asunción, Paraguay. Basic Education Physical Education teacher in the municipal school system of Castelo, Espírito Santo.

Contact: marcia_schia@hotmail.com | orcid.org/0009-0006-9355-0272

ABSTRACT

This scientific article sought to analyze, in an integrated manner, the complex relationship among Science, Technology, Education, and Society (STS), examining how the intentional incorporation of technological innovations redefines and enhances the contemporary teaching-learning process. The central research problem focused on pedagogical challenges and structural barriers to the use of technology at various educational levels. The method consisted of an in-depth literature review grounded in the analysis of a documentary corpus that included the author's previous studies and theoretical sources on multimedia resources, Instructional Design (ID), cognitive neuroscience, and curricular integration. The results showed that planning the use of technologies promotes more meaningful and lasting learning by making educational environments more dynamic and fostering student agency. The study concludes that the STS perspective requires technological integration to be accompanied by public policies that ensure equitable access, adequate infrastructure, and ongoing teacher education - fundamental elements for promoting inclusive education aligned with the challenges of human and social development.

Keywords: Technology. Meaningful learning. Educational equity.

INTRODUCTION

Contemporary society is marked by the restructuring of social, cultural, and economic relations, driven by rapid technological development and the consolidation of the network society, or digital society. In this context, the relationship among Science, Technology, Education, and Society (STS) transcends a mere academic subject and becomes a fundamental paradigm for understanding and coordinating discussions about educational innovation. As technology permeates everyday life, the educational system must incorporate it with clear and consistent pedagogical purposes and intentions in order to educate individuals who are competent and, above all, critical thinkers (Moran, 2012; Tedesco, 2004).

The social relevance of this topic lies in the urgent need for schools to align with the demands of the twenty-first century, preparing students not only to use digital tools instrumentally but also to develop critical awareness of their ethical, political, and economic implications. From a scientific standpoint, the study is justified by the need to connect and integrate concepts that, although interrelated, are frequently addressed in isolation: the benefits of Multimedia Resources (Santos & Santana-Menezes, 2022), the systematization of Instructional Design (ID) (Caiado et al., 2024), the foundations of Neuroscience applied to cognition (Gonçalves & Nogueira, 2015), and the Curricular Integration of technologies.

The STS perspective is the theoretical pillar guiding this investigation because it establishes that science and technology are social products and therefore are not neutral. From this standpoint, education is understood as a strategic space for developing the capacity to intervene in reality, countering technological determinism and the belief that technology alone will solve pedagogical problems.

On the contrary, the focus is on the teacher's pedagogical intentionality, with the teacher viewed as the principal agent in mediating knowledge. The research problem therefore consists of investigating the factors that limit or enhance this mediation, particularly unequal access and teacher education. The absence of public policies ensuring equitable access to technological infrastructure may widen social disparities, making the pursuit of digital inclusion an ethical and educational imperative.

Accordingly, this study aimed to analyze, in depth and in an integrated manner, the relationships among science, technology, education, and society; identify the impacts of technological integration - in its multimedia, instructional, and neurocognitive dimensions - on learning; and critically discuss the structural challenges and essential contributions to the contemporary educational landscape.

METHODOLOGY

The methodology used in this study was qualitative and based on a literature review design. This approach was selected because of the need to conduct a critical and integrated analysis of information and data already published in a documentary corpus relevant to the topic. The research universe consisted of academic publications and contemporary literature addressing the pedagogical use of digital technologies, their relationship with learning, Instructional Design, Neuroscience applied to Education, and the STS perspective.

The analytical corpus used for the theoretical foundation and discussion of the results was structured around four areas of thematic inquiry developed by the author in previous studies. These areas - Benefits of Multimedia, Instructional Design Using Technology, Neuroscience, Education and Technology, and Technologies Integrated into the Classroom - served as the primary analytical categories. They were complemented by secondary sources that provided theoretical and conceptual

support (Allan, 2015; Brito & Purificação, 2012; Castro & Mill, 2018; Moran, 2012; Tedesco, 2004).

The inclusion criteria encompassed publications that discuss the intentional and pedagogical use of technologies, their relationship with learning, teacher education, and the social implications for educational practice, in alignment with the STS perspective. Texts with a strictly technical or commercial focus and no connection to educational purposes were excluded. The analytical process consisted of an exploratory and systematic reading of the concepts and evidence presented in the primary studies, followed by thematic categorization and organization. The data were subsequently connected and compared with the STS theoretical framework to develop the theoretical foundation and expanded results.

Regarding ethical considerations, because this study was exclusively bibliographic and did not involve the direct or indirect collection of data from human participants or the use of private information, it was conducted in accordance with academic integrity guidelines and did not require submission to a Research Ethics Committee, as provided by Resolution No. 510/2016 of the Brazilian National Health Council.

PRESENTATION AND DISCUSSION OF RESULTS

The analysis of the studies and theoretical framework identified four essential areas of convergence for understanding educational innovation. The discussion of the results is based on the articulation of these areas, always through the lens of Science-Technology-Society (STS), which serves as both a catalyst and an ethical standard for technological applications.

The Multivector Structure of Meaningful Learning with Technology

The effectiveness of technological integration in education does not lie in the device itself, but in the synergistic combination of cognitive and pedagogical factors. The results showed that the planned use of technology promotes meaningful learning by stimulating the brain in ways that traditional methods do not achieve and by structuring instruction in an adaptable manner.

Table 1 summarizes the interconnection among the theoretical foundations analyzed and their direct contributions to the development of a teaching-learning methodology aligned with the digital age.

THEORETICAL FOUNDATION	CONTRIBUTION TO TEACHING AND LEARNING	RELATIONSHIP TO TECHNOLOGY
Multimedia Resources	Dynamism, attractiveness, flexibility, and accessibility.	A combination of sensory stimuli (visual and auditory) that engages attention and memory.
Instructional Design (ID)	Coherence, systematization, personalization, and alignment of the learning pathway.	Digital platforms and software are used to track progress and adapt content to each learner's pace.
Cognitive Neuroscience	Enhancement of synapses, attention, motivation, and memory consolidation.	Interactive tools (VR and gamification) stimulate neurotransmitter release (dopamine) and facilitate cognitive organization.
STS Perspective	Critical awareness, equity, and opposition to technological determinism.	Ethical and political guidance for using technology to promote social inclusion and civic education.

Source: Prepared by the author (2026), based on Santos and Santana-Menezes (2022), Caiado et al. (2024), Gonçalves and Nogueira (2015), and Moreira (2020).

The analysis of Table 1 demonstrates that the success of a technological intervention depends on integrating all of its columns. The dynamism of Multimedia Resources (Santos & Santana-Menezes, 2022) is fundamental to engagement, but their application must be systematically planned through Instructional Design (Caiado et al., 2024), which ensures that objectives remain coherent. This coherence, in turn, should draw on findings from Neuroscience, which confirms the value of interactive activities for neurotransmitter release and the strengthening of long-term memory (Gonçalves & Nogueira, 2015).

The contribution of technology to neurocognition is widely emphasized, as interactive tools such as Padlet in collaborative contexts intensify the exchange of ideas (Klein & Vosgerau, 2018) and facilitate the formation of new neural connections. This scientific foundation equips teachers to move beyond the role of mere transmitters and instead organize learning situations with intentionality, coherence, and a focus on evidence.

In addition, contemporary literature emphasizes that the use of technology must be connected to the development of intellectual autonomy and the active construction of meaning. From this perspective, Moreira (2020) provides a meaningful synthesis of the role of technologies in meaningful learning, as presented in the following quotation:

The use of educational technologies must be understood not as an isolated resource, but as an element within an interconnected system of pedagogical relationships. When critically integrated into planning, technology contributes to cognitive reorganization, expands the learner's capacity to construct meaning, and enables prior knowledge to interact with new information. This process goes beyond instrumental use and becomes a formative practice sustained by interactions, reflections, and experiences that continue over time. (Moreira, 2020, p. 47)

This conception reinforces that technology does not operate autonomously; it depends on careful pedagogical mediation and a methodological structure capable of guiding meaningful experiences. Virtual environments, simulators, and multimodal resources expand opportunities for experimentation, stimulate critical thinking, and create conditions for students to develop their own strategies for investigation and problem-solving. In this context, instructional design connects objectives, content, and digital resources, creating inclusive and dynamic learning pathways aligned with the demands of contemporary society.

Student agency, personalization, and the sociopedagogical dimension

When properly implemented, technology has profound effects on the sociopedagogical dimension, particularly by strengthening student autonomy and agency. Students, who belong to a generation deeply immersed in digital culture, find in multimedia resources fertile ground for actively constructing knowledge. Rather than remaining passive recipients, they develop investigative, creative, and collaborative competencies, assuming greater intellectual independence (Moran, 2012). This change shifts the focus of the educational process and places students at the center, allowing their experiences, curiosity, and learning pace to guide pedagogical work.

Although technology provides the means for this transformation, it does not operate in isolation. Instructional Design is essential for structuring flexible, coherent, and intentionally planned learning pathways. Models such as blended learning increase the capacity to personalize activities, explore multiple forms of expression, and create more meaningful experiences, especially when combined with collaborative and problem-posing practices (Castro & Mill, 2018).

Thus, personalization becomes an element that goes beyond the technical dimension and serves as a guiding principle for instruction that is more inclusive and responsive to individual differences.

The STS perspective reinforces this need by recognizing that the integration of science,

technology, and society requires consideration of the cultural, ethical, and political dimensions that shape education. From this perspective, personalizing instruction means more than adjusting a learning pathway; it means recognizing each student's uniqueness, context, history, and actual opportunities for participation. Personalization therefore functions as a strategy for mitigating inequality, expanding access, promoting equity, and strengthening the emancipatory potential of schools.

Specialized literature emphasizes that this process requires careful attention to diversity and to the material conditions that influence learning. The use of digital platforms, adaptive pathways, and collaborative environments, for example, allows students to progress at different paces, explore additional content, and revisit concepts whenever necessary. This expands instructional time and shifts the focus from lectures to an interactive dynamic in which teachers monitor individual pathways and mediate learning needs more precisely.

This conception is supported by studies that discuss personalization from a comprehensive perspective. Bacich and Moran (2018) summarize this understanding in the following quotation, which illustrates the breadth and social commitment involved in the process:

Personalization does not mean individualizing instruction in isolation or fragmenting the educational experience. It occurs when teachers create conditions for each student to progress at their own pace, using different forms of expression, digital resources, and collaborative practices. In this process, technology does not replace the educator; on the contrary, it expands the educator's capacity to monitor, guide, and offer appropriate challenges, making learning fairer, more meaningful, and more accessible. (Bacich & Moran, 2018, p. 63)

This approach reinforces that student agency does not emerge spontaneously; it requires a pedagogical environment that encourages decision-making, self-management, and the collective construction of solutions. Autonomy develops as students understand their learning objectives, identify their difficulties, seek strategies to overcome them, and establish critical relationships with knowledge. In this process, technology contributes by providing tools that expand opportunities for investigation, experimentation, and original production.

Virtual learning environments, simulators, creation applications, collaborative platforms, and automated feedback systems help students assume greater responsibility for their learning pathways. At the same time, they strengthen social-emotional competencies such as cooperation, organization, persistence, and communication, which are essential to comprehensive development. The sociopedagogical nature of this movement becomes evident when these practices promote active participation, foster a sense of belonging to the school community, and expand dialogue among peers.

From the teacher's perspective, this context requires new forms of pedagogical intervention. The teacher assumes the roles of mediator, content curator, experience designer, and facilitator of reflective processes. Rather than centralizing knowledge, the teacher creates conditions for learning to occur in multiple spaces, at different times, and through various formats. This reorganization does not diminish the educator's role; on the contrary, it values that role and reinforces the need for conscious, well-founded planning that is responsive to the demands of the digital age.

Thus, student agency and personalization constitute an integrated movement that redefines the school environment, promotes dialogic practices, and guides teaching toward a more equitable and inclusive perspective connected to contemporary realities. When applied with pedagogical intentionality, technology becomes an axis of transformation that expands opportunities and strengthens the social role of education.

The STS perspective and addressing structural and equity challenges

The principal conclusion of the analysis, viewed through the STS perspective, is that the effectiveness of technological innovation is constrained by structural challenges that perpetuate digital exclusion and unequal opportunities. Although contemporary discourse values the transformative potential of educational technologies, their implementation remains conditioned by political, economic, and institutional factors that often extend beyond the individual teacher's sphere of action. In this sense, it is clear that democratizing access to technologies involves more than making them available; it requires a critical understanding of the social mechanisms that produce and sustain inequalities.

Table 2 describes the main challenges identified and the strategies required to overcome them, following guidance derived from a critical educational policy grounded in equity, social justice, and inclusion.

IDENTIFIED STRUCTURAL CHALLENGE	SOCIAL IMPLICATION (STS PERSPECTIVE)	REQUIRED STRATEGY
Low Quality of and Access to Infrastructure	Widening social disparities and digital exclusion, penalizing students from low socioeconomic backgrounds.	Develop public policies for major investment in high-quality broadband, equipment, and maintenance throughout the school system.
Insufficient Teacher Education	Superficial use or rejection of technology, resulting in a failure to redefine methodology.	Provide continuous and permanent education that goes beyond technical operation and focuses on pedagogical intentionality and ID.
Curricular and Structural Resistance	Risk of replacing a traditional method without changing the essence of teaching - substitution without transformation.	Redefine teacher identity and the curriculum, transforming teachers into mediators and the curriculum into a means of accessing technology and high-quality knowledge (Rocha, 2009).

Source: Prepared by the author (2026), based on Júnior (2018) and Rocha (2009)

As shown in Table 2, the central challenge is no longer the acceptance of technology, but the equitable management of its use. Expanding the availability of devices and digital resources does not by itself overcome educational inequality, particularly when structural factors such as income, location, infrastructure availability, and teacher education determine who can fully benefit from these resources. Thus, the discussion shifts from technical access to an analysis of the actual conditions of use, participation, and continuity, which are essential elements of the STS perspective.

As an agent of change, the teacher needs solid and ongoing education to master the full range of possibilities offered by digital technologies (Júnior, 2018). In many contexts, however, teacher education remains limited to technical training and does not address the pedagogical, ethical, and political dimensions of technological integration. For the STS approach, this limitation reveals a structural problem: the absence of professional-development policies that recognize teachers as critical agents capable of transforming traditional practices and promoting more democratic learning.

In addition, curricular and institutional resistance continues to represent a significant barrier to innovation. Many schools reproduce rigid, inflexible models disconnected from contemporary demands, restricting the potential of technologies to practices of substitution rather than transformation. In this regard, Rocha (2009) emphasizes the importance of breaking with rigid

structures and understanding the curriculum as a dynamic, cultural, and political space. This perspective can be observed in the following quotation:

Curricular transformation cannot be reduced to simply adding technologies to everyday school life. It entails reinterpreting teachers' professional identity and understanding the curriculum as a social construction and a space for access to high-quality knowledge. Digital resources must be guided by democratic practices that question inequalities, promote active participation, and expand educational horizons. Without this substantive change, any innovation remains superficial and restricted to a select few. (Rocha, 2009, p. 112)

This reflection shows that technological innovation, when not accompanied by profound structural changes, tends to reinforce inequalities rather than overcome them. For this reason, the STS perspective calls for a broader understanding of educational policies, recognizing that technology fulfills its democratizing role only when connected to three fundamental dimensions: adequate infrastructure, qualified teacher education, and critical pedagogical intentionality. Without this three-part foundation - infrastructure, education, and intentionality - the transformative potential of technology risks becoming a privilege limited to well-resourced urban schools, thereby deepening historical disparities.

Under these conditions, innovation operates more as a mechanism of social distinction than as an instrument of inclusion. Ensuring infrastructure is not limited to providing equipment; it also involves ongoing maintenance, stable connectivity, technical support, and territorial expansion policies that include schools in rural, riverside, or vulnerable communities.

Likewise, teacher education must be ongoing, reflective, and context-specific, enabling teachers to recognize technology as a tool for mediation, expression, and social construction rather than as a merely technical resource. Such education makes it possible to plan more conscious and ethical pedagogical interventions committed to meaningful learning.

Finally, pedagogical intentionality ensures that technology is integrated into the curriculum in alignment with broad educational objectives, valuing critical thinking, participation, inclusion, and social justice. Only when these elements are coordinated does technology cease to be a privilege and become effective public policy capable of democratizing knowledge and strengthening educational practices guided by the STS perspective.

CONCLUSION

This study achieved its proposed objective by analyzing the implications of technological innovations for the teaching-learning process from the Science, Technology, and Society (STS) perspective. The analysis showed that technologies can foster more meaningful, participatory, and contextualized learning when used in a planned manner and connected to pedagogical foundations, including contributions from Instructional Design and Neuroscience.

Technology, however, does not in itself constitute a solution to educational challenges. From the STS perspective, its use is related to social, cultural, economic, and political factors and may contribute either to the democratization of knowledge or to the reproduction of inequalities. In this context, teacher mediation is fundamental to ensuring the critical, ethical, and inclusive use of technological resources.

The study concludes that technological innovation can contribute to the transformation of education when connected to intentional pedagogical practices and public policies committed to equity, inclusion, and teacher education. Empirical research in different educational contexts is recommended to deepen understanding of the effects of these innovations on learning and social transformation.

REFERENCES

- ALLAN, Luciana. **Educação na era digital: desafios e oportunidades**. São Paulo: Moderna, 2015.
- BACICH, L.; MORAN, J. **Metodologias ativas e personalização da aprendizagem**. São Paulo: Penso, 2018.
- BRITO, Glaucia da Silva; PURIFICAÇÃO, Ivonelia da. **Educação e tecnologias: o novo ritmo da informação**. 3. ed. Campinas: Papirus, 2012.
- CAIADO, K. R. M. et al. **Design instrucional e inovação pedagógica: fundamentos e aplicações**. Brasília: Liber Livro, 2024.
- CASTRO, A.; MILL, D. **Ensino híbrido e cultura digital: fundamentos e práticas**. Belo Horizonte: Autêntica, 2018.
- CASTRO, Cássio Roberto; MILL, Daniel. **Educação a distância e tecnologias: abordagens teóricas e práticas**. São Carlos: EdUFSCar, 2018.
- GONÇALVES, F.; NOGUEIRA, R. **Neurociência e aprendizagem: processos cognitivos e memória**. Rio de Janeiro: Wak, 2015.
- JÚNIOR, A. L. **Formação docente para tecnologias digitais: desafios e perspectivas**. Curitiba: CRV, 2018.
- KLEIN, A.; VOSGERAU, D. **Colaboração on-line e mediação pedagógica no uso do Padlet**. Revista Educação e Tecnologia, Curitiba, v. 23, n. 2, 2018.
- MORAN, José Manuel. **A educação que desejamos: novos desafios e como chegar lá**. 5. ed. Campinas: Papirus, 2012.
- MORAN, J. **Novas tecnologias e mediação pedagógica**. Campinas: Papirus, 2012.
- MOREIRA, M. A. **Aprendizagem significativa: tecnologia, mediação e construção de sentidos**. Porto Alegre: EDIPUCRS, 2020.
- ROCHA, S. **Currículo, tecnologia e transformação social: fundamentos críticos**. São Paulo: Cortez, 2009.
- SANTOS, A.; SANTANA-MENEZES, M. **Recursos multimídia na educação contemporânea**.

Revista Brasileira de Educação, São Paulo, v. 27, n. 1, 2022.

TEDESCO, Juan Carlos (org.). **As tecnologias da informação e comunicação na educação: sugestões para a preparação de professores**. São Paulo: Cortez, 2004.