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Information and Communication Technology in Brazilian Public Schools: A Sustainable Legacy of the Pandemic?

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Abstract: The present study aimed to analyze the sustainability of the post-COVID-19 pandemic Information and Communication Technology (ICT) legacy. The survey was conducted using raw secondary data from three census studies, one carried out before the pandemic and two after the return to in-person classes. The descriptive survey focused on Brazilian public schools and used a comparative intersectional design. Descriptive statistics were used to analyze the raw data. The poorest conditions in terms of the availability of technological resources were found in municipal public school systems. The amount of equipment available, bandwidth, and Internet data transmission rate in most public schools were far below desirable, despite advances in 2021 compared to 2019. Although there have been important improvements in ICT in Brazilian public schools, there was no evidence of inherited ICT resources as a legacy of the Government's COVID-19 policies related to education. The study highlights the need for government to implement enduring public policies that guarantee the use of sustainable ICT resources to improve education, irrespective of global or national health challenges.

Keywords: information and communications technology; public schools; sustainability; public policies

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1. Introduction

During the COVID-19 pandemic, resulting from the spread of the SARS-CoV-2 virus, education around the globe faced unprecedented challenges. In this chaotic period, the importance of Information and Communication Technology (ICT) in the educational ecosystem became clear [1].

In Brazil, despite significant investments in open Internet connection, computers, software, and other ICT tools in education [2], when the World Health Organization (WHO) elevated the status of the new coronavirus to a pandemic in early 2020, many schools faced a lack of access to material resources and basic infrastructure [3], particularly public elementary schools [4].

The Organization for Economic Cooperation and Development (OECD), when analyzing education in Brazil from an international perspective, found that public spending per pupil in compulsory education in 2017 was significantly lower than other OECD countries. However, even with limited public spending, the OECD suggested that it was possible to increase spending efficiency and improve resource allocation to obtain better results. The use of digital/learning resources was one of the possibilities mentioned [2]. Analyzing investment in childhood education in 109 low- and middle-income developing countries and territories, using data from 2008 to 2019, UNICEF pointed to the need to invest in early childhood education and strengthen childhood education systems to progress toward reaching the Sustainable Development Goals, reducing inequalities, and boosting economic growth [5].

In comparison with Latin American and OECD member countries, Brazil is behind in the availability of digital resources. According to data from the Program for International Student Assessment (PISA), in Brazilian schools there are about ten students per computer and data transfer rates for open access Internet networks are inadequate. In OECD and Latin American countries, the average number of students per computer is 1.2 and 2.4 students, respectively [2].

Alongside its report on the Brazilian educational system, the OECD disclosed the results of the Education Policy Outlook study [6] and noted that, despite important advances over the last three decades, the challenges in Brazilian education continue to be providing equal access and ensuring quality teaching–learning processes.

Among the solutions identified in post-COVID-19 pandemic education, based on international experiences, is the need to improve the digital infrastructure to ensure equitable access and teaching methodologies. For school digitalization, it is necessary that educators are trained to use tools that enhance learning.

Before the pandemic, many Brazilian schools experienced a range of problems in addition to poor digital resources, particularly public schools and those located in poorer regions [4]. These challenges include a lack of water, power, or sewage services (between 3% and 6%), no cafeteria (more than 65%), and poor infrastructure (approximately 10% reported inadequate repair of ceilings, roofs, floors, classrooms, and bathrooms) [2].

The pandemic created uncertainties and posed challenges for the future of education. However, progress has been made at national and international levels in various areas of research, including: the impact of technology on education [7]; the need for investment [8]; emergency transition to remote teaching [9–11]; digital exclusion [10]; the role of teachers [7–10] and students [12] in eLearning; and the use of ICT tools in Latin American schools [13]. Alongside these issues, studies have also been conducted on strengthening teaching and learning processes through digital transformation, using technology for quality education [14–17], teaching practices [18–22], educational innovation [23,24], defending the public school system [25,26], barriers to ICT implementation in educational institutions [27–29], good practices in teaching with ICTs [30], and international comparisons [13–31]. However, it is important to note that the majority of these analyses focus on higher education.

All cited studies consider the change in teaching methods from in-person to remote with the use of ICT tools as a result of the COVID-19 pandemic and the subsequent impacts on the teaching–learning process. However, the present study has few similarities with this previous work in terms of the data analyzed and methodology, and none of these studies provide an in-depth analysis of the educational situation in Brazil.

In terms of obstacles and barriers, wealthy countries such as the United States cited guaranteed access to online education for students in needy areas as a challenge [14,32]. In developing countries, such as Brazil, the inclusion of students without adequate access to electronic equipment, with poor-quality or no Internet connection, and inadequate teacher training for remote teaching were the main difficulties faced [29,33].

A decade ago, a study [34] raised flags about the perverse dualism of the Brazilian public school system: schools of learning for the rich; schools of social assistance for the poor. The COVID-19 pandemic further accentuated this duality, increasing the gap between the richest and the poorest. During social isolation, the poor were not only cut off from access to knowledge, but they also lost the support they received during classroom activities, especially in elementary schools [35]. A 2015 UNESCO report drew attention to the increased inequality in education affecting the poorest and most disadvantaged [36], and there are significant disparities between rich and poor in terms of attendance, completion, and learning outcomes [37].

ICTs are considered fundamental elements to achieve the SDGs outlined in the United Nations 2030 Global Agenda [38]. These technologies can contribute to the improvement of social, environmental, and economic sustainability, given that they have a direct impact on economic growth and access to information. In addition, the use of ICTs can

lead to improvements in the field of education, offering benefits to society in terms of social development.

The understanding of sustainability adopted in this study is that described in the 1987 report, Our Common Future (Brundtland Report), which was a result of the UN World Commission on Environment and Development. This report offered a new perspective by introducing the idea of sustainability into the concept of development, defining it as "meeting the needs of the present without compromising the ability of future generations to meet their own needs" [39].

In a review of the literature, no study was found addressing the Brazilian context that went beyond identifying the need for more technological resources. To address this gap, with a focus on Brazilian public schools (77.3% of the 178,370 elementary schools in 2021) [26], the study aimed to analyze the sustainability of the post-COVID-19 pandemic ICT legacy. Underlying this objective was the following research question: what aspects should be considered in public policies so that the ICT legacy in the post-COVID-19 pandemic era in Brazilian public schools is financially sustainable?

To respond to this research question, a survey of three national census studies was conducted and the secondary data analyzed.

2. Materials and Methods

This study is characterized as a predominantly quantitative, exploratory survey based on the technical procedures adopted and considering the objective and question addressed. The survey was designed as follows: the objective established was descriptive; the unit of analysis was Brazilian public schools; and the design was a comparative intersectional survey.

In the survey, raw secondary data were used from three census surveys: 2019 Elementary Education Census [4]; 2021 Elementary Education Census [40]; and 2022 Edutec Guide Report—diagnosis of level of technology adoption in Brazilian public schools [1].

The Elementary Education Census is an annual statistical survey coordinated by the Anísio Teixeira National Institute of Educational Studies and Research (INEP) in collaboration with state and municipal Secretaries of Education and public and private schools across the country. The survey aims to obtain statistics on the provision of elementary education in the Brazilian educational system, gathering information on all developmental stages and teaching modes. The methodology includes data collection through the *Educacenso* system, processing of data by INEP, publication of preliminary results to identify inconsistencies, and official publication of results in the same year that the survey was conducted. The data collected informs important public policies, government programs, and actions within the education sector across the three spheres of government.

The methodology adopted for the census in 2019 [4] and 2021 [40] was the same and can be summarized in four main steps:

1. Data collection: The data collection was performed through *Educacenso*, an electronic system that enables survey questionnaires to be completed directly by users (informants), or through a process of automatic data migration from school and teaching network information management systems. Thus, it is a statistical survey based on indirect document information collection through a self-completed electronic questionnaire.
2. Data processing: After collection, data are processed by the INEP team and systematized for official publication and communication with the different information users in the same year that the survey was completed. INEP validates, corrects, and analyzes the collected data, thus ensuring the reliability of information.
3. Publication of Preliminary Results: INEP publishes the preliminary results of the Elementary Education Census, so that school managers can identify any inconsistencies in the information provided and, if it is necessary, to present further resources. To view the preliminary results, users must register in the electronic evaluation system. Only one representative per teaching institution can register in the system.

4. Publication of final results: The publication of the official results and communication with different information users is done during the survey year. The results of the statistical census of elementary education are presented in the form of a national executive summary, ensuring the availability of the final outputs and dissemination of the results of the research to society as a whole.

The Edutec Diagnostic Guide is a free digital tool that evaluates the level of educational technology adopted by teachers and public schools. It consists of an online questionnaire with 35 multiple-choice questions, distributed across four dimensions: vision; competencies; digital educational resources; and infrastructure. Each response receives a score of 1 to 4, and the result is used to calculate the level of technology adopted for each dimension. From this information, the tool generates analytical reports for schools and education networks to help inform decision making about investments in educational technologies and public policy development.

From the 2019 Elementary Education Census (the last census conducted before the pandemic) and the 2021 Census (conducted after the return to in-person activities in Brazilian schools), raw data were collected regarding the technological resources available in public elementary schools. Both are available on the INEP website. Raw data were processed to enable comparison. In addition, the Educational Response to the COVID-19 pandemic in Brazil questionnaire was further mined to extract data on the strategies adopted with students and teachers by schools/Secretaries of Education in the public system to ensure continuity of pedagogical activities during the suspension of in-person activities.

The Edutec Guide Report was used to further detail the technological resources available in public schools in 2022. The data from the Report and 2021 Census provide an overview of the ICT situation in Brazilian public schools after the return to in-person classes.

Descriptive statistics were applied to analyze the data used in the study.

Figure 1 schematically illustrates the methodological steps followed in the construction of the present study.

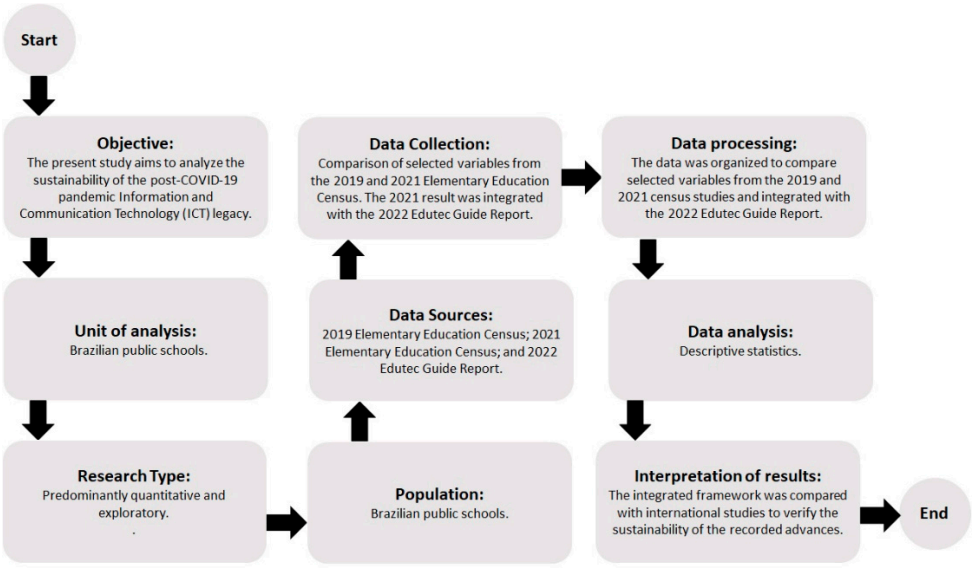

Figure 1. Steps taken for the construction of the study.

3. Results

From the 2019 Elementary Education Census, which offers a multitude of information, data were collected related to the availability of technological resources (digital whiteboard, laptops, tablets, and open access Internet available to teachers, students, and administration) in public schools (n = 101,244). With the results, the study provides an overview of Brazilian public schools in the prepandemic period. The poorest conditions identified in terms of

technological resources were in the municipal public school system, which also had the greatest number of elementary schools (Table 1).

Table 1. Technological resources available in public elementary schools (2019).

Technological Resource	Federal System (n = 47)	State System (n = 22,403)	Municipal System (n = 78,794)	Entire Public System (n = 101,244)
Digital whiteboard	46.8%	26.0%	8.8%	12.6%
Multimedia projector	91.5%	79.9%	52.9%	58.9%
Student desktop computers	89.4%	75.4%	34.3%	43.4%
Student laptops	51.1%	33.5%	20.4%	23.3%
Student tablets	34.0%	13.4%	5.7%	7.4%
Internet access	100.0%	86.7%	61.5%	67.1%
Internet for students	83.0%	57.2%	21.1%	29.1%
Internet for administrative use	100.0%	85.1%	58.2%	64.2%
Internet for teaching and learning	80.9%	64.0%	29.6%	37.2%

Source: Adapted from [4].

Table 2 shows similar results to those contained in Table 1 but considers the situation of elementary schools in 2021 after classroom activities in public schools had been suspended for an average of 287 days [40].

Table 2. Technological resources available in public elementary schools (2021).

Technological Resource	Federal System (n = 47)	State System (n = 21,648)	Municipal System (n = 77,250)	Entire Public System (n = 98,945)
Digital whiteboard	55.3%	29.8%	10.8%	14.9%
Multimedia projector	95.7%	79.1%	55.4%	60.6%
Student desktop computer	95.7%	76.9%	39.2%	47.5%
Student laptops	63.8%	37.7%	25.8%	28.4%
Student tablets	34.0%	12.6%	6.6%	7.9%
Internet	100.0%	92.0%	69.8%	74.7%
Internet for students	89.4%	65.2%	27.8%	36.1%
Internet for administrative use	100.0%	90.8%	66.3%	71.7%
Internet for teaching and learning	89.4%	74.1%	39.8%	47.3%

Source: Adapted from [40].

The comparison of the technological resources available in Brazilian public schools before and after the suspension of classes due to the pandemic is presented in Table 3. For all compared technological resources, there was a positive increase.

Table 3. Variation in technological resources available in public elementary schools from 2019 to 2021.

Technological Resource	Public System 2019 (n = 101,244)	Public System 2021 (n = 98,945)	Variation
Digital whiteboard	12.6%	14.9%	18.25%
Multimedia projector	58.9%	60.6%	2.89%
Student desktop computers	43.4%	47.5%	9.45%
Student laptops	23.3%	28.4%	21.89%
Student tablets	7.4%	7.9%	6.76%
Internet	67.1%	74.7%	11.33%
Internet for students	29.1%	36.1%	24.05%
Internet for administrative use	64.2%	71.7%	11.68%
Internet for teaching and learning	37.2%	47.3%	27.15%

Source: Adapted from Brazil [4,40].

Included in the 2021 Elementary Education Census were the results of the Educational Response to the COVID-19 Pandemic in Brazil questionnaire, carried out between February

and May 2021. The questionnaire was answered by 168,739 schools (94% of all elementary schools in 2020). From the total, 134,606 are from the public system (97.2% of all national public schools) [40].

The strategies adopted by schools/Secretaries of Education from the public system with teachers to ensure continuity of pedagogical activities during the suspension of in-person activities are shown in Table 4.

Table 4. Percentage of schools/Secretaries of Education by strategies adopted with teachers for the continuity of pedagogical activities during the suspension of in-person activities (n = 134,606).

Strategy	Percentage
Virtual meetings for planning, coordinating, and activity monitoring	88.2%
Reorganization/adaptation of planning/lesson plans with prioritization of skills and specific content	90.5%
Training in the use of methods/materials for remote teaching programs	59.4%
Equipment available for teachers—computer, notebook, tablets, smartphones, etc.	24.8%
Free or subsidized access to Internet at home	5.2%

Source: Adapted from [40].

Tables 5–7 show the strategies adopted with students to ensure continuity of pedagogical activities during the suspension of in-person activities in public schools.

Table 5. Percentage of schools by communication and technological support strategy provided to students to ensure continuity of pedagogical activities during the suspension of in-person activities (n = 134,606).

Strategy	Percentage
Maintaining a line of communication with the school (email, telephone, social networks, messaging application)	80.3%
Maintaining a direct line of communication with teachers (email, phone, social media, messaging applications)	84.7%
Free or subsidized access to Internet at home	6.15%
Availability of equipment for student use (computer, notebook, smartphone, etc.)	8.26%

Source: Adapted from [40].

Table 6. Percentage of schools by strategy and tool adopted to develop teaching–learning activities with students during the suspension of in-person activities to ensure continuity of pedagogical activities (n = 134,606).

Strategy	Percentage
Providing printed teaching–learning materials (printed textbooks, handouts, activity sheets, etc.) for pick-up at school by student or guardian and/or home delivery	94.4%
Providing teaching–learning materials on the Internet (videos, podcasts, social media publications, virtual platforms, mobile applications)	77.2%
Performing evaluations and tests remotely over the Internet or with physical material delivery/return	64.3%
Virtual or classroom assistance with students and their parents or guardians	60.0%
Support for students and their parents or guardians for the preparation and development of study plans/directed studies	54.3%
Live classes (real-time) on the Internet, with the possibility of direct interaction between students and teachers	35.2%
Prerecorded (offline) classes available over the Internet	50.9%
Live classes (real-time) broadcast over the Internet	14.3%
Training with parents and students in methods/materials of remote teaching programs	23.7%
Transmission of previously recorded classes (asynchronous) by TV or radio	14.3%
Transmission of live classes (real-time) by TV or radio	8.5%

Source: Adapted from [40].

Table 7. Percentage of schools per digital platform/tool used for Internet activities (n = 134,606).

Tool	Percentage
Applications or tools for conducting video conferences (WhatsApp, Zoom, YouTube, etc.)	85.6%
Google Classroom	34.7%
Platform developed specifically for the Municipal or State Department of Education or for the school	30.8%
Microsoft Teams for Education	9.8%
None of the options displayed	8.3%
Blackboard Learn/Blackboard Unite	0.5%

Source: Adapted from [40].

To provide greater detail of the technological resources used in public schools, the Edutec Guide Report was analyzed. With 104,219 responses from school managers, the Edutec Guide provides a more in-depth postpandemic diagnosis of the level of technology adoption in Brazilian public schools in 2022. In the study, the infrastructure was evaluated by means of the following indicators: access to Internet in the school and data transmission rate (connection); availability of equipment for teachers and students; and security of school equipment [1].

Regarding open Internet access in the school and data transmission rate (connection), less than half (46.87%) of public schools had Internet access in all environments (Table 8), and of these 89.12% had unsatisfactory connection quality (Table 9).

Table 8. Internet access in Brazilian public schools in 2022.

Internet Access Availability	Number (Percentage)
Internet access available in the administrative area only	28,618 (27.46%)
Internet access available in the administrative area, library, and/or computer labs	10,778 (10.34%)
Internet access available in the administrative area, library, and/or computer labs, classrooms, and innovation and technology spaces	15,972 (15.33%)
Internet access available in all school environments (internal and external)	48,851 (46.87%)

Source: Adapted from [1].

Table 9. Quality of Internet connection in Brazilian public schools in 2022.

Internet Connection Speed	Number (Percentage)
If an entire class connects to the network at the same time, regardless of the content accessed, the Internet stops working.	48,752 (46.78%)
An entire class can connect to the network at the same time. There is instability only if they access "heavy" content (for example videos, games, or file/data transfer).	31,979 (30.68%)
An entire class can connect to the network at the same time, simultaneously accessing "heavy" content (for example videos, games, or file/data transfer).	12,147 (11.66%)
Multiple classes can connect to the Internet at the same time, simultaneously accessing "heavy" content (for example videos, games, or file/data transfer).	11,341 (10.88%)

Source: Adapted from [1].

In terms of the availability of equipment for teachers and students, the parameters adopted for classification purposes are described in Table 10.

Table 10. Classification levels to evaluate the availability of equipment for students and teachers in Brazilian public schools in 2022.

User	Incipient	Basic	Intermediate	Advanced
Student	No device or a ratio greater than eight students per device	Eight students per device (used weekly)	Five students per device (used twice a week)	Two students per device (used daily)
Teacher	No equipment available	One piece of equipment for each eight teachers per shift	One piece of equipment for every five teachers per shift	Every teacher has a piece of equipment

Source: Adapted from [1].

Public schools showed a predominance of incipient levels of equipment availability, indicating the worst possible situation. The most desirable situation was found in 16.38% of the schools that answered the diagnostic that resulted in the Edutec Report (Table 11).

Table 11. Availability of equipment for teachers and students in Brazilian public schools in the year 2022.

Level	Number (Percentage)
Incipient	34,214 (32.83%)
Basic	29,657 (28.45%)
Intermediate	23,280 (22.34%)
Advanced	17,068 (16.38%)

Source: Adapted from [1].

With regard to the security of school equipment, the most frequent situation found was that schools do not have antivirus software or programs to support data security. When they do, the software is not frequently updated (Table 12).

Table 12. Equipment security in Brazilian public schools in 2022.

Equipment and Security	Number (Percentage)
None or few computers have antivirus software installed; the software is not frequently updated.	40,541 (38.90%)
Computers have antivirus software installed and the software is updated infrequently.	37,743 (36.22%)
There is a security device (firewall) and antivirus software installed on the computers; software is updated periodically.	17,762 (17.04%)
There is a security device (firewall) and antivirus software installed on the computers; software is updated periodically; there are tools for data security.	8173 (7.84%)

Source: Adapted from [1].

4. Discussion

PISA, the largest student evaluation program in the world, shows that the learning indices for Brazil remain stagnant at poor levels [41]. In the OECD's Education Policy Outlook study, reducing unequal access and guaranteeing quality teaching–learning processes were highlighted as the main challenges facing Brazilian education [6].

The state of technological resources in Brazilian public schools before the pandemic, particularly in municipal systems which are responsible for 77.8% of all elementary schools, was well below the standards of OECD and Latin American countries [2]. This scenario demonstrates the precarious situation of many Brazilian schools [2].

With the rapid proliferation of the SARS-CoV-2 virus on a global scale, the WHO declared a worldwide pandemic on 11 March 2020. To confront the serious health situation and given the lack of an effective vaccine against the virus, preventive measures such as social distancing, use of masks, and strict hygiene policies were adopted. In most

countries, education systems sought alternatives to minimize the effects of social isolation brought about by the pandemic, and many migrated to the use of ICT tools to continue educational activities in virtual environments [42]. In Brazil, these measures were supported legally by the Ministry of Education (MEC) through ordinance 343, of 17 March 2020 [43], and 345, of 19 March 2020 [44], which authorized the use of real-time teaching through digital resources.

In 2021, after the return of in-person activities in schools, an increase in the availability of technological resources can be observed in comparison with the prepandemic period (Table 2). This increase indicates that public investment occurred during that period. There was an increase in all inventoried technological resources (Table 3), but this increase was far below the investment necessary to reverse the precariousness of the situation.

During the pandemic period, the shift from in-person activities to virtual environments created a new reality for teachers and students. The lack of public or personal technological resources and teachers' unfamiliarity with the use of ICT tools became evident. Teachers had to be trained to teach remotely and acquire the necessary ICT skills for education. It became clear that virtual classrooms must be well organized to achieve productive learning [45]. A joint survey involving Ministries of Education from several countries found that at least one in three countries did not provide any training for teachers to use remote learning platforms [46].

Among the strategies adopted by public schools/Secretaries of Education with teachers to continue pedagogical activities, two of the most prominent were virtual meetings for planning, coordinating, and monitoring activities (88.2%), with the use of videoconferencing software Zoom and Google Meet, and the reorganization/adaptation of lesson plans prioritizing skills and specific content (90.5%) (Table 4). Another strategy widely adopted by public schools to address the limited digital literacy of a significant number of teachers [47] was training in the use of methods/materials for remote teaching programs (59.4%) (Table 4). Two strategies seen as important, but little used, were the provision of equipment for teachers (computer, notebook, tablet, smartphone, etc.) (24.8%) and free or subsidized access to the Internet at home (5.2%) (Table 4) [1].

Considering the strategies adopted with students to ensure continuity of pedagogical activities in public schools, the use of email, telephone, social networks, and messaging applications were widely used for communication with the school (80.3%) and for direct communication with teachers (84.7%) (Table 5). Similar to the situation with teachers, strategies such as the availability of equipment for students (8.26%) and free or subsidized access to the Internet at home (6.15%) were limited. Although a significant portion of students did not need equipment and Internet access, what was made available did not meet the demand [1,35].

Even with the social distancing imposed by the pandemic, the prevalent strategy adopted by Brazilian public schools (94.4%) to develop teaching–learning activities with students was providing printed teaching–learning materials for pick-up at school by students or guardians and/or delivery at home (Table 6). The use of this strategy is likely related to the lack of access of a proportion of students to ICT tools. Another important strategy was the availability of teaching–learning materials on the Internet (77.2%) (Table 6). The results in Table 6 indicate a predominance of asynchronous or offline activities to the detriment of real-time activities. Indeed, the distance between the teacher and the student was even greater than it could have been. Another result that is worth highlighting is the almost nonexistent, but very likely unnecessary, training of students in the use of methods/materials in remote teaching programs. The scenario is completely different from that found for teachers, but substantively well elucidated in the literature [45].

A facilitator in the shift from in-person to remote teaching was the number of existing digital platforms, including some that are free to use. WhatsApp, Zoom, and YouTube were the most commonly cited tools for holding videoconferences, employed by 85.6% of schools (Table 7). As they are tools that people use daily, it was easier to adapt them to remote

academic activities, with no need to develop new tools. Nevertheless, 30.8% of municipal or state schools developed specific software for remote educational activities (Table 7).

In comparison with the 2021 Elementary Education Census [40], the Edutec Guide Report provides more detail in identifying the technological resources available in Brazilian public schools. This is particularly evident in the inventory of Internet access in the school environment and data transfer (connection), availability of equipment for teachers and students, and school equipment security [1].

The use of open Internet access as an effective instrument capable of increasing educational performance has been the subject of investigation in recent years [48–52]. Regarding Internet access in schools for teaching and learning, the results presented in the Edutec Guide Report (Table 8) are relatively similar to the 2021 Elementary Education Census (Table 2) (52.1% vs. 46.87%, respectively). The difference can be explained by the methodology used in the two census surveys. In the Edutec Guide Report, Internet access is defined as available in all school environments (internal and external), while the 2021 Elementary Education Census considered only Internet access available for teaching and learning.

In the Edutec Guide Report, the data transfer rate (connection) was also analyzed. The ideal situation in which several classes manage to connect simultaneously accessing "heavy" content was found in just 10.88% of schools (Table 8). The poorest situation proposed was if an entire class connects to the network simultaneously, regardless of the content, the Internet stops working. This situation was found in 46.78% of Brazilian public schools (Table 9). In the 2021 Elementary Education Census, the availability of Broadband Internet was assessed, and this type of connection was identified in 51.1% of schools (Table 2).

Regarding the availability of equipment for teachers and students, the survey carried out by Edutec indicated that 61.28% of the schools were at an incipient (32.83%) or basic (28.45%) level (Table 10). At the incipient level, either there are no devices available to students, or the proportion is greater than eight students per device. In the basic situation, there are eight students per device (weekly use) (Table 11). The result is similar to that found in [2].

Regarding equipment security, the Edutec survey shows that in more than 75% of schools there is no (38.90%) or very limited concern (36.22%) about safety (Table 12). The ideal situation, in which there is a security device (firewall) and antivirus software installed on computers with periodic updates and the existence of data security tools, was found in only 7.84% of the schools.

Overall, the results indicate that approximately 50% of Brazilian public schools have access to the Internet for teaching and learning activities, with a predominantly poor-quality connection, a low ratio of equipment per student, and little or no security for equipment and data. The situation of municipal schools showed the poorest performance. The sad reality of Brazilian education reveals its structural precarity; more concerning is that this precarity occurs in schools with the greatest number of students and those that are the most in need.

In this context, it may be hasty to speak in terms of legacy. The development of an effective legacy will come with the test of time. Nevertheless, progress has been made, and as recorded by international organizations, such as [6], these advances have been occurring systematically over the last three decades. With the pandemic, ICT tools were brought into focus.

Some lessons have been learned. Teachers had to learn a lot and very quickly, which in most cases did occur. This learning has resulted in the necessary improvement in Brazilian education with the more widespread use of ICT tools. The low level of digital literacy produced a kind of resistance by teachers to its widespread use. It is essential that teachers have not only access to ICT tools, but also the capacity to use the tools properly and effectively. In this context, initiatives at different levels of education have emerged for teacher training. One of the most relevant international initiatives is the

European Framework for the Digital Competence of Educators (DigCompEdu), which aims to provide a structure to train teachers in digital skills.

Federal public schools (n = 665; 0.48% of the total) were notable exceptions in comparison with state and municipal schools. Specific initiatives also made a difference. For example, Eduroam, a wireless service that was developed for the international research and education community, allows students at educational institutions to connect to the Internet through wireless access points, using the same username and password registered at their home educational institution [53]; while the National Research Network (RNP), a Brazilian network developed for research and education, provides access to the Internet for universities, educational and cultural institutes, research agencies, teaching hospitals, and technology parks and centers [54].

Among the limitations of the study, it is important to consider that only secondary data were used, which may have limited the analyses of factors not captured in the census surveys and reports. In addition, the predominantly quantitative approach may have limited the understanding of qualitative and subjective elements related to ICT adoption in Brazilian public schools. It is important to highlight that these limitations may have affected the depth of analysis and the ability to make causal inferences.

5. Conclusions

In 2019, prior to the advent of the pandemic, the scenario of technological resources in Brazilian public schools was significantly inadequate in relation to international standards, as seen in OECD member countries and across Latin America, which is consistent with the precarious situation of many Brazilian educational institutions. After the return of in-person school activities in 2021, there was an increase in the availability and use of technological resources compared to the period prior to the pandemic, indicating public investment, although this investment was insufficient to improve the existing inadequacies.

In practical terms, although it may be too soon to refer to legacy, one can infer that it is necessary to transform the current scenario so that advances made during the pandemic are not lost. Quality education demands investment, and Brazil invests little and poorly in elementary education [34]. In addition, quality education in today's world requires ICTs [55].

For ICTs to survive, they must be sustainable. It is not enough to simply acquire technological tools; there is a need to provide enough tools/resources for students and teachers to master their use and for government to implement public policies that ensure sustainability. In Brazil, one of the risks of not allocating resources to guarantee the sustainability of ICT investment during the pandemic is that the gains and advances that occurred in education during the period will be lost over time. In a country where poor communities lack school meals and investment in education is not a priority [34], it is hard to imagine that ICT levels similar to those of other OECD countries will be reached sustainably in the coming decades without adequate government public policies.

6. Recommendations

In the aftermath of the COVID-19 pandemic, there is a need to enact public policies that guarantee the effective inclusion and use of ICTs in Brazilian education.

1. These policies must be permanent and centralized and must not be left solely in the hands of municipal and state governments.
2. For ICTs to become a sustainable reality in Brazil, there must be public policies that guarantee continued financial investment by government in infrastructure, maintenance, upgrading of equipment, and provision of personnel to support the use of equipment, laboratories, and training for teachers.
3. As Brazil is a country of multiple realities, there is a need for public policies to guarantee the sustainability of the widespread use of ICTs to reduce the inequalities between public schools in economically developed regions and those in regions with less favorable social conditions.

4. Due to its centrality and coordination capacity, the Federal Ministry of Education must propose public policies that ensure that even the most disadvantaged municipalities and states have the opportunity to maintain the use of ICT tools in elementary schools.

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