Analysis and Metaphysics
ISSN: 1584-8574, eISSN: 2471-0849
Vol 23 (1), 2024
pp.784-811

Models of Technological Inclusion in Technology-Level Distance Programs

Rubén Darío Cárdenas Espinosa[1,*], Diego López Franco[2], Julio César Caicedo Eraso[3]

[1]Universidad de Caldas Facultad de Ingeniería. Colombia. es PhD. Information Technology, DSc. Cum Laude Electronic Engineering. Candidato a Doctor en Ingeniería. ORCID http://orcid.org/0000-0002-2417-844X, Correo electrónico. ruben.cardenas@ucaldas.edu.co*

[2]Universidad de Caldas. Colombia. Facultad de Ingeniería. Colombia, Magister en Educación y Magister en Tecnologías digitales, Estudiante Doctorado en Ingeniería.. ORCID https://orcid.org/0009-0004-1407-1819, Correo electrónico julioc.caicedo@ucaldas.edu.co.

[3]Universidad de Caldas. Colombia. Facultad de Ingeniería. Colombia, PhD Ciencias Biomédicas. ORCID https://orcid.org/0000-0003-4073-9152, Correo electrónico julioc.caicedo@ucaldas.edu.co.

Abstract

The purpose of this study is to carry out a systematic review of the models of technological inclusion in technology-level distance learning programs. Characterize the practices of technological inclusion in these countries for the articulation of innovation, technological development, applied research and technology transfer that allow it to be validated through a pilot model. Scientific information published between 2012 - 2022 was collected from Science Direct, Scopus, Springer and Google Scholar. Based on a series of filters and a manual search, 85 articles were found, distributed as follows: 27 on the Technological Inclusion Model, 18 articles on Articulation or validation of Technological practices with Applied Research, and 40 articles on Virtual and Distance Technologies. It was found that the trends of educational technological models and innovations focus on the three innovative pedagogies of Education 4.0 (heutagogy or self-directed learning, pedagogy or effective peer-to-peer learning, and cybergogy, where autonomous and collaborative student-centered learning is technologically enabled in a virtual environment) with the capabilities of three technological learning tools (Facebook, Learning Management System and Blog). The pilots

that have been validated have focused on computational simulation tools and software development.

Keywords: Social inclusion, educational innovation, scientific development, applied research, technology transfer

Introduction

Research, technological development and innovation contribute to the continuous improvement and development of all economic sectors in a country (Espinosa, 2019). Despite having at our disposal a baggage of technological tools and information and communication technologies, students in the areas of specialty of technological programs in Higher Education Institutions in Colombia are not obliged to carry out processes of research, innovation and/or artistic and cultural creation, but paradoxically, The Ministry of National Education (MEN) through Decree 1330 of 2019 and Resolution 021795 of 2020 requires that these programs develop strategies for training in these fields as a requirement to achieve qualified registration, renewal or approval, as well as the mechanisms provided for their implementation. The same happens with the technological programs of Training for Work and Human Development before the Ministry of Labor through Resolution 0447 of 2022.

Considering that the educational quality of Universities should be the same for all those who are interested in obtaining a professional degree without distinction of the type (Technical, Technological or Professional) or modality of study that they choose, whether face-to-face, distance or virtual, in this work it was proposed as an objective to carry out a systematic review of the models of technological inclusion in distance programs of technological level. Characterize the practices of technological inclusion in these countries for the articulation of innovation, technological development, applied research and technology transfer that allow it to be validated through a pilot model.

Very interesting reviews have been presented on: the innovative pedagogical principles and capabilities of technological tools for immersive blended learning (Bizami, Tasir & Kew, 2023); Song et al., 2022). The cognitive impact of interactive design functions for the learning of complex materials in medical education (Song et al., 2014). The Catalytic Capacity of Technological Innovation: Multidimensional Definition and Measurement from the Perspective of Knowledge Spillover (Song et al., 2022). These cover some aspects such as:

Mixed reality rehabilitation programs: research into the design features of augmented reality and augmented virtuality (Howard & Davis, 2022). Student Rules: Exploring Patterns of Student Computer Effectiveness and Engagement with Digital Technologies in Learning (Howard et al., 2016). Technological practices through confirmatory factor analysis and exploration of teachers' technological integration in subjects (Howard et al., 2015). Changing educational practice around a repository of learning resources (Millard et al., 2013). However, the analysis of Technological Inclusion Models in technology-level distance programs that articulate innovation, technological development, applied research and technology transfer has not been the main objective or focus of his research.

The purpose of this work is to obtain a panoramic vision that contributes to characterize the practices of technological inclusion in distance technology level programs for the articulation of innovation, technological development, applied research and technology transfer that allow validation through a pilot model.

Disability, Inclusion and Information and Communication Technologies ICT

According to Muñoz González et al., 2014, the Salamanca Affirmation 1994 reaffirmed the trance of favoring the use of Training for All, promoted by the United Nations Organization for Pedagogy, Technology and Enlightenment UNESCO and the Management of Spain and approved by 92 governments and 25 international organizations within the framework of the Ecumenical Discourse supra Special Educational Needs, referring to all children and young people whose needs Derived from their arching or their difficulties of lesson, Alegría Exposición rethinks the formal model that started from hoof urbanity in which children were the ones who had to adapt to educational institutions, towards a model, in which they have the capacity to adapt to the particular needs of children and especially to those who referred to some category of disability.

Six years later, in 2000, in the town of Dakar, Senegal, the General Education Forum was held, with the note of representatives of 186 countries, reaffirmed their commitments of the previous decade at the Jomtien Conference, which recognized the fundamentals of education as a vital right, inviting the other countries of the planet to increase their efforts to meet educational needs (UNESCO, 2000b, p. 8 cited by Muñoz González et al., 2014).

In New York (2006) an International Treaty for Persons with Disabilities was made, the states belonging to the UN Assembly validate the need to guarantee fundamental rights and freedoms in all fields with homogeneity of opportunities, ensuring an inclusive environment of culture including education. (UN, 2006, p. 19 cited by Muñoz González et al., 2014).

In 2012, UNESCO and the Foundation for the Americas (an associate of the Organization of American States (OAS) provided a detailed overview of the use of Information and Communication Technologies in Education for people with disabilities (Muñoz González et al., 2014). Table 1 taken from Muñoz González et al. (2014) presents the regulations that relate Education to ICTs, disability and inclusion in Argentina, Chile, Colombia and Mexico.

Table 1. Regional regulatory framework for disability, inclusion and ICT

Country	Argentina	Chile	Colombia	Mexico
Regulatory framework	Law 22431, 1981 (Updated with Laws 25635, 25634, 25504, 24901, 24314, 24308, 2387, 23021), Law 2378, 2008 and the Law 26206 on National Education.	Law 20422, 2010	Law 1618, 2013	General Law for the Inclusion of Persons with Disability, 2011
The end	Law 22431, 1981 Art 1. It creates the mechanism to comprehensively protect people with disabilities, ensuring them medical treatment, education and social security.	Art. 1. Ensure the right to equal circumstances of persons with disabilities, for their social inclusion, ensuring the enjoyment of their rights and eliminating any form of discrimination based on disability.	Art. 1. Guarantee and ensure the effective exercise of the rights of persons with disabilities, through the adoption of measures of inclusion, ratification, legitimate measures and exclusion of marginalization	Art 1: Promoting jurisprudence, human rights and freedoms fundamental issues in disability, strengthening their social inclusion with respect, equity and equality In Toda Occasion.

			due to disability	
Disability Perspective (People)	Law 26378/2008 confirms and integrates jurisprudence on the Rights of Individuals with Disabilities, validates their conception, errors, limiting gaps and inequalities in Society.	Art. 5. It exposes the Individual with disabilities: physical, mechanical and mental, errors, limiting gaps and inequalities in Society.	Art. 2. It exposes the Individual with disabilities: physical, mechanical and mental, errors, limiting gaps and inequalities in Society.	Art. 2. Numeral XXI. It exposes the Individual with disabilities: physical, mechanical and mental, errors, limiting gaps and inequalities in Society.
Inclusive Education Perspective and Constitutive Factors	National Education Law 26206: A pedagogical approach based on disability-inclusive education, all rights with specific measures in all areas (Art. 44)	Paragraph 2. Inclusion in the School Art 34 and 36: Pedagogical approach based on disability-inclusive education: all rights with specific measures in all educational areas.	Art. 11. Num 4. Inclusive education policy in accordance with Article 24 No. 2.de the UN Convention, based on the needs of individuals with specific measures in all areas	Chapter III. Art. 12. Num II. Promotes Inclusive Education at all levels and Provides specific measures in all areas .
ICT Perspective	It does not pronounce or provide measures for the educational inclusion of PWD, except for Article 44, subsection to Title VII of the Education Law, the Art. 100 on modes of special education	It does not give measures to the Education Centres, but it does in public libraries in infrastructure and customer service (Art 27)	Art 11. Par 4 Inc k. provides financing For digital literacy in children with disabilities throughout the territory.	Chapter III. Art 12 Num VI. Provides human and technological support equipment and resources for educational quality And Art 13 in infrastructure and customer service in libraries and study sites

Source: (Muñoz González *et al.*, 2014) 17-21

Competencies in applied research

Competencies correspond to group and individual skills that are acquired throughout life and that are contrasted when certain inconveniences are solved in daily life at home or work caused by doubt and technical difficulty. For educational institutions, competence does not only come from curriculum development, but also from experience in solving situations that they receive in a different way than the traditional one; they bring together technical knowledge and experiences given in research and university exploration (Espinosa, 2019). According to (Espinosa, 2019) research merges with the skills to produce applied science periodically first-hand in its context, articulating theory and practice in a tangible way in 3 phases to make a marketable product according to the requirements identified in the community as follows:

1. Openness (investigating applications and adjusting them to theoretical references or documented models);
2. Design incorporating the technical or social requirements of the opening phase (this leads to creativity by applying the theoretical conceptualization in the design of the product under the aspects that were investigated for the expected consumer, validating aspects such as functionality and adaptability);
3. Implementation of the research where the gestation and socialization of the results obtained are presented (here the functional prototypes are made that will be validated for serial production and commercialization).

For Ramírez and Vega (2015), innovation implies the personalization or improvement that, in the form of a product, process, commercialization or organization according to the Oslo Manual,

This contributes to the development of skills that are quickly incorporated into the training that students receive from the University (Espinosa, 2019).

Method

The present work was carried out with descriptive exploratory methodology, so an inquiry was formalized in the databases of ScienceDirect, Scopus, Springer and Google Scholar around Technological Inclusion for innovation, technological development, applied research and technology transfer in distance programs of technological level. We began by developing a protocol for the systematic review, specifying the method and process to be carried out. The protocol established data and search sources, research questions, search equations, inclusion criteria, exclusion criteria.

These articles were analyzed in response to the following research questions, emphasizing current discussions and relevant topics, as well as the development of these topics over the last ten (10) years:

1. How to design the model of technological inclusion in technology-level distance programs for the articulation of innovation, technological development, applied research and technology transfer?

2. How to characterize the practices of technological inclusion in technology-level distance programs for the articulation of innovation, technological development, applied research and technology transfer?

3. How to validate the technological inclusion model in a pilot sample?

The search equations that were developed for each research question were:

- Ecuación de búsqueda 1. (“characterize Technological Inclusion practices” OR “determine exercise scientific introduction” OR “singularize academic insertion praxis“ OR “qualify disciplinary penetration experience”) OR (“v programs” OR “virtual programs”) OR (“technological level” OR “technological grade”) OR (“applied research, applied exploration, technological delivery, discovery”)

- Ecuación de búsqueda 2. ("inclusion model" OR "integration modeling") OR ("distance programs" OR "virtual programs" OR "distance bashelor") AND ("technological level" OR "technological grade") AND ("applied research" OR "applied exploration, technological delivery, discovery")

- Ecuación de búsqueda 3. (validate OR certify OR approve OR corroborate) AND (model OR “exemplary sample” OR pattern) AND (pilot) OR (“applied research, applied exploration, technological delivery, discovery”)

- The systematic search began with the identification of keywords and search terms in English for each research question. The relevant keywords are presented in Table 2.

Table 2. Keyword and search term research

Research Question	Search Terms	Synonymous search terms
How to design the model of technological inclusion in technology-level distance programs for the articulation of innovation, technological development, applied research and technology transfer?	Component 1 technological inclusion model; Component 2 distance programs Component 3 technological level Component 4 applied research technological development innovation transfer	Component 1 technological integration modeling; technological socialization modelling; TIC inclusion model Component 2 distance programs; virtual programs; unchooled programs; distance bashelor Component 3 technological level; technological grade; technological category; TIC level Component 4 applied exploration technological delivery discovery transfer
How to characterize the practices of technological inclusion in technology-level distance programs for the articulation of innovation, technological development, applied research and technology transfer?	Component 1 characterize technological inclusion practices Component 2 model Component 3 pilot Component 4 applied research technological development innovation transfer	Component 1 determine exercise scientific introduction; Singularize academic insertion praxis; Qualify disciplinary penetration experience Component 2 exemplary sample pattern Component 3 prototype Component 4 applied exploration technological delivery discovery transfer
How to validate the technological inclusion model in a pilot sample?	Component 1 validity Component 2 distance programs Component 3	Component 1 Certify; approve; corroborate Component 2 distance programs Component 3

	technological level Component 4 applied research technological development innovation transfer	technological grade Component 4 applied exploration technological delivery discovery transfer

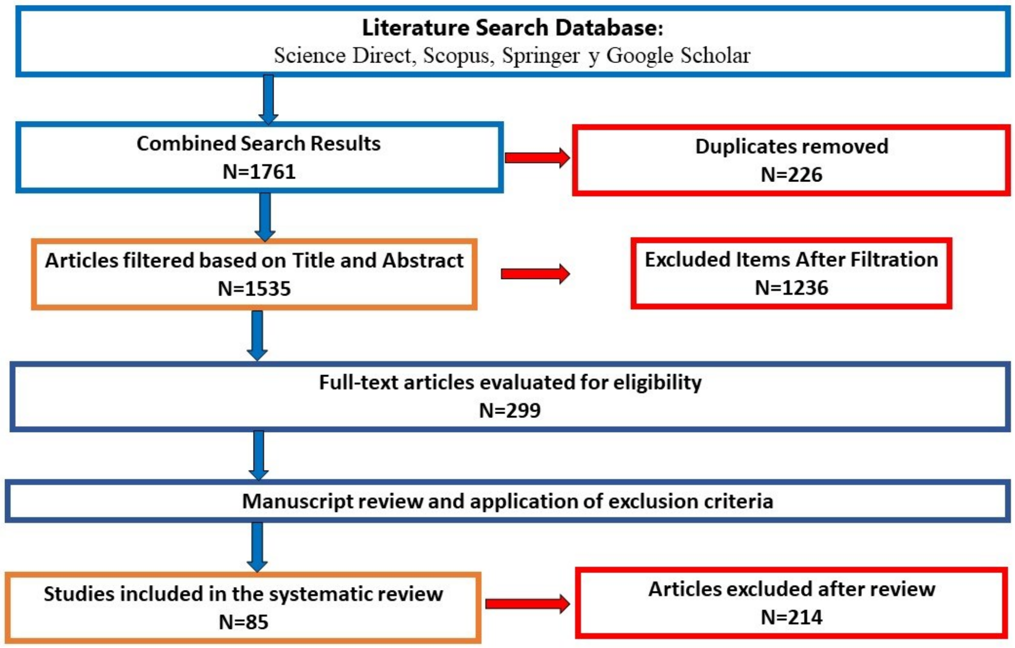
The selected inclusion criteria were:

- Citation databases: Science Direct, Scopus, Springer, Google Scholar, Explora, Web of Science, Scopus, Scimago
- Type: Open Access, Narrative Review, Systematic Mapping or Review, Book Chapter, Event Chapter
- Fields: Title, Abstract, Keywords
- Language: English, Spanish.
- Years: 2012 to 2022
- The selected exclusion criteria were:
- Not be scientific research.
- Duplicate between databases.
- Unrelated to the topic of the review.
- Related to preschool, primary or secondary education, pilots in fields other than higher education at the technological level, software and hardware development models unrelated to innovation, technological development, applied research, technology transfer.

Results

Figure 1 shows the search results using the protocol adapted from (Moreno et al., 2018).

Figure 1. Systematic review protocol



Note: Adapted from (Moreno et al., 2018)

The systematic review with the search strategy proposed as shown in Figure 1, managed to obtain a total of 1761 articles (ScienceDirect: 844, Scopus: 303, Springer: 460 and Google Scholar: 154), which correspond to each of the three research questions as follows: 592 articles on the Technological Inclusion Model, 581 articles on Articulation or validation of Technological practices with Applied Research, and 588 articles on Virtual and Distance Technologies. Subsequently, duplicate documents were eliminated (226). Filters based on title and abstract were applied to 1236 articles that were excluded based on a series of filters until 299 articles were evaluated for eligibility. A detailed review and handsearch of the manuscripts were carried out and exclusion criteria were applied to 214 articles, resulting in the selection of 85 articles included for the systematic review.

Figure 2 presents the synthesis of 94 articles selected for the systematic review, distributed as follows: 27 on the Technological Inclusion Model, 18 articles on Articulation or validation of Technological practices with Applied Research, and 40 articles on Virtual and Distance Technologies.

Figure 2. Synthesis of articles by year and category selected for systematic review

One of the reviews found (Bizami, Tasir & Kew, 2023) corresponds to the innovative pedagogical principles and capabilities of technological tools for immersive blended learning, addresses a conceptual mapping of technopedagogy with limited scope and involves only three types of innovative pedagogical approaches such as heutagogy or self-directed learning, pedagogy or effective peer learning and cybergogy, where autonomous and collaborative student-centered learning is technologically enabled in a virtual environment and three tools (Facebook, Learning Management System and Blog). This mapping needs to be empirically validated so that a proper framework of innovative pedagogies and learning technology tools can serve as a feasible source of reference for instructors to design an immersive blended learning environment and visualize its practical aspect.

(Howard & Davis, 2022) conducted a meta-analysis and systematic review of the literature of mixed reality rehabilitation (MRR) programs addressing the design features of augmented reality and virtuality. This review showed that there was no significant effect with respect to all the features studied of MRR programmes, including the incorporation of gaming elements, the use of head-mounted displays, and the adjustment of tasks and technology.

It was observed that the methodologies used in the studies have a greater tendency to carry out systematic reviews, case studies and pilot experiments. In addition to scientific journals, there is a significant production of articles at conferences and symposia, indicating a significant inclusion of technology and education topics in academic forums. These articles address the relationship between technology and education, show a growing interest in technological inclusion in the educational field, and at the same time, a need for further research to identify and solve the challenges that technology in education presents.

The authors analyzed agree that the appropriate use of these tools and the implementation of innovative pedagogical strategies can significantly improve the effectiveness of distance education. Several of the research focused on measuring teachers' pedagogical, technological, and content competence, and others explored the use of technology in education.

Regarding the models presented in the articles, effective teaching-learning models to improve the quality of teaching, models for the inclusion of people with disabilities, training models based on virtual reality, educational models based on mobile technologies, collaboration and learning models, and theme-based learning models stand out. technology-assisted teaching models, teacher training models and pedagogical models for effective learning, autonomous learning model, problem- and project-based learning model, flipped classroom model, blended learning (B-Learning) education model and gamification model

For those who used mixed methods, they performed regression analysis, exploratory and confirmatory factor analysis, content analysis, and social network analysis.

The research approaches are mostly quantitative, the data analysis methods used were analysis of variance (ANOVA), regression analysis, exploratory factor analysis, confirmatory factor analysis (CFA), measurement model analysis, analysis of variance, student's t-test, chi-square test, factorial and correlation data analysis.

Those who focused qualitatively performed content analysis.

Through the VOSviewer software, the bibliometric networks of the searches carried out in the 1607 articles found with the search equations of point 2.1.3 corresponding to 844 articles in ScienceDirect, 303 articles in Scopus and 460 articles in Springer were carried out. Based on the options given in this tool, Figures 3 and 4 show the display of authors and in Figures 5 and 6 by keywords.

Figure 3. Visualization Authors with the highest production per year

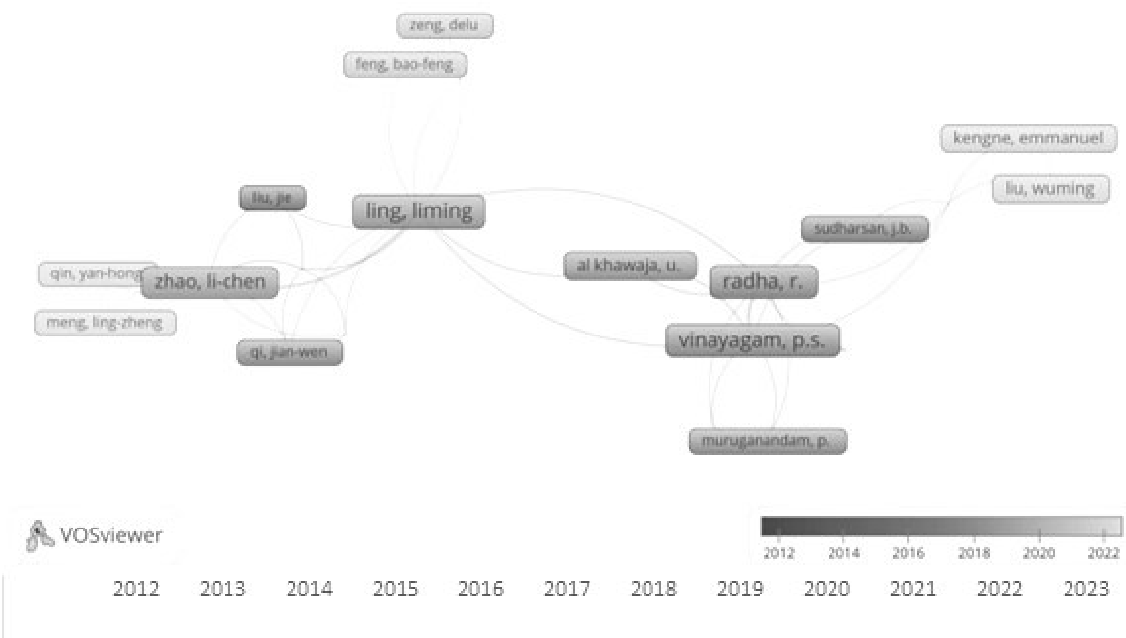
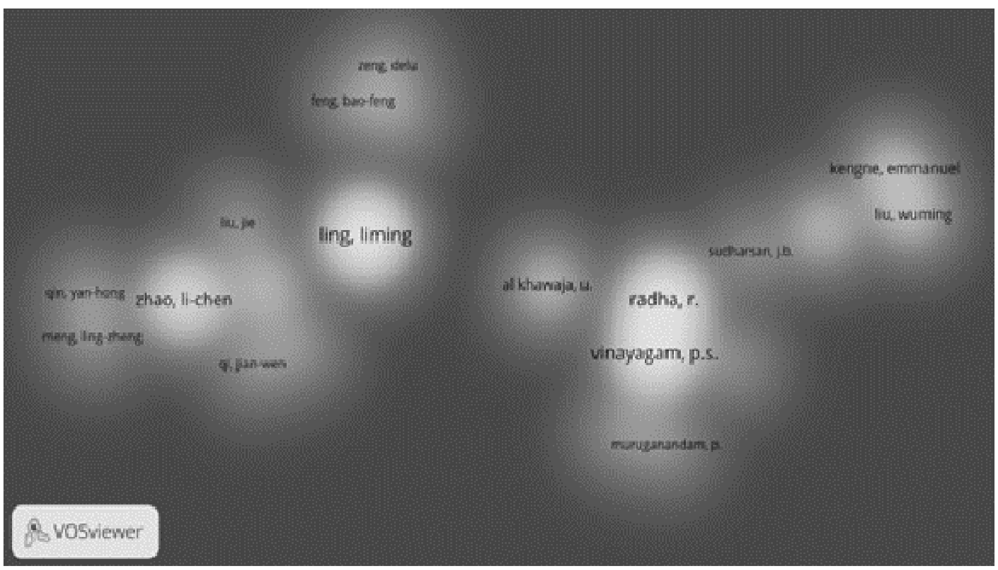


Figure 4. Density map visualization Authors with the highest production per year



In figures 4 and 5 that record the authors with the highest production per year, it was possible to verify that the authors with the highest production are Ling, Limin with 18 articles published between 2017 and 2018, followed by Radha and Vinayagam each with 15 articles between 2016 and 2018, Zhao, Li-chen with 12 articles in 2018, The highest production took place between 2016 and 2022. Kenge, Emmanuel and Liu Wiming with 6 articles between 2021 and 2022, the others registered have less than 3 articles each between 2015 and 2018.

The articles with the highest number of citations are the articles "Technological Transition in Higher Education Institutions: A Case Study" and "Cloud computing in education: A systematic review". Most of the articles were published in technology, education, and computer science journals. The most cited authors in the articles are Wu, J. and Huang, R. in relation to technology in education.

The main topics addressed in these were technological inclusion, distance education, online learning, technology in the classroom, artificial intelligence, computer security.
An interconnection can be observed between the topics included in the articles, where many of them focus on technological inclusion in education and improvements in learning thanks to the implementation of technology in the classroom. Regarding the methodologies used in the studies, the tendency to carry out systematic reviews, case studies and pilot experiments can be identified.

Figure 5. Display of keywords with the highest production per year

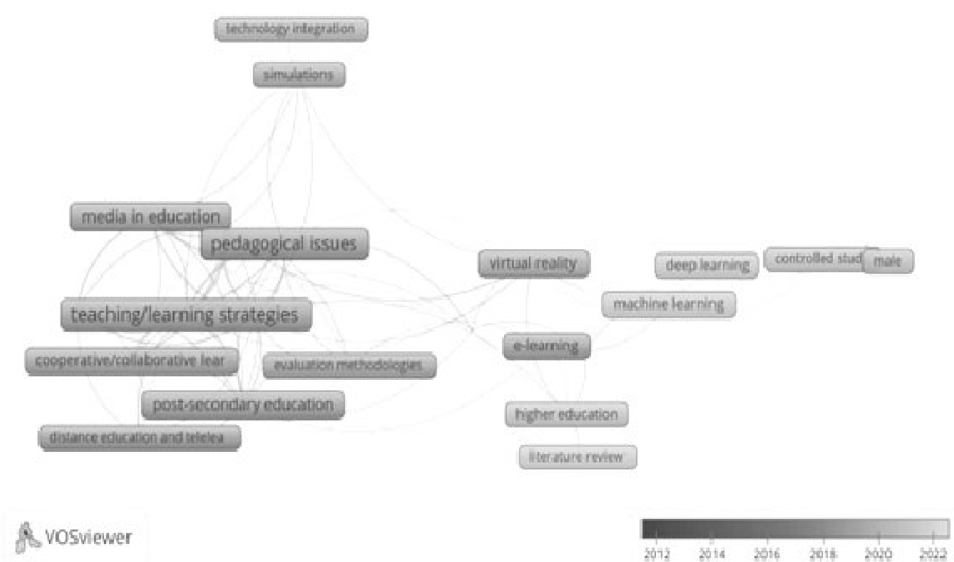
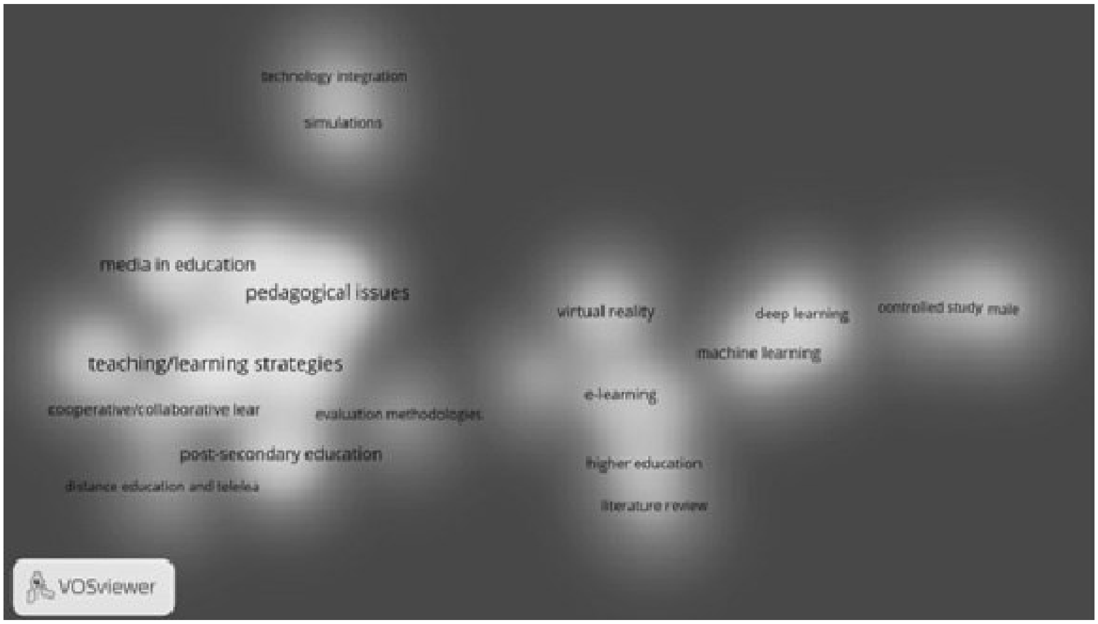


Figure 6. Density map visualization of keywords with highest production per year



Figures 4 and 5, which show the keywords with the highest production per year, showed that the most significant nodes correspond to teaching/learning strategies, pedagogical issues, media in education, cooperative/collaborative learning, evaluation methodologies, post.secundary eduction and distance eduation and telealea. A second block of keywords relate to the terms e-learning, virtual reality, higher eduaction, literature review, machine learning, deep learning and controlled study male. The third term node block relates technology integration and simulations. In general, the selected articles that address the relationship between technology and education show a growing interest in technological inclusion in the educational field, and in turn, a need for further research to identify and solve the challenges that technology in education presents.

Discussion of results:

Around the processes of technological inclusion for innovation, technological development, applied research and technology transfer in technology-level distance programs, there are important challenges and opportunities to improve distance education and ensure that participants have access to the necessary technologies and information according to the current and future context in which they move. According to what was stated by (Espinosa, 2019) regarding ICTs, it was evident that they contribute to educational processes through the technological appropriation of social networks, edublogs, the internet as long as they are mediated from the research seedbeds to analyze, reflect and motivate the research culture, to reduce barriers that occur due to access and use of the technology and information necessary for their professional and occupational performance:

- Accessibility and equity: One of the main discussions around technological inclusion in distance learning programs is accessibility and equity. How can we ensure that trainees have access to the technology and information needed to engage them?
- Quality of Teaching: Another important discussion is the quality of teaching in distance learning programs. How can we ensure that distance learning programs provide a quality educational experience comparable to that of face-to-face programs?
- Applied research: There are also discussions about how to integrate applied research and technology transfer into technology-level distance learning programs. How can we ensure the opportunity for students to apply knowledge and skills to real, relevant problems in their community or industry?
- Interaction and collaboration: Another important discussion is how to encourage interaction and collaboration between students and faculty in distance learning programs. How can we ensure the opportunity for collaborative work in a virtual learning environment?
- Discussion of the technological inclusion model
- For applying technology in training contributes to meeting current demands and questions, therefore I agree with his position when he affirms the importance of incorporating ICTs to include all interest groups from the local and regional context, based on values such as respect, solidarity, companionship in education, in this way, articulate to institutional policies for those who have learning difficulties, technological adaptation, thus making pedagogical planning and learning path more flexible in favor of the promotion of innovation from the classroom. This invites us to analyze the following:
- Importance of technology infrastructure: It has been shown that the availability of technological resources is essential for effective technological inclusion.
- Role of public policies: They play a critical role in promoting technological inclusion, especially in terms of access to technology and the skills needed to use it.

- Socioeconomic differences: Socioeconomic differences continue to be a major obstacle to technological inclusion, and these challenges need to be addressed in order to achieve equitable technological inclusion.
- Accessibility: This is a key aspect of technological inclusion, and it is necessary to ensure that technology is accessible to everyone, including people with disabilities.
- Education and training: These are essential for the effective use of technology, and it is necessary to provide learning opportunities for all

According to (Castillo et al., 2017), the execution of distance multimedia education policies in Colombia requires leaders to generate, operate and manage them, based on strategy, relevance and government directives. It is relevant to recognize the qualification in distance and virtual programs that contribute to hybrid education processes that support the transformation of traditional education by incorporating the advantages of virtuality, which increased thanks to the COVID-19 Pandemic that began in 2020 that abruptly caused distance education in Colombia, This leads us to rethink the importance of the evolution of education with the support of technology from virtuality, contemplating the following aspects:

- Flexibility and accessibility: Virtual and distance education has improved the flexibility and accessibility of higher education for a wide range of students, including those who are unable to attend face-to-face classes due to geography or time.
- Improvement in the quality of education: Virtual and distance technologies allow for greater interaction and collaboration between students and teachers, which can improve the quality of education.
- Suitability to industry requirements: Virtual and distance education allows for better suitability to the requirements and demands of industry and the labor market.
- Technological challenges: The implementation of virtual and distance technologies poses technical challenges, such as limited access to technology and a shortage of digital skills by some students.
- Evaluation and accreditation: applied to virtual and distance education programs is a challenge that is still being addressed, and it is necessary to ensure that these programs meet the same quality standards as face-to-face programs.

- According to the approach of (Castro Maldonado et al., 2023), applied research, unlike basic or pure research, does not generate new knowledge, but rather from the findings of basic research it allows theory to be linked to practice in the development of a product or service. In order to achieve an articulation or validation of technological practices with applied research, the following must be taken into account:
- Improving the quality of research: Combining technological practices with applied research can improve the quality of research, as it facilitates better efficiency and effectiveness in data collection and analysis.
- Increased social impact: Applied research combined with technologies can have a greater social impact, as it allows for better identification of problems and more effective solutions.
- Technological challenges: The integration of technologies into applied research can pose technical challenges, such as poor access to advanced technologies and a lack of digital skills on the part of some researchers.
- Ethical and legal requirements: The combination of technologies and applied research raises ethical and legal issues, such as privacy and data protection, and it is important to ensure that applicable rules and regulations are adhered to.
- Interdisciplinary collaboration: Articulating technology practices with applied research requires interdisciplinary collaboration between researchers, technology experts, and other stakeholders, which can be challenging.
- None of the reviews described the categories Technological Inclusion Model, Articulation or Validation of Technological Practices with Applied Research, and Virtual and Distance Technologies.

Regarding the design of the technological inclusion model in technology-level distance programs, there are gaps in the scientific literature regarding the determination and validation of technical or operational requirements, the selection of appropriate inclusive technologies, the definition of routes for implementation, monitoring of results and their possible impact.

Regarding the characterization of technological inclusion practices in technology-level distance programs, the scientific literature presents gaps in the definition of technological inclusion indicators, the way data are collected and analyzed, the relationship between technological inclusion practices and innovation, technological development, applied research, and technology transfer.

In relation to the validation of the technological inclusion model in a pilot sample, there are gaps in the scientific literature in terms of the definition of validation criteria and standards, the methodology and tools for the evaluation of the model, and the generalization of the results to other contexts and populations.

Conclusions

- There are important challenges and opportunities to improve distance education and ensure that participants have access to the necessary technologies and information according to the current and future context in which they operate. Some of these challenges are accessibility, equity, quality of teaching, applied research, interaction, and collaboration.
- Technological infrastructure, public policies, socioeconomic differences, accessibility and education and training play a key role in technological inclusion.
- Virtual and distance education has improved the flexibility and accessibility of higher education but poses technical and evaluation and accreditation challenges.
- The articulation of technological practices with applied research can improve the quality of research, social impact, but requires overcoming technological, ethical, legal and interdisciplinary collaboration challenges.
- There are gaps in the scientific literature regarding the design and implementation of technological inclusion models in distance programs at the technological level, as well as in the characterization of these practices and their validation.
- Further research is required to design, characterize, and validate effective models of technological inclusion in distance education at the technological level, considering the challenges and opportunities that this entails.

Availability of data and materials

This is a review paper and all data has been presented throughout the paper. Declarations Competing interests the authors have no competing interest to declare

Funding

University of Caldas, Ministry of Science, Technology and Innovation. Call for the allocation for the SGR STeI for the creation of a list of eligible project proposals for doctoral training in the regions. Manizales, Colombia. BPIN 2022000100078

Acknowledgements

We would like to express our sincere gratitude to the Corporación Centro Internacional de Marketing Territorial para la Educación y el Desarrollo (CIMTED) for the invitation to present a keynote lecture at the The XXIX International Congress on Distance, Hybrid, Virtual, Electronic, and Online Education, TELEDU 2023, will be held on Thursday, August 3, 2023, in Bogotá, Colombia, in a digital format. The theme of the congress is "Digital Skills for Formative Research in Distance Programs in the Digital Age" This was an excellent opportunity to present our research project, which was supported by the Bienestar Universitario and the Vicerrectoría de Investigaciones y Posgrados of the Universidad de Caldas.

The development of this research has been funded by the Convocatoria 22 Plan General 21-22 del Ministerio de Ciencia Tecnología e Innovación. This call for proposals was for the allocation of CTeI funds from the SGR to create a list of eligible project proposals for doctoral training in the regions. The project, entitled "Formación de capital humano de alto nivel para atender las demandas territoriales de la región eje cafetero corte 2- Antioquia, Caldas, Quindío, Risaralda," with code BPIN 2022000100078, was approved by Agreement No. 25 of August 9, 2022.

We are grateful for the opportunity to have participated in COINCOM2023 and to have shared our research with such a distinguished audience. We look forward to continuing to collaborate with CIMTED and other organizations to advance the field of artificial intelligence in education.

Author contributions

RDCE was in charge of the research design, data collection and analysis, and writing. DLF was in charge of conceptualization, JCCE was in charge of data analysis, writing and editing. The author(s) read and approved the final manuscript.

Competing interests section

There are no competing interests to declare.

We declare no competing interests.

This work was conducted in the absence of any competing interests.

References:

Ala J. (2006). Computational thinking. ACM Communications, 49(3): 33-35.

Al-Badi A., Khan A. (2022). Technological Transition in Higher Education Institution in the Time of Covid-19. Procedia Computer Science, 203: 157-164.

Alharbi H.E. (2019). An Arabic assessment tool to measure Technological Pedagogical and Content Knowledge. Computers & Education, 142: 103650.

Alves-Passoni P. (2022). The medium-high and high technological intensity sectors in Mexico and Brazil: a structural decomposition analysis between 2000-2014. Problemas del Desarrollo, 53(211): 79-106.

Arpaci I., Basol G. (2020). The impact of preservice teachers' cognitive and technological perceptions on their continuous intention to use flipped classroom. Education and Information Technologies, 25(5): 3503-3514.

Arriaga-Pizano L.A., Gonzalez-Olvera M.A., Ferat-Osorio E.A., Escobar J., Hernandez-Perez A.L., Revilla-Monsalve C., Lopez-Macias C., León-Pedroza J.I., Cabrera-Rivera G.L., et al.

(2021). Accurate diagnosis of sepsis using a neural network: Pilot study using routine clinical variables. Computer Methods and Programs in Biomedicine, 210.

Barreto C.R., Haydar J.M. (2016). Pedagogical intercultural practice of teachers in virtual enviroments. Turkish Online Journal of Distance Education, 17(4): 190-202.

Bhat S.K., Pande N., Ahuja V. (2017). Virtual Team Effectiveness: An Empirical Study Using SEM. Procedia Computer Science, 122: 33-41.

Bizami, N. A., Tasir, Z., & Kew, S. N. (2023). Innovative pedagogical principles and technological tools capabilities for immersive blended learning: a systematic literature review. Education and Information Technologies, 28(2), 1373-1425.

Chen M., Chai C.S., Jong M.S.Y., Chao G.C.N. (2021). Modeling learners' self-concept in Chinese descriptive writing based on the affordances of a virtual reality-supported environment. Education and Information Technologies, 26(5): 6013-6032.

Chen Y.-L., Hsu C.-C. (2020). Self-regulated mobile game-based English learning in a virtual reality environment. Computers & Education, 154: 103910.

Cheng C., Ren X., Dong K., Dong X., Wang Z. (2021). How does technological innovation mitigate CO2 emissions in OECD countries? Heterogeneous analysis using panel quantile regression. Journal of Environmental Management, 280: 111818.

Chien K.-P., Tsai C.-Y., Chen H.-L., Chang W.-H., Chen S. (2015). Learning differences and eye fixation patterns in virtual and physical science laboratories. Computers & Education, 82: 191-201.

Cho I., Park M. (2015). Technological-level evaluation using patent statistics: model and application in mobile communications. Cluster Computing, 18(1): 259-268.

Cimpan C., Maul A., Jansen M., Pretz T., Wenzel H. (2015). Central sorting and recovery of MSW recyclable materials: A review of technological state-of-the-art, cases, practice and implications for materials recycling. Journal of Environmental Management, 156: 181-199.

Doumanis I., Economou D., Sim G.R., Porter S. (2019). The impact of multimodal collaborative virtual environments on learning: A gamified online debate. Computers & Education, 130: 121-138.

Duran C.A., Cordova F.M. (2016). Conceptual Model to Identify Technological Synergic Relationships of Strategic Level in a Medium-sized Chilean Port. Procedia Computer Science, 91: 382-391.

Espinosa R.D.C.J.H.A. (2019). Tecnologías de Información y comunicación desde la virtualidad para la formación en investigación aplicada e innovación “caso semilleros de investigación en los programas tecnológicos Universidad de Caldas”. Hamut'ay, 5(1): 105-117.

Fan F., Dai S., Yang B., Ke H. (2023). Urban density, directed technological change, and carbon intensity: An empirical study based on Chinese cities. Technology in Society, 72: 102151.

Fan L.-W., You J., zhang W., Zhou P. (2021). How does technological progress promote carbon productivity? Evidence from Chinese manufacturing industries. Journal of Environmental Management, 277: 111325.

Ferreira Gonzaga J., Vilpoux O.F., Gomes Pereira M.W. (2019). Factors influencing technological practices in the Brazilian agrarian reform. Land Use Policy, 80: 150-162.

Gao, R., Chuang R., Murphy, W. H., & Anderson, R. E. (2020). Transformational leadership effects on salespeople’s attitudes, striving, and performance. Journal of Business Research, 110, 237–245. https://doi.org/10.1016/j.jbusres.2020.01.023

Guimarães L.B.d.M., Ribeiro J.L.D., Echeveste M.E., de Jacques J.J. (2013). A study of the use of the laptop XO in Brazilian pilot schools. Computers & Education, 69: 263-273.

Hernaiz-Sánchez A., Villaverde-Caramés E.J., González-Valeiro M., Fernández-Villarino M.A. (2021). Physical literacy and teacher training: Pilot study. Education Sciences, 11(2): 1-9.

Howard M.C., Davis M.M. (2022). A meta-analysis and systematic literature review of mixed reality rehabilitation programs: Investigating design characteristics of augmented reality and augmented virtuality. Computers in Human Behavior, 130: 107197.

Howard S.K., Chan A., Mozejko A., Caputi P. (2015). Technology practices: Confirmatory factor analysis and exploration of teachers' technology integration in subject areas. Computers & Education, 90: 24-35.

Howard S.K., Ma J., Yang J. (2016). Student rules: Exploring patterns of students’ computer-efficacy and engagement with digital technologies in learning. Computers & Education, 101: 29-42.

Kleinheksel A.J., Ritzhaupt A.D. (2017). Measuring the adoption and integration of virtual patient simulations in nursing education: An exploratory factor analysis. Computers & Education, 108: 11-29.

Konak A., Clark T.K., Nasereddin M. (2014). Using Kolb's Experiential Learning Cycle to improve student learning in virtual computer laboratories. Computers & Education, 72: 11-22.

Lachner A., Fabian A., Franke U., Preiß J., Jacob L., Führer C., Küchler U., Paravicini W., Randler C., Thomas P. (2021). Fostering pre-service teachers' technological pedagogical content knowledge (TPACK): A quas-experimental field study. Computers & Education, 174: 104304.

Lahav O., Schloerb D.W., Srinivasan M.A. (2015). Rehabilitation program integrating virtual environment to improve orientation and mobility skills for people who are blind. Computers & Education, 80: 1-14.

Lauder J., Harris J., Layton B., Heire P., Sorani A., DeSancha M., Davison A.K., Sammut-Powell C., Lindner C. (2022). A fully automatic system to assess foot collapse on lateral weight-bearing foot radiographs: A pilot study. Computer Methods and Programs in Biomedicine, 213.

Liébana-Cabanillas F., Sánchez-Fernández J., Muñoz-Leiva F. (2014). The moderating effect of experience in the adoption of mobile payment tools in Virtual Social Networks: The m-Payment Acceptance Model in Virtual Social Networks (MPAM-VSN). International Journal of Information Management, 34(2): 151-166.

Lieberman L.J., Ball L., Beach P., Perreault M. (2022). A Qualitative Inquiry of a Three-Month Virtual Practicum Program on Youth with Visual Impairments and Their Coaches. International Journal of Environmental Research and Public Health, 19(2).

Limperos A.M., Buckner M.M., Kaufmann R., Frisby B.N. (2015). Online teaching and technological affordances: An experimental investigation into the impact of modality and clarity on perceived and actual learning. Computers & Education, 83: 1-9.

Lin B., Zhu J. (2019). Determinants of renewable energy technological innovation in China under CO2 emissions constraint. Journal of Environmental Management, 247: 662-671.

Lin C.W., Kuo L.C., Lin Y.C., Su F.C., Lin Y.A., Hsu H.Y. (2021). Development and Testing of a Virtual Reality Mirror Therapy System for the Sensorimotor Performance of Upper Extremity: A Pilot Randomized Controlled Trial. IEEE Access, 9: 14725-14734.

M. Area Moreira, J. Alonso Cano, J. Correa Gorospe, J. del Moral Pérez, L. de Pablos Pons, D. Paredes Labra, J. Peirats Chacón, M. Sanabria Mesa, J. San Martín Alonso y M. Valverde Berrocoso, «Las políticas educativas TIC en España después del Programa Escuela 2.0: las tendencias que emergen,» RELATEC: Revista Latinoamericana de Tecnología Educativa, vol. 13, no. 2, pp. 11-33, 2014.

M. Prendes, F. M. Martínez y G. Gutiérrez, «Competencia digital: una necesidad del profesorado universitario en el siglo XXI,» RED Revista de Educación a Distancia, vol. 56, no. 7, pp. 1-22, 2018.

Mawatwal K., Sen D., Roy R. (2020). Performance analysis of a SAGE-Based semi-blind channel estimator for pilot contaminated MU Massive MIMO Systems. IEEE Access, 8: 46682-46700.

Millard D.E., Borthwick K., Howard Y., McSweeney P., Hargood C. (2013). The HumBox: Changing educational practice around a learning resource repository. Computers & Education, 69: 287-302.

Mishra H.B., Singh P., Prasad A.K., Budhiraja R. (2022). OTFS Channel Estimation and Data Detection Designs with Superimposed Pilots. IEEE Transactions on Wireless Communications, 21(4): 2258-2274.

Moons J., De Backer C. (2013). The design and pilot evaluation of an interactive learning environment for introductory programming influenced by cognitive load theory and constructivism. Computers & Education, 60(1): 368-384.

Moreno, B., Muñoz, M., Cuellar, J., Domancic, S., Villanueva, J., & Moreno, B. (2018). Systematic Reviews: definition and basic notions. Revista clínica de periodoncia, implantología y rehabilitación oral, 11(3), 184-186.

Moreno, Begoña, Muñoz, Maximiliano, Cuellar, Javier, Domancic, Stefan, & Villanueva, Julio. (2018). Revisiones Sistemáticas: definición y nociones básicas. Revista clínica de periodoncia, implantología y rehabilitación oral , 11 (3), 184-186. https://dx.doi.org/10.4067/S0719-01072018000300184

Oh J.H., Hong J.W., You Y.Y., Na G.S. (2016). Effects of patent indicators on national technological level: concentrated on mobile communication, network, and convergence technologies. Cluster Computing, 19(1): 519-528.

Okoye, K., Hussein, H., Arrona-Palacios, A., Quintero, H. N., Ortega, L. O. P., Sanchez, A. L., ... & Hosseini, S. (2023). Impact of digital technologies upon teaching and learning in higher education in Latin America: an outlook on the reach, barriers, and bottlenecks. Education and Information Technologies, 28(2), 2291-2360.

Özgür H. (2020). Relationships between teachers' technostress, technological pedagogical content knowledge (TPACK), school support and demographic variables: A structural equation modeling. Computers in Human Behavior, 112: 106468.

Moughari, M. M., & Daim, T. U. (2023). Developing a model of technological innovation for export development in developing countries. Technology in Society, 75, 102338.

Park S., Jang H., Simeone O., Kang J. (2021). Learning to Demodulate from Few Pilots via Offline and Online Meta-Learning. IEEE Transactions on Signal Processing, 69: 226-239.

Park T.Y., Jeong J.H., Chung Y.A., Yeo S.H., Kim H. (2022). Application of subject-specific helmets for the study of human visuomotor behavior using transcranial focused ultrasound: a pilot study. Computer Methods and Programs in Biomedicine, 226.

Passig D. (2015). Revisiting the Flynn Effect through 3D Immersive Virtual Reality (IVR). Computers & Education, 88: 327-342.

Passig D., Tzuriel D., Eshel-Kedmi G. (2016). Improving children's cognitive modifiability by dynamic assessment in 3D Immersive Virtual Reality environments. Computers & Education, 95: 296-308.

Peralbo-Uzquiano M., Fernández-Abella R., Durán-Bouza M., Brenlla-Blanco J.-C., Cotos-Yáñez J.-M. (2020). Evaluation of the effects of a virtual intervention programme on cognitive flexibility, inhibitory control and basic math skills in childhood education. Computers & Education, 159: 104006.

Song H., Hou J., Zhang Y. (2022). Catalytic capacity of technological innovation: Multidimensional definition and measurement from the perspective of knowledge spillover. Technology in Society, 68: 101898.

Song H.S., Pusic M., Nick M.W., Sarpel U., Plass J.L., Kalet A.L. (2014). The cognitive impact of interactive design features for learning complex materials in medical education. Computers & Education, 71: 198-205.

Sox C.B., Kline S.F., Crews T.B., Strick S.K., Campbell J.M. (2017). Virtual and Hybrid Meetings: A Mixed Research Synthesis of 2002-2012 Research. Journal of Hospitality and Tourism Research, 41(8): 945-984.

Sülter R.E., Ketelaar P.E., Lange W.-G. (2022). SpeakApp-Kids! Virtual reality training to reduce fear of public speaking in children – A proof of concept. Computers & Education, 178: 104384.

Sun Q., Chase J.G., Zhou C., Tawhai M.H., Knopp J.L., Möller K., Shaw G.M. (2022). Over-distension prediction via hysteresis loop analysis and patient-specific basis functions in a virtual patient model. Computers in Biology and Medicine, 141.

van Ginkel S., Gulikers J., Biemans H., Noroozi O., Roozen M., Bos T., van Tilborg R., van Halteren M., Mulder M. (2019). Fostering oral presentation competence through a virtual reality-based task for delivering feedback. Computers & Education, 134: 78-97.

W. Ali, «Online and remote learning in higher education institutes: a necessity in light of COVID-19 pandemic,» Higher Education Studies, vol. 10, no. 3, pp. 16-25, 2020.

Wang M., Yue D.W., Jin S.N. (2020). Downlink Transmission of Multicell Distributed Massive MIMO with Pilot Contamination under Rician Fading. IEEE Access, 8: 131835-131847.

Wang S., He Y., Song M. (2021). Global value chains, technological progress, and environmental pollution: Inequality towards developing countries. Journal of Environmental Management, 277: 110999.

Wang Y., Ma P., Zhao R., Huang Y., Li C., Zhu J., Huang K., Wang B. (2018). Near-Optimal Pilot Signal Design for FDD Massive MIMO System: An Energy-Efficient Perspective. IEEE Access, 6: 13275-13288.

Wei Y., Zhu R., Tan L. (2022). Emission trading scheme, technological innovation, and competitiveness: Evidence from China's thermal power enterprises. Journal of Environmental Management, 320: 115874.

Wollscheid S., Sjaastad J., Tømte C., Løver N. (2016). The effect of pen and paper or tablet computer on early writing – A pilot study. Computers & Education, 98: 70-80.

Xian Y., Wang K., Wei Y.-M., Huang Z. (2020). Opportunity and marginal abatement cost savings from China's pilot carbon emissions permit trading system: Simulating evidence from the industrial sectors. Journal of Environmental Management, 271: 110975.

Yang C.-T., Liu J.-C., Huang K.-L., Jiang F.-C. (2014). A method for managing green power of a virtual machine cluster in cloud. Future Generation Computer Systems, 37: 26-36.

Yasmeen H., Tan Q., Zameer H., Tan J., Nawaz K. (2020). Exploring the impact of technological innovation, environmental regulations and urbanization on ecological efficiency of China in the context of COP21. Journal of Environmental Management, 274: 111210.

Zhang W., Zhang T., Li H., Zhang H. (2022). Dynamic spillover capacity of R&D and digital investments in China's manufacturing industry under long-term technological progress based on the industry chain perspective. Technology in Society, 71: 102129.