



ARTIFICIAL INTELLIGENCE IN DISTANCE EDUCATION: A SYSTEMATIC LITERATURE REVIEW OF BRAZILIAN STUDIES

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Abstract

Artificial Intelligence (AI) is changing the way people live in society. New technologies powered by AI have been applied in different sectors of the economy and the educational context is no different. AI has been considered a key to the development of learning strategies, especially in distance education. In this sense, this research aimed to identify the current state of Brazilian literature on AI applied to distance education. The Higher Education market in Brazil, which is the biggest in Latin America regarding the number of individuals able to enroll in a program, is still developing and distance education has grown rapidly. To reach the purpose of this paper, it was performed a Systematic Literature Review (SLR) to find the research conducted in graduate programs that investigate the subject of AI applied to distance education. The final analysis used a total of 63 studies – 26 master's theses and 37 doctoral dissertations. The main results show that most of the research on AI in distance education in Brazil was conducted in Computer Science (56%) and Engineering (27%). Only 6% of the studies reviewed are from masters' or doctoral programs in Education. The result also shows that limited attention is paid to critical topics related to the growing introduction of AI in distance education, as such teachers' employability and technological training or the ethical implications of using AI for the educational process. As a result of this SLR, it was possible to suggest research opportunities considering the international agenda on AI.

Keywords: artificial intelligence, distance education, educational technology, systematic literature review

Introduction

Each period is marked by a technological development that seeks to meet the needs of individuals. New solutions are proposed and implemented to solve the existing problems, facilitating and improving some aspects of people's lives. In the last decades, society has witnessed technological revolutions in several sectors, impacting production, sales, and jobs (Albuquerque, 2019). The so-called 4th Industrial Revolution (4IR) has been the focus of analysis of several researchers (Schwab, 2017; Xu et al., 2018) and it is considered a strategy to improve competitiveness in business production (Gázquez et al., 2021). Described in 2016 by Klaus Schwab, the founder of the European Symposium of Management, the precursor of the World Economic Forum, the 4IR refers to the context in which the offline world interacts directly and constantly with the online world.

Powered by innovations arising from the Internet of Things (IoT), big data, and AI, among other innovations, the 4IR is already showing its impacts on the job market in several areas (Eberhard et al., 2017). According to specialists, the current technological changes, unlike previous revolutions, may not generate new jobs in the same proportion as they reduce the existing occupations (Gleason, 2018). Researchers have drawn attention to the risk of the implementation of these new technologies creating a mass of qualified unemployed people around the world (Bessen, 2020; Peters, 2017; Peters & Jandric, 2019, Teng et al., 2019).

The more standardized the task is, the more likely it is to be replaced by AI technology (Eberhard et al., 2017). AI has different definitions, depending on the area in which it takes place. Some experts define it as the creation of intelligent agents, which represent systems that perceive their environment and perform actions aimed at maximizing the cases of success (Russel & Norvig, 2019). Others consider AI as the developed technology that provides interaction between humans and machines, either by coupling artificial intelligent systems to the biological organism or by the virtual connection between these agents (Kaufman, 2020). It is also defined by the literature as the study of how to make computers do things that humans are currently better at (Ertel, 2018).

Despite the bias that many researchers have of transferring a human aspect to AI, it is important to clarify that all technologies represent the product of human ideas (Pinto, 2005). They are created by individuals to solve the challenges that they face when in contact with the environment. Therefore, it is not possible to understand AI as an alive agent that has its own will. The claim that robots will control humanity only belongs on the movie screens. Nevertheless, AI might be implemented in some production processes by the desire of a specific group that can generate adverse consequences for the masses. However, in this context, it is not the technology that has the power of destruction, but rather a privileged social group that controls the productive forces.

AI has been used in the educational setting for more than 30 years, but little is known about the effects of these technologies on teaching and learning in higher education. Previous surveys have shown that most of the research about AI comes from Computer Science and deals with its application in four areas: i) Profiling and Prediction; ii) Assessment and Evaluation; iii) Adaptive Systems and Personalization; and iv) Intelligent Tutoring Systems (Zawacki-Richter et al., 2019). Among the positive points that came with application technology in higher education is the greater support and tutoring for students. On the other hand, there are still controversial points about the use of AI in education such as the ethical problems regarding the use of machines, the threat to the employability of teachers (Peters & Jandric, 2019; Wogu et al., 2019; Zawacki-Richter et al., 2019) and the mismanagement of educational data to power AI (Figaredo, 2020).

In distance education, in particular, AI has more applicability. This is because the operation of distance learning in its essence requires a basic technological structure that can be easily combined with AI through Machine Learning (ML) techniques and more specifically with Deep Learning (DL) methods (Yu et al., 2017). DL can be understood as a representation learning method that allows the ML use of complex and multi-layer representations (LeCun et al., 2015). In this sense, the broad set of information available in online environments, such as the time spent by students on materials, participation in forums, and grades, among other possibilities, represents a great opportunity for the introduction of AI for various purposes.

In addition, the application of AI in distance learning has been considered important to improve teachers' performance. Since 2016, with the first assistant teacher created through AI to assist in the educational process in a course at the Georgia Institute of Technology (Goel & Polepeddi, 2016), many tutoring proposals carried out by machines have been applied around the world, from application in the assistance provided on online forums to the evaluation of activities (Kim et al., 2020). AI defenders argue that these technologies can free teachers from basic manual tasks, allowing them to dedicate themselves to activities that demand greater critical capacity and creativity (Goel & Polepeddi, 2016).

However, recent evidence around the world suggests that the number of teachers may be reduced by the implementation of AI technology (Kim et al., 2020; Melim & Moraes, 2021). Technological innovations represent a possibility of reducing costs, which makes the introduction of AI for profit-based private Higher Education Institutions (HEI) a must for the maintenance and/or increase of economic results (Ramble, 2014). For HEIs that belong to conglomerates

with shares traded on the market, the pressure for the adoption of AI technologies may occur even more strongly, given the need for accountability to shareholders.

In Brazil, the educational context may encourage HEI to introduce AI strategies. Brazilian higher education is the largest in Latin America with almost two million students completing high school each year and who can enroll in an undergraduate program (MEC, 2022). The Brazilian government's goal for 2024 is to achieve a gross enrollment rate in higher education of 50% and a net rate of 33%. In 2019, these parameters were 37.4% and 21.4%, respectively. In this sense, the distance education modality has been used by the Brazilian Government to accelerate the number of graduates and AI has been considered essential for reaching a greater number of students and maintaining the quality of education (Torres et al., 2019). In 2020, for the first time, the number of freshman students on the distance education model was higher than the face-to-face undergraduate programs in Brazil (MEC, 2022).

In this way, the general research question that guided this study was: What is the current state of research on AI that is applied to distance education in Brazil? In this sense, the objective of this paper was to identify the current state of Brazilian literature on AI applied to distance education. To do this, it was conducted an SLR, based on the following questions:

- (1) Where does Brazilian research on AI in distance education come from?
- (2) What are the main topics covered by the Brazilian literature on AI in distance education?
- (3) What are the theoretical bases used in Brazilian studies on AI in distance education?
- (4) Which results do Brazilian research suggest on the use of AI in distance education?

Understanding how Brazilian researchers are addressing this theme is important to identify the trends, gaps, and opportunities of research in distance education. Given the relevance of the Brazilian education market for Latin America, research evidence may be useful for several other countries that face similar issues regarding their educational structure. The development and implementation of educational technologies should be based on scientific evidence to introduce best practices to the learning process. Otherwise, when the academy is not utilizing technologies that have been implemented in educational practice, it can lead to inefficacy and inequality in the learning process.

Research Methodology

General Background

The research aimed to identify the current state of Brazilian literature on AI applied to distance education. In this sense, it is characterized as exploratory because it deals with a topic still little explored by Brazilian researchers in the field of Education. It is also classified as bibliographic research, as it performs an SLR to answer the proposed research question. Finally, the data were analyzed using qualitative strategies to interpret the results and quantitative metrics to present the findings.

Procedures

The SLR conducted in this study used the five steps indicated by Klun et al. (2003). To know: i) framing questions for a review, ii) identifying relevant work, iii) assessing the quality of studies, iv) summarizing the evidence, and v) interpreting the findings. For the first step, the questions formulated should enable achieving the objective stated, which was to identify the current state of Brazilian literature on AI applied to distance education. As mentioned in the introduction topic, four questions were addressed to achieve the paper's objective.

To cover the second step, it was used the database named Brazilian Digital Library of Dissertations and Theses (known as BDTD in Portuguese), which contains all of the master's theses and doctoral dissertations of the most important Brazilian HEIs. The reason for using theses and dissertations is due to the research question that guides this study. In this sense, through the review of theses and dissertations produced in Brazilian graduate programs, it is possible to identify the solidity of the research on the subject. By analyzing the theses and dissertations on this subject it is possible to identify research groups and projects that are developed in graduate programs, which reveal the state of research on AI that is applied to distance education in Brazil.

Data Collection and Analysis

Using the BDTD database (<https://bdtd.ibict.br/vufind/>), it was applied a protocol of research that was composed of the combination of the following codes of search (all in the Portuguese language): “artificial intelligence” with “teaching”, “distance education”, “education”, and “learning”. The codes were used for the titles, abstracts, and keywords of theses and dissertations registered in the BDTD. By this protocol, it was possible to find the first amount of 519 studies. Table 1 shows the results of this search. In this first sample, 241 studies appeared more than once. After excluding the repeated research, it was analyzed the content of each study and applied the excluding protocol. With this process, it was possible to select a final sample of 63 studies to conduct the SLR. Of this total, 26 are master's theses and 37 doctoral dissertations.

Table 1
Results of Theses and Dissertations Collected on BDTD

Codes	Research Data			Total
	Keywords	Title	Abstract	
“Artificial Intelligence” & “Teaching”	0	0	4	4
“Artificial Intelligence” & “Distance Education”	0	0	30	30
“Artificial Intelligence” & “Education”	51	2	154	207
“Artificial Intelligence” & “Learning”	54	4	220	278
Total	105	6	408	519

The excluding protocol was processed as follows:

- (a) 105 studies were discarded because they were related to the use of AI at some level of education but not in the context of distance education.
- (b) 60 theses and dissertations collected dealt with AI but were not directly applicable to teaching at any level or modality.
- (c) 14 studies analyzed were not directly related to AI and were also excluded from the final study sample.
- (d) 36 studies were not available for consultation on the platform of their respective graduate programs when the analysis was conducted, either due to a link failure or because the file was unavailable for consultation.

The data collection, which represents the second step of our SLR, was done between March 2021 and June 2021.

For the third step of SLR, it was analyzed the format of the studies collected. The topic covered by this SLR is multidisciplinary, so it was common to find a different theoretical basis

and methodological procedures. Despite this diversity, it was possible to consider all of the results found well supported by the research conducted. In this sense, it was not necessary to discard any more research.

The fourth step was covered by qualitative analysis, as such a codification process. In this stage, the main parts of the theses and dissertations were read, making it possible to understand the topic as it related to the results. The codification was conducted using the themes identified by Zawacki-Richter et al. (2019). Furthermore, throughout the process, three new codes were added, as the themes that emerged from the data were not found in the previous research.

Finally, the fifth and last step of the SLR, shown in the last section of this paper, provides our conclusion about the stage of Brazilian literature in AI, identifying the maturity of the research in this field, highlighting the gaps existing, and suggesting trends for future research.

Research Results

The Programs that the Studies Came from

Figure 1 shows the distribution of 63 theses and dissertations collected in the SLR by the year of publishing. The first study analyzed was published in 1994 and the last in 2020. In almost this entire period at least one study was published on AI in Brazilian HEIs. The exceptions were 1995, 1996, 1998, 2012, and 2015. Figure 1 also indicates that, from 2001 to 2004, it was the period with more studies on AI, representing 26 occurrences (41%). Despite said evidence, the last four years analyzed (2017-2020) also showed an improvement in the number of theses and dissertations on AI with 13 occurrences (21%).

Figure 1

Number of Studies Collected in SLR by the Year of Publishing

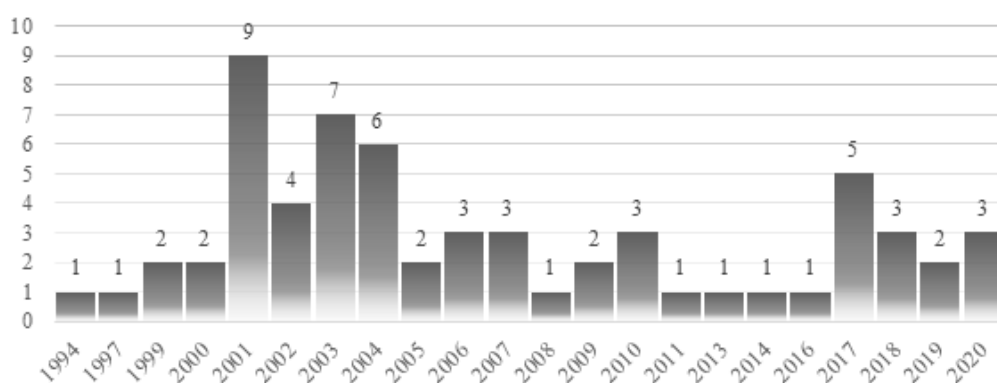


Table 2 shows the HEIs in which the selected studies were developed. It also presents the type of graduate program that the theses and dissertations were carried out. The first evidence it brings is the relevance of Brazilian public HEIs to the research developed on AI. From 63 theses and dissertations, only three studies were carried out at private institutions (International University Center - UNINTER, University of Vale do Rio dos Sinos – UNISINOS, and Presbyterian Mackenzie University - UPM). All of the other studies came from public institutions, that is, organizations maintained by the Brazilian government.

Table 2 also shows that the two HEIs with the most research selected were the Federal University of Rio Grande do Sul (UFRGS) and Federal University of Santa Catarina (UFSC) with 15 studies each. The following is the Federal University of Campina Grande (UFCG) with nine studies. The fourth is the State University of Campinas (Unicamp), with seven selected studies. The next three HEIs appeared with two occurrences, which are the Federal University of Amazonas (UFAM), Federal University of Pernambuco (UFPE), and Federal University of Pelotas (UFPEL). In total, 18 HEIs had at least one thesis/dissertation on AI applied to distance education. However, 11 HEIs appeared with only one study, which indicates that this subject may not be a strong research topic for these institutions.

Table 2
Programs in Which the Studies Were Developed

HEI	Absolute Frequency	Graduate Program
UFRGS	15	Computer Science (12) / Multidisciplinary (3)
UFSC	15	Engineering (12) / Computer Science (3)
UFCG	9	Computer Science (9)
Unicamp	7	Computer Science (3) / Engineering (2) / Portuguese Language and Literature (1) / Education (1)
UFAM	2	Computer Science (2)
UFPE	2	Computer Science (2)
UFPEL	2	Portuguese Language and Literature (1) / Computer Science (1)
UFAL	1	Computer Science (1)
UFMA	1	Engineering (1)
UFPA	1	Engineering (1)
UFPB	1	Education (1)
UFRN	1	Computer Science (1)
UFV	1	Computer Science (1)
UFVJM	1	Education (1)
UnB	1	Arts (1)
UNINTER	1	Education (1)
Unisinos	1	Portuguese Language and Literature (1)
UPM	1	Engineering (1)

Note. Number of occurrences in parentheses

In addition, Table 2 also shows that the theses and dissertations published in Brazilian graduate programs came from diverse backgrounds. This is important evidence, as the AI subject requires a multidisciplinary perspective. However, it was also possible to identify a

predominance of Computer Science programs with 38 studies (56%), followed by Engineering with 17 studies (27%). Theses and dissertations from Education programs represented only four occurrences (6%).

The Topics Covered by the Selected Studies

Table 3 shows the topic covered by the studies selected in the SLR. It was possible to classify all the research into seven codes: (i) Intelligent Tutoring Systems, (ii) Adaptive Systems and Personalization, (iii) Assessment and Evaluation, (iv) Profiling and Prediction, (v) Development and Management of Educational Content, (vi) Virtual Learning Environment, and (vii) Theoretical and Empirical Basis for Educational Software Development.

Table 3
Topics Covered by Selected Studies

Topics Covered	Absolute Frequency	Relative Frequency (%)
Intelligent Tutoring Systems	28	44
Adaptive Systems and Personalization	11	18
Assessment and Evaluation	9	14
Profiling and Prediction	5	8
Development and Management of Educational Content	5	8
Virtual Learning Environment	3	5
Theoretical and Empirical Basis for Educational Software Development	2	3
Total	63	100

The most frequent topic in the selected Brazilian theses and dissertations was the “Intelligent Tutoring Systems”, with 28 occurrences (44%). In this type of research, it was possible to find AI propositions and assessments created to help teachers and students in the process of teaching-learning. The second most frequent topic, in turn, was “Adaptive Systems and Personalization”, with 11 studies (18%). In this type of research, it was common to present solutions to help students with their own needs in the educational process. The third most common topic in the Brazilian theses and dissertations on AI applied to distance education was “Assessment and Evaluation”, with 10 cases (16%). These studies usually presented solutions to improve strategies for valuing students’ achievement.

Together, these three first topics represented an amount of 76% of selected studies in this SLR. Therefore, despite the other four occurrences, it was possible to notice that the Brazilian literature on AI applied to distance education selected in this SLR was concentrated on only a few themes. The “Profiling and Prediction” and “Development and Management of Educational Content” represented each 8% of the occurrences. Finally, the last two topics were “Virtual Learning Environment” with five studies (5%) and “Theoretical and Empirical Basis for Educational Software Development” with only two cases (3%).

The Theoretical Bases Used in Selected Studies

Table 4 shows the educational theories most used by the theses and dissertations selected to support the phenomenon studied. The result indicated that the three highlighted theories are centered on students' learning process.

Table 4
Educational Theories Commonly Used in Selected Studies

Theories	Brief Explanation	Authors
Learning Styles	It elucidates the different aspects of student's learning process, assuming that different individuals have different learning styles	David Kolb
Self-Regulated Learning	It explains how students self-manage their thoughts, feelings, and actions to achieve their personal goals and objectives	Barry Zimmerman
Cognitive Learning Theories	Explains the mental process related to the learning process and shows how it is influenced by internal and external factors	Jean Piaget, Lev Vygotsky, and Reuven Feuerstein

Although many studies from different areas have used important educational theories, it was possible to identify theses and dissertations that did not support their research from the perspective of education. In addition, it was possible to perceive that little attention is given to the teachers' perspectives on the use of AI. As many studies focused on the implementation of AI to (direct or indirectly) improve the teachers' work, it is important to understand how AI changes the teaching process. A critical theoretical perspective on the use of AI was also neglected in the studies selected. The use of technologies in the educational process might cause negative impacts on the society that must also be investigated through a critical lens, highlighting points that go beyond improving student learning.

Exemplification of Research on the Use of AI in Distance Education

As highlighted before, this SLR found that a large part of the theses and dissertations reviewed could be classified as related to the topic of "Intelligent Tutoring Systems" (44% of the total). Although the subject investigated in this area is diverse, it was possible to identify that, in this group, the methodology usually employed by authors was related to the development and/or testing of new technologies powered by an AI solution. Intelligent tutoring systems can be implemented at the educational level for many users: students, teachers, educational staff, and administrators. In this SLR, almost all 28 studies analyzed from the "Intelligent Tutoring Systems" group were applied at the student level.

An example of research collected in this SLR and classified in this group was the doctoral dissertation of Jaques (2004), developed in the Computer Science program at the Federal University of Rio Grande do Sul. This study proposed an intelligent tutoring system to support students affectively. The mediator agent developed in this study acted according to students' emotions, which was structured based on cognitive learning theories (see Table 4). To do this, the system proposed used events that had occurred in the virtual environment, such as the type of answer given by students (right or wrong) and whether the student was up to date or not with the activities or content of the course. Despite the proposition of this mediator agent, this research did not evaluate the effectiveness of the AI proposed.

Another example of research classified in the "Intelligent Tutoring Systems" group in this SLR was the master's thesis carried out in the Portuguese Language and Literature program by Moro (2019) which analyzed the adequacy of a software program, named Skylar, which automatically transcribes and translates speech. Skylar was used in a video class for the MBA

in Agrobusiness from the University of São Paulo, which used the format of distance education. To allow the internationalization of the program, experts from different countries were invited to participate in the classes. In this sense, AI such as Skylar becomes important to help students with gaps in international languages to understand what is being said during classes. Using a mixed methods approach, this research found that the AI analyzed was positive in expressing what the speaker said. Nevertheless, the system showed gaps when the context of the sentences was analyzed.

Even though the majority of studies from the “Intelligent Tutoring Systems” group in this study were applied to the student level, it is necessary to highlight that one study was conducted at the administrative level. This was the case of the dissertation of Lucena (2018), which was carried out in a Computer Science program. It studied an intelligent agent built to manage distance learning courses based on previous problems and solutions detected in distance education courses at the Federal University of Amazonas. After the development of the system (called iDE) by the researcher, using the framework of jCOLIBRI 2, it was validated by ten specialists in distance education. The results of this validation showed that the proposed technological solution was positively evaluated and considered relevant for the management of distance courses.

The second most frequent topic of this SLR was the “Adaptive Systems and Personalization” with 18% of all of the cases. An example of study from this group was the master’s thesis of Ferreira (2018), carried out in the Computer Science program at the Federal University of Pernambuco. This research developed and tested an AI solution to recommend learning activities to students from distance education courses based on autoregulated patterns available in the virtual environment. In this sense, the software proposed allowed for: (i) analyzing the students’ performance; (ii) extracting the behavioral characteristics that influence their performance, and (iii) recommending actions to improve it. This AI was tested with more than 30,000 students from a Brazilian university and the results showed that the technological solution was capable of properly capturing the students’ learning styles and their behavioral characteristics. With this good fit, the software was efficient in recommending additional training (texts and/or videos) to students according to their performance.

The third most recurrent topic that emerged from this SLR was “Assessment and Evaluation” with 16% of all the research. Among this group was Riedo (2020), a dissertation from the Education program at the State University of Campinas. It is important to remember that only 6% of theses and dissertations selected in the present SLR came from Education programs, despite the importance of the phenomenon analyzed in this area. In this sense, the aforementioned dissertation aimed to develop and test an AI program able to evaluate students’ texts in the context of distance education, given to participants’ immediate feedback. To test the AI solution proposed in this research, the author used data from three courses offered by the State University of Campinas in the Massive Open Online Course (MOOC) model. Using a total of 8,788 essays, the study was able to confirm the ability to qualitatively differentiate the analyzed texts, indicating that this AI solution had wide applicability in distance education.

In general, the theses and dissertations analyzed in this study confirmed the ability of AI to transform the distance education system, despite some points of attention. More importantly, these studies explicitly detailed the current presence of AI in the context of distance education. In addition, since the most used methodology in the selected studies consisted of carrying out tests for AI-based solutions, it was possible to predict some impacts of these technologies on the educational process.

Discussion

The introduction of AI in the education field has the potential to transform the way society learns (Bregant & Aberšek, 2011). As in many other areas, AI solutions in the educational environment can transform jobs and impact teaching activities. In this sense, the SLR carried out in this research makes it clear that AI is already an alternative to improve the distance learning environment in Brazil since many theses and dissertations from Brazilian graduate programs develop and evaluate technologies powered by AI.

However, corroborating with previous research (Zawacki-Richter et al., 2019) despite the relevance of this topic for the present, most Brazilian theses and dissertations on AI applied to distance education came from Computer Science and Engineering. This evidence is concerning as it shows that the Education field is not as engaged with the subject related to the application of AI in distance education as other areas of knowledge and this phenomenon may have some roots. Despite the expressive growth of the distance education system in Brazil in the last decade, and especially during the Covid-19 pandemic, this modality still presents resistance within the field of Education (Machisotti, 2022). This finding may also reflect the teachers' fear that technological solutions might replace them, making AI research undesirable in the Education graduate programs.

The timid participation of Education graduate programs in this topic can have consequences for the field. First, it can delay the improvements AI can generate to the learning process in distance education. It is important to note that this modality of education has the potential to reach individuals who have no other possibility of studying, which in a continental country like Brazil, it is a significant portion of the population. In this sense, the delay in improving the quality of distance learning has direct economic and social impacts on society. Additionally, the absence of the Education area in the discussion of AI applied to distance education can also make technological solutions developed in other fields (like Computer Science and Engineering) pedagogically fragile (Aberšek & Kordigel-Aberšek, 2011).

Additionally, it was also possible to identify that the topics covered by Brazilian research on AI are concentrated on just a few themes. Just three topics represent an amount of 76% of selected studies in this SLR. Many of the studies reviewed, especially from Computer Science, propose and analyze a new educational innovation. Technology represents a demand from society to solve the problems that people face in the environment (Pinto, 2005). With the development of the Internet, computer, and other technologies, new demands are made by society, including for distance education (Chen et al., 2020), and AI has been considered a key tool to solve these issues (Ertel, 2018). In this sense, the attention paid by the Brazilian researchers to restricted topics may limit the capability of innovation of AI applied to distance education. The greater the diversity of themes on AI, the more likely it will be that new disruptive technologies can be implemented in distance education.

Another important evidence of this SLR is the predominance of the “Adaptive Systems and Personalization” topic in Brazilian theses and dissertations. As highlighted by Zawacki-Richter et al. (2019), there is no agreement in the literature on the definition of an adaptive system and sometimes it is coincident with intelligent systems. Although the studies classified in this group by this SLR also showed many approaches, all of the research collected was related to the possibility of providing individualized education through AI solutions, which makes this kind of investigation a specific topic of research. Adaptive systems for the personalization of the learning process have been considered important to all educational levels, but especially to distance education due to its heterogeneity (Maghsudi et al., 2021). For developing countries like Brazil, which still have large socioeconomic disparities, personalized education has the potential to improve the learning environment.

Through this SLR, it is possible to suggest some trends for future research, considering the international agenda on AI applied to distance education. The first one is the need to better understand the impact of AI on changes in teachers' work. Many new technologies already implemented in the educational market are changing the teaching process, demanding teachers to learn new skills and reducing their job opportunities in the market. A critical approach may be needed for a deep understanding of these changes, including the ethical implications of using AI in distance education.

Conclusion and Implications

This research aimed to identify the state of Brazilian literature on AI applied to distance education. In this sense, an SLR was carried out using the BDTD database, which contains theses and dissertations from Brazilian HEIs. Following the five steps suggested for an SLR, it was possible to select 26 master's theses and 37 doctoral dissertations (63 studies in total). Through this procedure, it was possible to reach some conclusions and point out some implications.

The first evidence is that studies on AI applied to distance education in Brazil come mostly from different areas of knowledge, such as Computer Science and Engineering. Only 6% of the selected studies in this SLR came from the Education field. This might represent a significant gap related to research in distance education of Brazilian Education graduate programs, as AI represents an important instrument already used in virtual courses in Brazil.

Other important evidence of this SLR is that the production of the theses and dissertations on AI applied to distance education in Brazil is mainly concentrated on a few HEIs, all of which are public institutions. This also represents a risk regarding the development of the topic since AI implementation should be encouraged from a multidisciplinary perspective. The more concentrated it is, the less chance there is of innovation. Therefore, the most common themes were also focused on three topics: "Intelligent Tutoring Systems", "Adaptive Systems and Personalization", and "Assessment and Evaluation". The concentration of themes is also a risk for the literature on AI applied to distance education since many problems already faced by society with the introduction of technological innovation may not be investigated in this research.

Finally, the SLR shows that the theoretical approach of many selected studies is flawed. Despite the use of some important frameworks that explain the learning process from students' point of view, little is discussed about teachers' interaction with AI in distance education. This is also important, as almost all of the selected theses and dissertations propose and analyze new technological solutions that will impact the teaching process and, possibly, the teaching career.

It is important that the Education area becomes more familiar with the topic of AI applied to online education. Only a few works collected in this SLR came from a program in Education in Brazil, which is evidence that agrees with the findings of international literature. For studies developed in areas other than Education, it is important to improve the theoretical framework, deepening theories that explain the whole phenomenon that affects the teaching-learning process in distance education.

Although this SLR analyzed the Brazilian context, its results are in line with the previous research carried out in different contexts. In this sense these findings can also contribute to the development of international research, adding the Brazilian evidence to the international literature on AI applied to distance education.

Additionally, Brazil has some specificities that make its educational system an important case to analyze. First, this country represents the biggest educational market in Latin America, with many individuals still without access to an HEI, which is also the reality of many developing countries. Moreover, in the Brazilian private educational market, there has been a concentration in the last years with a few private higher education companies controlling a significant part of

the distance education market. In this sense, the research developed in the Brazilian graduating programs reflects these complexities, searching for solutions for the problems researchers perceive in their educational context.

Declaration of Interest

The authors declare no competing interest.

References

- Aberšek, B., & Kordigel-Aberšek, M. (2011). Do intelligent e-learning tools need more pedagogical methodology or ICT? *Problems of Education in the 21st Century*, 37, 9-17. <http://www.scientiasocialis.lt/pec/node/633>
- Albuquerque, E. M. (2019). Capitalismo pós-www: Uma discussão introdutória sobre uma nova fase na economia global [Post-www capitalism: An introductory discussion on a new phase in the global economy]. *Cadernos de Desenvolvimento*, 14(24), 131-154.
- Bessen, J. (2020). Automation and jobs: When technology boosts employment. *Economic Policy*, 34(100), 589-626. <https://doi.org/10.1093/epolic/eiaa001>
- Bregant, J., & Abersek, B. (2011). Artificial intelligence versus human talents in learning process. *Problems of Education in the 21st Century*, 37, 38-47. <http://www.scientiasocialis.lt/pec/node/636>
- Chen, X., Xie, H., & Hwang, G. (2020). A multi-perspective study on artificial intelligence in education: Grants, conferences, journals, software tools, institutions, and researchers. *Computer and Education: Artificial Intelligence*, 1, 1-11. <https://doi.org/10.1016/j.caeai.2020.100005>
- Eberhard, B., Podio, M., Alonso, A. P., Radovica, E., Avotina, L., Peiseniece, L., Sendon, M. C., Lozano, A. G., & Solé-Pla, J. (2017). Smart work: The transformation of the labour market due to the fourth industrial revolution (I4.0). *International Journal of Business and Economics Science Applied Research*, 10(3), 47-66.
- Ertel, W. (2018). Introduction to artificial intelligence. Springer.
- Domínguez Figaredo, D. (2020). Data-driven educational algorithms pedagogical framing. *RIED -Revista Iberoamericana de Educación a Distancia*, 23(2), 65-84. <https://doi.org/10.5944/ried.23.2.26470>
- Ferreira, V. A. S. (2018). Um modelo de recomendação de recursos educacionais baseado em aprendizagem de máquina para autorregulação da aprendizagem [A machine learning-based educational resource recommendation model for self-regulation of learning] [Master's thesis, Universidade Federal de Pernambuco]. <https://repositorio.ufpe.br/handle/123456789/34472>
- Gázquez, J. L. R., Delgado, M. V. B., Gras, J. J. O., Lova, J. G., Gómez, M. V. G., & Zbiec, M. (2021). Lack of skills, knowledge and competences in higher education about Industry 4.0 in the manufacturing sector. *RIED - Revista Iberoamericana de Educación a Distancia*, 24(1), 285-313. <https://doi.org/10.5944/ried.24.1.27548>
- Gleason, N. W. (2018). Higher education in the era of the fourth industrial revolution. Palgrave Macmillan.
- Goel, A. K., & Polepeddi, L. (2016). *Jill Watson: A virtual teaching assistant for online education*. <https://smartech.gatech.edu/handle/1853/59104>
- Huang, J., & Chen, Z. (2016). The research and design of web-based intelligent tutoring system. *International Journal of Multimedia and Ubiquitous Engineering*, 11(6), 337-348. <https://doi.org/10.14257/ijmue.2016.11.6.30>
- Jaques, P. A. (2004). Using an animated pedagogical agent to interact affectively with the student. [Doctoral dissertation, Federal University of Rio Grande do Sul]. <http://hdl.handle.net/10183/5886>
- Kaufman, D. (2020). Inteligência artificial: Repensando a mediação [Artificial intelligence: Rethinking mediation]. *Brazilian Journal of Development*, 6(9), 66742-66760. <https://doi.org/10.34117/bjdv6n9-264>
- Kim, J., Merrill Jr., K., Xu, K., & Sellnow, D. D. (2020). My teacher is a machine: Understanding students' perceptions of AI teaching assistants in online education. *Journal of Human-Computer Interaction*, 36(20), 1902-1911. <https://doi.org/10.1080/10447318.2020.1801227>

- Klan, K. S., Kunz, R., Kleijnen, J., & Antes, G. (2003). Five steps to conducting a systematic review. *Journal of the Royal Society of Medicine*, 96(3), 118-121. <https://doi.org/10.1258/jrsm.96.3.118>
- LeCun, Y., Bengio, Y., & Hinton, G. (2015). Deep learning. *Nature*, 521, 436-444. <https://doi.org/10.1038/nature14539>
- Lucena, K. K. T. (2018). iDE a framework to support the management of courses in distance education [Doctoral dissertation, Federal University of Amazonas]. <https://tede.ufam.edu.br/handle/tede/6918>
- Machisotti, G. G., França, S. L. B., Farias Filho, J. R. de, & Pinto, S. R. da R. (2022). Guidelines for the dissemination of distance education, from the analysis of prejudice against this education modality. *Acta Scientiarum. Education*, 44(1), Article e53622. <https://doi.org/10.4025/actascieduc.v44i1.53622>
- Maghsudi, S., Lan, A., Xu, J., & van der Schaar, M. (2021). Personalized education in the artificial intelligence era: What to expect next. *IEEE Signal Processing Magazine*, 38(3), 37-50. <https://doi.org/10.1109/MSP.2021.3055032>.
- Moro, L. (2019). Linguistic training for software in post-edition of automatic transcription and translation machines in distance learning [Master's thesis, Campinas State University]. <https://doi.org/10.47749/T/UNICAMP.2019.1097326>
- Melim, J. I., & Moraes, L. C. G. (2021). Projeto neoliberal, ensino remoto e pandemia: Professores entre o luto e a luta [Neoliberal project, remote teaching and pandemic: Teachers between grief and struggle]. *Germinal: Marxismo e Educação em Debate*, 13(1), 198-225. <http://dx.doi.org/10.9771/gmed.v13i1.43547>
- Ministério da Educação – MEC. (2022). Censo da educação superior 2020 [2020 higher education census]. <https://www.gov.br/inep/pt-br/areas-de-atuacao/pesquisas-estatisticas-e-indicadores/censo-da-educacao-superior/resultados>
- Peters, M. A. (2017). Technological unemployment: Educating for the fourth industrial revolution. *Educational Philosophy and Theory*, 49(1), 1-6.
- Peters, M. A., & Jandric, P. (2019). Education and technological unemployment in the fourth industrial revolution. In G. Redding, A. Drew, & S. Crump (Eds.), *The Oxford handbook of higher education systems and university management* (pp. 394-413). Oxford University Press.
- Pinto, A. V. (2005). *O conceito de tecnologia* [The concept of technology]. Contraponto.
- Riedo, C. R. F. (2020). Immediate qualitative assessment of written productions in distance education [Doctoral dissertation, State University of Campinas]. <https://doi.org/10.47749/T/UNICAMP.2020.1129481>
- Ramble, G. (2014). The costs and economics of online distance education. In O. Zawacki-Richter, T. Anderson, (Eds.), *Online distance education: Towards a research agenda* (pp. 197-216). AU Press.
- Russel, S., & Norvig, P. (2009). *Artificial intelligence: A modern approach* (3rd ed.). Prentice Hall.
- Schwab, K. (2017). *The fourth industrial revolution*. Crown Business.
- Teng, W., Ma, C., Pahlevansharif, S., & Turner, J. J. (2019). Graduate readiness for the employment market of the 4th industrial revolution: The development of soft employability skills. *Education + Training*, 61(5), 590-604. <https://doi.org/10.1108/ET-07-2018-0154>
- Torres, P. L., Roesler, J., Vianney, J., Santos, K. E. E., & Coelho, A. S. (2019). Desafios da qualidade na expansão da Educação Superior a Distância no Brasil [Quality challenges in the expansion of Distance Higher Education in Brazil]. In C. R. Vitale, M. M. Quezada (Eds.), *Prospectiva de la Educación a Distancia en América Latina y el Caribe [Prospective Distance Education in Latin America and the Caribbean]* (pp. 43-71). Ediloja.
- Wogu, I. A. P., Misra, S., Assibong, P. A., Olu-Owolabi, E. F., Maskeliunas, R., & Damasevicius, R. (2019). Artificial intelligence, smart classrooms, and online education in the 21st century: Implications for human development. *Journal of Cases on Information Technology*, 21(3), 66-79. <https://doi.org/10.4018/JCIT.2019070105>
- Xu, M., David, J. M., & Kim, S. H. (2018). The fourth industrial revolution: Opportunities and challenges. *International Journal of Financial Research*, 9(2), 90-95. <https://doi.org/10.5430/ijfr.v9n2p90>
- Yu, H., Miao, C., Leung, C., & White, T. J. (2017). Towards AI-powered personalization in MOOC learning. *npj Science of Learning*, 2(15), 1-5. <https://doi.org/10.1038/s41539-017-0016-3>
- Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education – Where are the educators? *International Journal of Educational Technology in Higher Education*, 16(39), 1-27. <https://doi.org/10.1186/s41239-019-0171-0>

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