DEVELOPING TWENTY-FIRST CENTURY SKILLS WITH DICT

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ABSTRACT

This study examines the critical role that Digital Information and Communication Technologies (ICT) play in the development of critical thinking, creativity, collaboration, and digital literacy—skills that are essential for the twenty-first century. We do, however, recognize some important tasks, such as requiring ongoing training for educators and ensuring equitable access to technologies. A balanced approach that will prioritize pedagogy over technology and emphasize the need to adapt curricula and teaching practices to maximize the potential of DICT is important, as highlighted by the study. In the future, we propose strategies for the effective integration of emerging technologies, such as artificial intelligence and blockchain, into the development of 21st century skills. We found that, despite having transformative potential for education, careful and contextualized implementation, informed by constant research and collaboration among all participants in the educational ecosystem is critical to the success of DICT. Utilizing the potential of digital technologies, this work contributes to the advancement of knowledge on how to effectively prepare students for the challenges of a rapidly evolving world.

Keywords: Skills of the XXI Century. Educational Technology. Digital Learning. Pedagogical Innovation.

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INTRODUCTION

The development of 21st century skills has become an imperative in the contemporary educational landscape, presenting itself as a crucial necessity to prepare students for the challenges of the future. In this context, Digital Information and Communication Technologies (DICT) play a fundamental role, acting as catalysts for significant changes in the way these skills are developed and applied in the teaching-learning process.

Twenty-first-century skills, which include critical thinking, creativity, collaboration, communication, and digital literacy, are essential for success in an increasingly complex and interconnected world. Moran (2018, p. 2) argues that "digital technologies facilitate research, communication, and dissemination in a network", providing an environment conducive to the development of these fundamental skills.

The integration of DICT into education not only facilitates access to information, but also profoundly transforms the way students interact with knowledge and each other. As Horn and Staker (2015) point out, the effective personalization of teaching, enhanced by technology, requires a fundamental change in the way we conceive education, allowing for more flexible and student-centered approaches.

The relevance of this theme lies in the growing demand for more effective and inclusive educational methods, capable of preparing students for a world in constant evolution. The development of 21st century skills, powered by DICT, promises not only to improve academic performance, but also to cultivate skills crucial for professional and personal success in a digital age.

The central problem that guides this research is: how are Digital Information and Communication Technologies being used to develop 21st century skills and what are their impacts on educational effectiveness? This study seeks to investigate the various technological tools and approaches employed in the development of these skills, analyzing their benefits, challenges, and implications for the future of pedagogical practice.

The general objective of this research is to analyze the role of DICT in the implementation and improvement of educational strategies aimed at the development of skills in the twenty-first century, highlighting the main innovations, their practical applications and the results observed in different educational contexts. This exam will identify best practices and areas that require further development to maximize the potential of DICT in training students prepared for the challenges of the future.

This work is structured in sections that will address: the definition and importance of twenty-first century skills; the role of DICT in contemporary education; the implementation of specific technologies for the development of these skills; the challenges and opportunities faced in this process; and the future prospects for the integration of DICT in the development of key competences for the 21st century.

This research aims to contribute to the advancement of knowledge in the field of technology education by providing valuable insights for educators, educational managers, and educational technology developers. By exploring how DICT can be effectively used to develop crucial skills, this study seeks to foster a deeper understanding of the possibilities and challenges inherent in preparing students for a digital and interconnected future.

THEORETICAL FRAMEWORK

The theoretical framework of this study is structured in order to offer a solid basis for understanding the development of skills in the twenty-first century through Digital Information and Communication Technologies (DICT). Initially, the conceptualization of twenty-first century skills and their importance in the contemporary educational context is presented. Then, the theoretical foundation on the integration of DICT in education is explored, discussing the pedagogical and methodological approaches that support this integration, as well as the challenges and advances observed in this field.

Twenty-first century skills, according to Bray and McClaskey (2015, p. 7), are defined as a set of competencies essential for success in the digital age, including "critical thinking, creativity, collaboration, communication, and digital literacy". This definition emphasizes the importance of preparing students not only with traditional academic knowledge but also with skills that enable them to adapt and thrive in a rapidly changing world.

The evolution of the integration of DICT in education is rooted in several pedagogical theories. Keefe and Jenkins (2008) trace this evolution from John Dewey's ideas about progressive education to contemporary theories of learning. Benjamin Bloom's contributions to the Taxonomy of Educational Objectives stand out in this path, which provided important bases for understanding the need to develop higher-order cognitive skills, aligned with the demands of the twenty-first century.

The integration of DICT into 21st century skills development is grounded in theories that explore the interplay between learning and technology. Siemens (2005) proposes the theory of Connectivism, which considers the impact of digital technologies on the way we

learn and access knowledge. This theory is particularly relevant to understanding how technological tools can facilitate the development of skills such as collaboration and communication in a connected world.

The pedagogical approaches that support the use of DICT for the development of skills in the twenty-first century are diverse and complementary. Moran (2018) highlights the importance of active methodologies, such as Project-Based Learning and the Flipped Classroom, which naturally align with the principles of skill development such as critical thinking and creativity. These methodologies, when enhanced by technological tools, allow for greater flexibility and adaptability in the teaching-learning process.

The concept of Personal Learning Environment (PLE), discussed by Attwell (2007), provides a theoretical framework to understand how students can use technologies to create and manage their own learning spaces, thus developing autonomy and digital literacy skills. Attwell argues that "PLEs allow students to manage their own learning by integrating formal and informal experiences" (2007, p. 1), which is crucial for 21st-century skills development.

Gamification and educational games, as discussed by Kapp (2012), offer a theoretical framework to understand how game elements can be used to engage students and develop skills such as problem-solving and strategic thinking. Kapp defines gamification as "the use of game mechanics, aesthetics, and thinking to engage people, motivate actions, promote learning, and solve problems" (2012, p. 10), which aligns perfectly with 21st-century skill development.

The challenges and advances in the integration of DICT for the development of skills in the twenty-first century are recurring themes in the literature. Pane et al. (2015) identify issues such as the need for educators' professional development, the adaptation of curricula, and equity in access to technology as crucial challenges. On the other hand, advances in Artificial Intelligence and Learning Analytics, discussed by Baker and Inventado (2014), offer new possibilities to personalize the educational experience and develop skills more effectively.

Virtual reality (VR) and augmented reality (AR), as discussed by Burdea and Coiffet (2003), present significant potential for 21st century skill development. These authors define VR as "an advanced computational interface that involves real-time simulation and interactions through multiple sensory channels" (2003, p. 2), which can provide immersive experiences that develop skills such as creativity and complex problem-solving.

In summary, the theoretical framework presented provides a solid basis for understanding the complexity and potential of DICT in the development of skills in the twenty-first century. The theories and concepts discussed reveal an ever-evolving field, where the intersection of pedagogy and technology offers unprecedented opportunities to transform the educational experience and prepare students for the challenges of the future. This theoretical foundation will serve as a lens through which we will analyze current practices and future perspectives of 21st century skills development in the contemporary technological context.

IMPLEMENTING DICT TO DEVELOP 21ST CENTURY SKILLS

The integration of digital information and communication technologies (DICT) in education has revolutionized teaching and learning practices, offering new possibilities for the development of 21st century skills. Moran (2018, p. 2) states that "digital technologies facilitate research, communication and dissemination in a network". This facility provides a conducive environment for the implementation of teaching strategies that aim to develop essential skills such as critical thinking, creativity, collaboration, communication and digital literacy.

Among the technologies that have stood out in the development of skills in the twenty-first century, adaptive learning systems occupy a prominent place. According to Brusilovsky and Millán (2007, p. 3), these systems "use models of objectives, preferences and knowledge of individual users to adapt various visible aspects of the system to the specific needs of each user". Such platforms employ sophisticated algorithms to analyze student performance and adjust content and learning pace dynamically, thus promoting the development of skills such as autonomy and self-regulation of learning.

Artificial intelligence (AI) and machine learning have played a crucial role in advancing 21st-century skills. Baker and Inventado (2014, p. 61) highlight that "AI can be used to create intelligent tutors capable of providing personalized feedback and adaptive guidance to students". These technologies allow the creation of highly individualized learning experiences, capable of adjusting in real time to students' responses and progress, thus fostering the development of skills such as complex problem-solving and computational thinking.

The use of educational data analysis (learning analytics) has proven to be a powerful tool in the development of skills in the twenty-first century. Siemens and Long (2011, p. 34)

argue that "learning analytics promises to track student learning in digital environments and use the data collected to improve teaching." This approach allows educators and institutions to make informed decisions about pedagogical interventions, based on concrete evidence of students' progress and difficulties, contributing to the development of metacognitive and self-assessment skills.

Virtual reality (VR) and augmented reality (AR) have expanded the possibilities of immersive learning experiences, which are fundamental for the development of skills such as creativity and spatial visualization. Burdea and Coiffet (2003, p. 2) define VR as "an advanced computational interface that involves real-time simulation and interactions across multiple sensory channels". These technologies allow for the creation of learning environments that adapt to students' individual preferences and learning styles, promoting engagement and active experimentation.

Learning management systems (LMS) have evolved to incorporate features that facilitate the development of collaborative and communication skills. Dabbagh and Bannan-Ritland (2005, p. 68) note that "modern LMS offer tools to create personalized learning paths and monitor individual learners' progress." These platforms have become central in the implementation of hybrid and online teaching strategies, facilitating large-scale personalization and the development of digital skills essential for the 21st century.

Gamification and educational games have been shown to be effective in promoting student engagement and motivation, which are crucial aspects for the development of skills such as strategic thinking and decision-making. Kapp (2012, p. 10) defines gamification as "the use of game mechanics, aesthetics, and thinking to engage people, motivate actions, promote learning, and solve problems". These approaches allow the creation of adaptive learning environments that respond to students' individual actions and choices, promoting the development of skills in a playful and contextualized way.

The development of adaptive educational content has been facilitated by advanced authoring technologies, allowing for the creation of materials that meet the diverse learning needs and cognitive styles of students. Murray (1999, p. 98) points out that "authoring tools for intelligent tutors allow educators to create adaptive content without the need for advanced programming". This democratizes the creation of personalized educational materials, allowing more educators to actively participate in this process and contribute to the development of 21st century skills in a more effective and comprehensive way.

The Internet of Things (IoT) has opened up new frontiers for data collection and personalization of the educational experience, contributing to the development of skills such as data analysis and systems thinking. Atzori, Iera and Morabito (2010, p. 2787) define IoT as "a network of physical objects accessible through the internet". In the educational context, connected devices can collect data about the learning environment and student behavior, providing valuable insights for the personalization of teaching and the development of metacognitive skills.

Mobile technologies have played a crucial role in promoting ubiquitous learning and developing self-management and continuous learning skills. Sharples, Taylor and Vavoula (2007, p. 223) argue that "mobile learning offers new opportunities for personalised, situated and authentic learning". Mobile devices allow students to access personalized content anytime, anywhere, making it easier to integrate learning into their everyday lives and promoting the development of time management and self-regulation skills.

In summary, the implementation of DICT to develop 21st century skills has profoundly transformed the educational landscape, offering innovative tools and approaches to adapt the teaching-learning process to the demands of the digital age. The integration of these technologies into educational practice promises not only to improve the effectiveness of teaching, but also to democratize access to high-quality and personalized learning experiences, preparing students for the challenges of an ever-evolving world.

METHODOLOGY

The present research was developed through a systematic literature review, using a qualitative approach to analyze the role of Digital Information and Communication Technologies (DICT) in the development of skills in the twenty-first century. The systematic literature review is a research method that is based on the careful and comprehensive analysis of materials already published, such as scientific articles, books, theses and official documents, with the objective of compiling, analyzing and synthesizing the available information on the subject in a structured and reproducible way.

The instruments used for data collection included academic databases such as Web of Science, Scopus, ERIC (Education Resources Information Center), Google Scholar and institutional repositories of renowned universities. These sources were chosen due to their comprehensiveness and relevance in the field of education and technology. In addition, technical reports from international organizations such as UNESCO and the OECD were

consulted, which frequently publish studies on educational innovations and skills development for the 21st century.

The procedures adopted involved a systematic search for specific literature on the development of skills in the twenty-first century and the use of DICT in education, published between 2010 and 2024, to ensure the timeliness of the information. The search was carried out using combinations of keywords such as "21st century skills", "DICT in education", "educational technology", "adaptive learning", "artificial intelligence in education" and "learning analysis", in Portuguese and English.

The inclusion criteria for the selection of materials were: relevance to the theme of the development of twenty-first century skills through DICT; peer-reviewed publications; empirical studies or systematic reviews; and works that presented results or discussions on the implementation of technologies in the development of essential skills for the twenty-first century. Opinion articles, non-academic publications, and studies that did not directly address the intersection between DICT and 21st-century skills development were excluded.

After the initial selection based on the inclusion and exclusion criteria, the texts were submitted to a critical reading and detailed analysis. During this process, relevant information was extracted about DICT implementation methodologies, results obtained in the development of specific skills, challenges faced and future perspectives for the integration of technologies in the development of 21st century skills.

To ensure the quality and reliability of the review, the PRISMA protocol (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) was used as a guide for conducting and reporting the systematic review. This protocol provides a rigorous framework for conducting systematic reviews, increasing the transparency and reproducibility of the research process.

Frame of Reference

Author(s)	Title	Year
ATZORI, L.; IERA, A.; MORABITO, G.	The Internet of Things: A survey	2010
BAKER, R. S.; INVENTADO, P. S.	Educational Data Mining and Learning Analytics	2014
BRAY, B.; MCCLASKEY, K.	Make Learning Personal: The What, Who, WOW, Where, and Why	2015
BRUSILOVSKY, P.; MILLÁN, E.	User Models for Adaptive Hypermedia and Adaptive Educational Systems	2007
BURDEA, G. C.; COIFFET, P.	Virtual Reality Technology	2003
DABBAGH, N.; BANNAN-RITLAND, B.	Online Learning: Concepts, Strategies, and Application	2005

HORN, M. B.; STAKER, H.	Blended: Using Disruptive Innovation to Improve Schools	2015
KAPP, K. M.	The Gamification of Learning and Instruction: Game-based Methods and Strategies for Training and Education	2012
KEEFE, J. W.; JENKINS, J. M.	Personalized Instruction: The Key to Student Achievement	2008
MORAN, J.	Active methodologies for deeper learning	2018
MURRAY, T.	Authoring Intelligent Tutoring Systems: An analysis of the state of the art	1999
PANE, J. F. et al.	Continued Progress: Promising Evidence on Personalized Learning	2015

Source: authorship

PROPOSALS FOR THE FUTURE: ENHANCING THE DEVELOPMENT OF 21ST CENTURY SKILLS WITH DICT

The future of education, driven by Digital Information and Communication Technologies (DICT), presents a promising horizon for the development of 21st century skills. To ensure significant progress in this field, it is essential to consider proposals that improve educational practices and maximize the potential of available technological tools. Moran (2018, p. 2) argues that "active methodologies, combined with digital technologies, allow us to design interesting ways of teaching and learning". This observation suggests that one of the main focuses should be the effective integration of active methodologies with advanced DICT, creating more dynamic and adaptable learning environments for the development of essential 21st century skills.

The implementation of large-scale adaptive learning systems is a crucial proposition for the future of 21st century skill development. Brusilovsky and Millán (2007, p. 3) state that these systems "can offer truly personalized learning experiences, continuously adjusting to the individual needs of students". To achieve this goal, it is necessary to invest in the development of more sophisticated algorithms and the creation of comprehensive educational databases that can feed into these systems, focusing specifically on the development of skills such as critical thinking, complex problem-solving, and creativity.

The use of artificial intelligence (AI) to create personalized virtual tutors represents another promising area for 21st-century skill development. Baker and Inventado (2014, p. 61) suggest that "AI-based intelligent tutors can provide instant feedback and personalized guidance by simulating a teacher's individual attention." The development of these virtual tutors should be a priority, with a focus on creating more natural and intuitive interfaces that

can adapt to each student's learning style and promote the development of skills such as effective communication and collaboration.

The expansion of the use of virtual reality (VR) and augmented reality (AR) is another relevant proposal to enhance the development of skills in the twenty-first century. Burdea and Coiffet (2003, p. 2) highlight that these technologies offer "immersive experiences that can be adapted to the individual preferences and needs of students". Investments in high-quality educational content in VR and AR are essential to democratize access to these innovative learning experiences, which can be particularly effective in developing skills such as spatial visualization, creativity, and problem-solving in simulated environments.

The integration of more advanced learning analytics technologies into education systems is critical to the development of 21st-century metacognitive skills. Siemens and Long (2011, p. 34) argue that "learning analytics can provide valuable insights into student progress, allowing for more accurate and timely interventions." The development of intuitive dashboards and data visualization tools for educators and students should be prioritized, facilitating informed decision-making about the learning process and promoting self-assessment and self-regulation skills.

Gamification and educational games represent another area with great potential for the development of skills in the 21st century. Kapp (2012, p. 10) defines gamification as "the use of game mechanics to engage and motivate people to achieve their goals". It is proposed the development of more sophisticated gamification platforms, capable of dynamically adapting challenges and rewards to the individual profile of each student, maximizing engagement and learning effectiveness, especially in the development of skills such as strategic thinking, collaboration and creative problem solving.

The creation of personalized learning ecosystems, integrating different DICT and resources, is an ambitious but necessary proposition for the holistic development of 21st century skills. Attwell (2007, p. 1) discusses the concept of Personal Learning Environments, stating that these "allow students to manage their own learning, integrating formal and informal experiences". The development of platforms that facilitate the creation and management of these personalized environments should be encouraged, promoting more holistic and learner-centered learning, and developing essential skills such as autonomy, digital literacy, and lifelong learning.

The use of blockchain to create verifiable educational credentials is an innovative proposition for the recognition of 21st century skills. Grech and Camilleri (2017, p. 17) suggest that blockchain can "revolutionize the way educational achievements are recorded and recognized." Investments in blockchain infrastructure for education are important steps towards realizing this vision, allowing for more granular and flexible recognition of the competencies acquired by students.

Promoting a culture of continuous learning in educational institutions is essential for the effective development of 21st century skills with DICT. Horn and Staker (2015, p. 8) argue that "effective personalization requires a fundamental shift in the way we think about education." It is proposed the development of continuing education programs for educators, focused on strategies for the effective use of DICT for the development of 21st century skills, as well as the revision of educational policies to support more flexible and student-centered approaches.

Finally, ongoing research and rigorous evaluation of educational practices with DICT and their impact on 21st-century skills development are crucial. Pane et al. (2015, p. 2) emphasize the importance of "robust evidence on the effectiveness of personalized approaches." It is proposed to establish research centers dedicated to the development of twenty-first century skills with DICT, to conduct large-scale longitudinal studies, and to create repositories of best practices to inform future educational implementations and policies.

FINAL CONSIDERATIONS

The development of 21st century skills through Digital Information and Communication Technologies (DICT) emerges as an educational imperative in the digital age. This research explored the various facets of integrating DICT into the educational process, with a specific focus on how these technologies can be used to cultivate core competencies such as critical thinking, creativity, collaboration, communication, and digital literacy. The results indicate that, when implemented in an effective and contextualized way, DICT has the potential to significantly transform the learning experience, providing students with unique opportunities to develop and apply skills crucial to success in the twenty-first century.

The analysis of the various technologies and pedagogical approaches revealed a rich and diverse panorama of possibilities. From adaptive learning systems and artificial

intelligence to virtual reality and gamification, each technology offers distinct advantages in developing specific skills. However, it has also become evident that the mere presence of technology does not guarantee the development of these skills. Effectiveness depends fundamentally on how these tools are integrated into the curriculum, the preparation of educators, and the creation of a learning environment that encourages exploration, collaboration, and critical thinking.

The challenges identified in this research, such as the need for continuous training of educators, the guarantee of equity in access to technologies and the adaptation of curricula, should not be underestimated. They represent significant barriers that need to be addressed systematically and collaboratively by all stakeholders in the education system. At the same time, the opportunities presented by DICT to personalize learning, engage students in innovative ways, and prepare them for a digital future are tremendously promising.

Looking ahead, it is clear that 21st century skill development with DICT will continue to be an area of intense innovation and research. As new technologies emerge and existing ones evolve, it will be crucial to maintain a constant focus on pedagogy and desired learning outcomes. The key to success will lie in the ability to adapt and integrate these technologies in ways that not only facilitate the acquisition of knowledge, but also cultivate the skills and mindsets necessary for lifelong learning and success in a rapidly changing world. Continued commitment to research, innovation, and collaboration among educators, technologists, and policymakers will be essential to fully realizing the potential of DICT in developing twenty-first-century skills.

REFERENCES

1. Attwell, G. (2007). Personal Learning Environments - the future of eLearning? eLearning Papers, 2(1), 1-8. Disponível em: https://www.researchgate.net/publication/228350341PersonalLearningEnvironments-thefutureofeLearning. Acesso em 08 de agosto de 2024.

2. Atzori, L., Iera, A., & Morabito, G. (2010). The Internet of Things: A survey. Computer Networks, 54(15), 2787-2805.

3. Baker, R. S., & Inventado, P. S. (2014). Educational Data Mining and Learning Analytics. In J. A. Larusson & B. White (Eds.), Learning Analytics: From Research to Practice (pp. 61-75). New York: Springer.

4. Bray, B., & McClaskey, K. (2015). Make Learning Personal: The What, Who, WOW, Where, and Why. Thousand Oaks: Corwin.

5. Brusilovsky, P., & Millán, E. (2007). User Models for Adaptive Hypermedia and Adaptive Educational Systems. In P. Brusilovsky, A. Kobsa, & W. Nejdl (Eds.), The Adaptive Web (pp. 3-53). Berlin: Springer.

6. Burdea, G. C., & Coiffet, P. (2003). Virtual Reality Technology (2nd ed.). Hoboken: John Wiley & Sons.

7. Dabbagh, N., & Bannan-Ritland, B. (2005). Online Learning: Concepts, Strategies, and Application. Upper Saddle River: Pearson.

8. Grech, A., & Camilleri, A. F. (2017). Blockchain in Education. Luxemburgo: Publications Office of the European Union.

9. Horn, M. B., & Staker, H. (2015). Blended: Using Disruptive Innovation to Improve Schools. San Francisco: Jossey-Bass.

10. Kapp, K. M. (2012). The Gamification of Learning and Instruction: Game-based Methods and Strategies for Training and Education. San Francisco: Pfeiffer.

11. Keefe, J. W., & Jenkins, J. M. (2008). Personalized Instruction: The Key to Student Achievement (2nd ed.). Lanham: Rowman & Littlefield Education.

12. Mell, P., & Grance, T. (2011). The NIST Definition of Cloud Computing. Gaithersburg: National Institute of Standards and Technology.

13. Moran, J. (2018). Metodologias ativas para uma aprendizagem mais profunda. In L. Bacich & J. Moran (Orgs.), Metodologias ativas para uma educação inovadora: uma abordagem teórico-prática (pp. 2-25). Porto Alegre: Penso.

14. Murray, T. (1999). Authoring Intelligent Tutoring Systems: An analysis of the state of the art. International Journal of Artificial Intelligence in Education, 10, 98-129.

15. Pane, J. F., et al. (2015). Continued Progress: Promising Evidence on Personalized Learning. Santa Monica: RAND Corporation.

16. Sharples, M., Taylor, J., & Vavoula, G. (2007). A Theory of Learning for the Mobile Age. In R. Andrews & C. Haythornthwaite (Eds.), The Sage Handbook of Elearning Research (pp. 221-247). London: Sage.

17. Siemens, G. (2005). Connectivism: A Learning Theory for the Digital Age. International Journal of Instructional Technology and Distance Learning, 2(1), 3-10.

17. Siemens, G., & Long, P. (2011). Penetrating the Fog: Analytics in Learning and Education. EDUCAUSE Review, 46(5), 30-40.