Revista Brasileira de Informática na Educação – RBIE
Brazilian Journal of Computers in Education
(ISSN online: 2317-6121; print: 1414-5685)
https://sol.sbc.org.br/journals/index.php/rbie

Submission: 01/Dec/2023; 1st round notif.: 27/Mar/2024; New version: 05/May/2024; 2nd round notif.: 14/May/2024;
Camera ready: 02/Sep/2024; Edition review: 08/Oct/2024; Available online: 08/Oct/2024; Published: 08/Oct/2024;

Moving From Remote Education: Instructional Design Lived Experiences

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Abstract

Digital Technological Resources (DTRs) are considered by many to be essential in everyday life, influencing pedagogical practices, culture, relationships, learning, and teaching practices. Due to the COVID-19 pandemic, Brazilian educational institutions needed to migrate from face-to-face to remote teaching supported by digital technological resources in pedagogical practices. This transition brought several challenges and opportunities for education professionals, especially those involved in instructional design, as they adapted face-to-face teaching methods and included new teaching methodologies to maintain school activities. New opportunities have arisen to explore new pedagogical approaches, such as online collaborative learning, multimedia resources, and the personalization of instruction to meet students' individual needs. This movement has highlighted remote classroom preparation and design, which is critical for future educational strategies in remote education. This study investigates the experience and perceptions of education professionals using teaching methodologies during the pandemic and the impact on their practices after returning to face-to-face classes. A survey was conducted with 276 education professionals from primary to higher education from public and private institutions in Brazil. The survey results showed the diversity of digital technology resources and teaching methodologies used, the active ones in particular, such as problem-based learning and flipped classrooms. Moreover, our results reveal that while using DTRs, several education professionals complained of lacking certain features and reported desired ones. We hope this study can provide information to support educational software development projects and contribute to improving teaching-learning activities and curriculum design research in the remote teaching modality.

Keywords: *Digital technological resource; Teaching and learning practices; Remote teaching; Teaching methodologies; Instructional design.*

Cite as: Lima, M. S. L., David, J. M. N. & Maciel, R. P. (2024). Moving From Remote Education: Instructional Design Lived Experiences. Revista Brasileira de Informática na Educação, 32, 533-567. https://doi.org/10.5753/rbie.2024.3894.

1 Introduction

Digital technological resources (DTRs) have significantly impacted and shaped people's behavior, including relationships and communications between individuals (Tajra, 2019). DTRs are evolving continuously, presenting themselves as possibilities for interaction, communication, information search, entertainment, and knowledge production. While used to assist pedagogical practices in face-to-face teaching, DTRs have played a crucial role in facilitating collaboration between students and educators in remote teaching contexts.

The massive migration from face-to-face teaching to RTs at the beginning of 2020 led to a sudden increase in the everyday use of RTs. Some classes did not immediately migrate to Virtual Learning Environments (VLEs) in several institutions. According to Souza (2020), schools had to organize themselves to teach using digital Technologies, and this migration generated a transposition of practices and methods from classroom teaching to remote teaching. Moreover, some institutions have trained their teachers in educational technologies. Web conferencing platforms (e.g., Microsoft Teams, Zoom, and Google Meet) were used when adapting teaching practices (Sperandio et al., 2022). Adapting education professionals to new forms of remote teaching and learning is critical to providing practical experiences for students. By applying instructional design principles (Filatro, 2022), such as detailed needs analysis, engagement and motivation to the process, and facilitating learners' understanding, these professionals can create more meaningful and efficient experiences in the virtual environment. This shift highlights the importance of remote learning, where organizations opened up to face a global crisis, from providing content to providing the necessary infrastructure for educational institutions (Mattar et al., 2022).

The competencies of educational professionals in RT have evolved from a simple concept to means, resources, and technological tools applied to educational practice. This transformation was catalyzed by the sudden transition from face-to-face to remote modalities. Simultaneously, educational systems had to enhance accessibility, flexibility, and usability to ensure the effective development of high-quality education.

Numerous studies have investigated using DTRs as educational artifacts, focusing on various aspects of the shift from face-to-face to remote teaching (Hartwig et al., 2019; Reis et al., 2018) (J. V. V. Lima et al., 2020; Martins & Rangni, 2020; Reis et al., 2018). More recently, it has focused on investigating distinct aspects of the shift between these two teaching modalities (J. V. V. Lima et al., 2020; Martins & Rangni, 2020; Packowski & Amaral, 2021). However, investigating DTRs and their interaction with teaching methods remains a pressing challenge for education professionals adapting to the RT modality. Questions arise related to the experiences of education professionals and their pedagogical design practices. What do the lived experiences of education professionals reveal for instructional design? How have adaptations to RT occurred? What is the understanding of the support given by DTRs? Our research group has been investigating software requirements for collaboration-intensive pedagogical practices in educational software (Venega et al., 2019). This work aims to support education professionals in adapting and using DTRs and teaching methods in their pedagogical practices by identifying software requirements for current and future teaching-learning scenarios.

This work presents a survey conducted with education professionals from public and private institutions in the 27 Brazilian states. The survey's main objective was to identify the RT practices,

the DTRs used, the teaching methods, and the experiences had with the change of RT for the continuity of pedagogical practices and adoption of technologies in the school environment. The data was collected from January to March 2021, and we obtained 276 responses from higher, middle, and elementary education professionals. We analyzed qualitative data using coding techniques that identify concepts (or codes) and categories (Glaser, 1992).

With the adaptation and increasing use of new technologies in RT by education professionals, it was observed that, although some already had previous experience with DTRs in the face-to-face modality, they faced challenges when applying active methodology and instructional design principles in the context of RT. The simultaneous adoption of several DTRs to carry out their pedagogical practices was notable. The need to incorporate new teaching methods and DTRs in RT, such as active methodologies, resulted in diverse experiences, such as learning new technologies to conduct classes and using videoconferencing platforms and virtual environments (e.g., Moodle). However, the challenges faced regarding internet connection problems, which impact the ability to deliver quality online courses, and the difficulty of maintaining interaction with some students may have led to poorer class performance.

The analysis of this survey provides valuable insights into the experiences of educational professionals and the challenges they faced in adopting new technologies for RT. This has significant implications for the educational software industry and academic research. We gathered data to summarize a rich list of new adoptions of methodologies tried in RT, lack of functionalities in the DTRs, perceived impact on RT, and possible future adoption of these DTRs or methodologies in their teaching activities.

The findings suggest a considerable demand for educational technologies that can support using DTRs and active methodology in RT. Educational software developers could use this information to create and customize tools to support these pedagogical practices. Moreover, further research is needed into the impact of RT on pedagogical practices, understanding the challenges faced by educational professionals during the transition to RT, and the benefits and drawbacks of using DTRs in this context. We also highlight some research opportunities.

In a previous phase, from the perspective of only teachers in higher education professionals, we obtained a total of 140 responses (M. d. S. Lima & Maciel, 2021). This paper extends the previous work comprising 276 respondents from three educational levels (elementary, middle, and higher education). The data analysis of this survey was carried out qualitatively and quantitatively. The qualitative analysis used the coding technique, which identifies concepts (or codes) and categories (Sampaio & Lycarião, 2021). The analysis, therefore, was a multi-method (quantitative and qualitative data) that allowed the investigation of the use of DTR in RT, the adaptations of pedagogical practices, and several research opportunities in returning to face-to-face teaching.

The rest of this paper is organized as follows. Section 2 presents related work on the use of teaching methodologies and DTRs in RT. Section 3 discusses the survey method. Section 4 presents the survey results by level (elementary, middle, and high school). Discussion, open questions, and validation are discussed in sections 5 and 6, with conclusions and future work.

2 Related Works

Similar studies were initially sought to conduct an informal review of the literature. Bremgartner et al. (2017) conducted a systematic literature review to identify the primary information obtained from the literature on student adaptation in VLEs supported by a pedagogical theory plan. In RT, teachers and students are connected by DTRs, which was an alternative to quickly and effectively meet the demands of pedagogical practices during the migration from face-to-face modality to RT. In this format, open educational platforms were used for the school to share content and foment collaboration among participants. This approach establishes a pedagogical dynamic based on direct student interaction and participation to build knowledge with teachers in charge (Anastacio, 2020). The rapid change from face-to-face teaching to remote teaching required the adaptation of different DTRs in pedagogical practices for teachers to carry out their activities. Thus, most of the time, this transition occurred despite the lack of pedagogical strategies to promote more dynamic and interactive lessons, such as collaborative learning (Ahmady et al., 2020).

The search for related works was carried out within the research timeframe, especially considering the post-pandemic context, which was July 2021 to January 2024. To find relevant studies related to our research topic, we elaborated a search string that used key terms such as technological digital resources, remote teaching, instructional design, and e-learning. The search included repositories such as RBIE; CBIE; ACM Library; IEEE Xplore; DBLP Computer Science Library; and SBES (Brazilian Symposium on Software Engineering).

Collaborative peer-to-peer learning activities are one of the fundamental principles of remote teaching (Shearer et al., 2020). DTRs in RT are intensively used for the pedagogical mediation of teachers in their classrooms (Júnior & Silva, 2020). The migration to the RT modality in Brazil allowed it to continue pedagogical activities over the internet, mitigating the impacts on children and youth learning while they were away from school (Gracino et al., 2021).

Research studies in RT indicate that DTRs, pedagogical strategies, and former education staff should be encouraged (Shearer et al., 2020). Júnior and Silva (2020) emphasize that RT happens through digital technological mediation, giving rise to the proposed course and subject models in which interactions occur through chat rooms, video conferences, or forums. Hodges et al. (2020) explain that RT practices were the most appropriate strategies to mitigate the gaps in teaching and learning processes. However, for this to happen optimally, more studies are needed to focus on capturing the perceptions and needs of students and teachers (Hodges et al., 2020).

Some studies on teaching methodologies and DTRs in RT have been conducted in other countries(Villarreal et al., 2023)(Araujo et al., 2020)(Freire et al., 2020)(Bailey, 2022). Villarreal et al. (2023), conducted a qualitative approach based on an inductive analysis of narratives written by mathematics teachers in initial training from three South American universities. The 24 teachers reported aspects related to the experiences learned in the transition to RT and the opportunities and limitations experienced about using technologies. About lived experiences, the transition to RT was characterized as something new and challenging that caused strangeness. It brought changes, for example, in the video-conference classes where the interactions and teaching made it possible to understand the changes that happened to them and their students in this new learning environment. Regarding technology, the study by Villarreal et al. (2023) highlights that the perceptions and uses of technology reported by teachers transformed over time, allowing us

to consider two main aspects. Technology was considered the 'last hope' to continue studying during RT, and the other, the technological access gap, was a driving factor for inequalities and exclusions.

Bailey (2022) conducted a survey of 547 university students in South Korea in classes using English as a foreign language. An investigation of students' learning through videoconferencing using Zoom was carried out. The results suggested from the analysis of student interactions and academic learning expectations comprised three levels of mediation: student-student, student-teacher, and student-content. These interactions refer to proactive engagement in classroom environments that contribute to better learning. The analysis of mediations indicated that student-instructor interactions had the most significant effect, followed by student-content interactions. Instructors should keep social interactions in mind when designing video conferencing courses to achieve higher levels of learning and satisfaction. Increasing social presence should include integrating video conferencing meetings with features such as chat, screen sharing, and meeting rooms (Bailey, 2022).

The study by Serrano et al. (2022) explores how teachers adapted to the Moodle platform for the continuity of teaching activities during the pandemic, focusing on the users' experience and the effectiveness of the applied instructional design. An object, whether instructional or not, is designed visually to reach an audience in a structured way, taking into account the basic principles of instructional design so that communication is established consistently without breaking the experience on the part of the student. They investigated 773 education professionals who used the Moodle platform, a solution implemented at the Federal University of Paraíba to measure the teaching and learning process during RT. The results of this research formulated a set of inferences that make it possible to understand the education professionals who used the system and how they interacted with the theme of this instance of the system called Classes (Serrano et al., 2022).

In Brazil, some studies have also been conducted in this area. Deus et al. (2020) interviewed 137 computer science teachers from public and private educational institutions in Brazil, from the Technical, Undergraduate, and Graduate levels to record the perceived impacts and the strategies used during the pandemic. The main instruments adopted were: Google Meet, WhatsApp, YouTube, and Google Classroom. Although the teachers considered that they needed better training for pedagogical practices in the RT modality, the experience led to improvements in the course and, therefore, some strategies could be permanently incorporated, such as synchronous or asynchronous classes, video-based classes, or active methodology such as the flipped classroom, where content is deepened and discussed among classmates, and later, the teacher brings complementary subjects, develops specific projects and group activities, and problem-based learning (PBL) - (Filatro, 2022).

Classe et al. (2023) present survey-based research investigating students' perceptions of technological acceptance and motivation to use the metaverse as an active learning environment supporting hybrid teaching and learning. Results show that students pointed out that this technology is easy to use, helpful in accomplishing tasks, and provides a positive environment for remote teaching, especially regarding collaboration, interpretation, and relevance.

In another study in Brazil Juli et al. (2023), an observational, cross-sectional, descriptive, and temporally prospective approach was adopted to analyze graduate students' perceptions of gamification implemented in a gamified education and also investigated gamification's psycho-

logical and behavioral effects on these students. The results indicated that the students perceived the gamification elements in the system differently and experienced different positive psychological and behavioral effects from this approach. However, the gamified educational system analyzed in this study included several game elements, making it challenging to identify which observed behavior individually is associated with a specific game element.

The study by Preuss and Lima (2023) focuses on the high failure rates in programming and algorithms in computer science undergraduate courses. The aim is to identify and analyze free online platforms and tools to help students overcome difficulties. A survey was carried out among a group of students in an Internet computing technical course to investigate the usability of online tools. The results show that although all the tools analyzed have positive points (attractiveness, apprehensibility, and intelligibility) and negative points (excellent rejection of using the tools studied among the participants), one is more suitable for the remote teaching context. The Coding Roomse platform stands out, with a high score in usability and the most significant number of technical features.

Nascimento et al. (2022) report that adopting new teaching practices during emergency remote teaching, gamification, and exceptionally personalized gamification is a promising alternative to improve the quality of education. The study carried out mixed research (qualitative and quantitative) based on descriptive data analysis (of the students), a semi-structured interview with the subject's teacher, and a semi-structured interview with five of the 17 students in the study. The aim was to understand how social and performance-based gamification impacts the teaching and learning process in remote teaching. The results revealed that both gamification designs can positively influence the student experience, highlighting the need to understand more deeply how each affects students according to their profiles. However, it was observed that the most impacted student profiles differed from those expected, suggesting the importance of personalizing gamified educational systems according to student profiles.

Freire et al. (2020) addressed accessibility for students with disabilities in a survey. The study investigated technologies and other resources available from 53 higher education institutions in Brazil to support these students in RT. The study results showed the most used DTRs were Moodle, Virtual Classroom - SIGAA, and Google Classroom. They thus designed a scenario using tools, equipment, and multimedia resources to contribute to digital accessibility. The results of the study detail the capacity installed in institutions to support digital accessibility for students in this context, such as the preparation of VLEs, accessibility of multimedia content, specialized professionals (such as sign language translators-interpreters), accessibility of digital books and Assistive Technology resources. It concluded that a significant advance has already been made in public higher education institutions in Brazil to improve accessibility. However, many institutions will need to adapt to continue using the digital educational resources that are expected to grow after the experience with remote teaching and provide adequate accessibility.

Araujo et al. (2020) surveyed teachers' perceptions of signs and symptoms of stress associated with pursuing RT activities. During the pandemic, they changed with 456 university professors from public and private institutions. Teachers reported on their activities in RT, their need to acquire high-speed internet access, and purchase new DTRs, such as a graphics tablet, microphone, digital whiteboard, webcam, and video editor, to adapt classes that had been face-to-face. This was a source of stress experienced among higher education teachers in Brazil who taught using RTs during the pandemic (Araujo et al., 2020).

These studies presented various issues faced by educators who had to adapt to the teaching format required by social distancing. While these studies dealt with more general aspects of RT, our work investigates the use of teaching methodologies adopted during this period as adaptations and perceptions for pedagogical practices in teaching and learning. Brazil is a country of great diversity. and the experiences teachers and students had during the pandemic can be integrated into their pedagogical practices, improving the teaching and learning process. Therefore, designing scenarios based on tools, equipment, and multimedia resources improves digital accessibility.

3 Survey Research Methodology

A survey was the mechanism chosen to support our research work, and we followed the procedures proposed by Kitchenham et al. (2010) and Kasunic (2005).

M. d. S. Lima and Maciel (2021) focus on higher education professionals and quantitative data analysis. This study extends the previous one in the number of respondents, 276 professionals from elementary, middle, and higher education. The analysis is exploratory, using the qualitative technique to analyze the results. The steps of the method adopted for this extensive study are shown in Figure 1: identification of the research object (the research should start on the problem and how the survey will answer the questions); identification and characterization of the target audience (who the respondents of the survey will be); creation of the survey design (objectives and the internal questions should be written in survey items to facilitate analysis and interpretation); execution of the pilot survey (the survey must be tested with members of the target audience to remove bugs and improve the instrument); distribution of the survey (distribution of the survey to selected members of the target audience); analysis of the results and writing of the report (the results must be collected and shown in graphs or tables that facilitate understanding) (Kitchenham et al., 2010).

We chose the Grounded Theory strategies for qualitative data analysis emphasizing systematic data collection, processing, and analysis (Glaser & Strauss, 2017). Coding aims to check the systematically derived core categories that become the focal concepts that contribute to theory development. The questions raised in our study provide some answers about categories and their relationships, creating distinctions between codes that produce dimensions and sub-dimensions (Merriam & Tisdell, 2015). I. In our study, the data and interpreted concepts were developed and related through relational statements. In analyzing the codes for the open-ended questions, four people were involved in transcribing the survey responses using the coding technique.

3.1 Identifying the Research Object

Our goal was to observe the education professionals' adaptations to changing from face-to-face to RT modalities and their perceived impacts.

The following research questions were stated:

RQ1. *What were the experiences of education professionals about teaching methodologies in the context of instructional design in RT during the pandemic?* This question investigates the most used methodologies and the experiences had by educators when adopting them, seeking

to understand the challenges, successes, and learnings when adapting pedagogical practices for remote teaching.

RQ2. *How did education professionals deal with digital technological resources in their RT practices?* This question explores the experiences of education professionals when using technological resources to develop teaching activities during remote teaching.

3.2 Identify and Characterize the Target Audience

The main concern when sampling subjects is to ensure that they represent the target audience; that is, the proportion of participants who answered, compared to the number of those who aborted the survey (Kasunic, 2005). In this study, our target audience is education professionals who work in face-to-face teaching and then switched to remote teaching. The respondents should be involved in the classroom process and teaching activities before and during the pandemic.

To ensure valid results, we selected only education professionals who migrated from the face-to-face modality to RT. The points considered in the selection were (i) the profile with experience in education from elementary to higher education and (ii) the function in education for the RT modality.

The 276 respondents were education professionals from public or private institutions, from elementary school to higher education. We invited them through emails explaining the survey goals. We also asked them to share the invitation with their colleagues by accessing the questionnaire link in the email text. Before the respondents began the response process, they accessed the informed consent form containing information about completing the survey, the authors, and the research ethics. The exclusion criteria for the participants were not accepting the informed consent form for the survey, having no experience in remote teaching, and not answering all the survey questions.

3.3 Questionnaire Design

All survey questions related to the predetermined research question. Based on the research questions, the questionnaire was structured into four main blocks, consisting of 26 questions (16 of which were multiple-choice). The first block obtained information about the profile of the education professionals. The second block consisted of five questions about using DTRs in pedagogical practices in the face-to-face teaching modality. The third block presented six questions highlighting the adopted DTRs, practices, and methodologies in the RT modality to address RQ1.

The fourth and final block consisted of eight questions about practitioners' perceptions of the RT modality experience to answer RQ2. When applicable, the questions presented options available to the participant to complement their answer.

3.4 Pilot Test Questionnaire

To help ensure a complete understanding of the survey, on January 5, 2022, we asked four educational professionals to answer the questionnaire, make sure the questions were clear and precise, and finally, identify further improvements. Following their suggestions, we updated the survey, for example, adding more multiple-choice options to some questions, changing some terms to

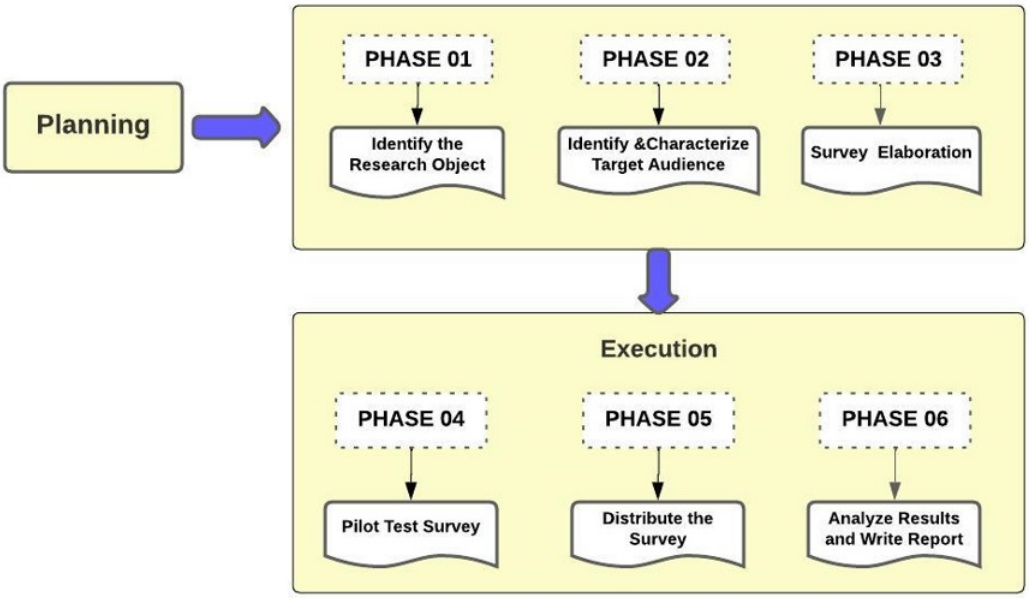

Figure 1: Survey Design..

improve understanding, and changing the order of some questions. As a result, we improved the quality of the questions and refined some alternatives to enhance the respondents' understanding in a second version.

3.5 Questionnaire Distribution

On January 15, 2022, an email with a link to the survey and information about the privacy policies of the study was sent to social networks, mailing lists, and lists of participants of scientific societies. By accessing the link, the participant had access to the survey, which took an average of 20 minutes to complete. First, the study and the informed consent form were presented. The participant had the option to accept or not participate in the survey. Only after acceptance did they have access to the questions. At the end of the questions, the respondent provided their email to be informed of the publication of the study findings. The data were obtained between February 1 and March 30, 2022. During this period, we sent reminders by email, lists, WhatsApp groups, and social networks.

4 Survey Results

We obtained two hundred and seventy-six (276) responses. However, it is worth noting that 19% of the questions were open questions dealing with adaptations and perceived aspects of remote teaching, and 98% of the respondents answered all of these questions. To report the analysis of the results, we adopted the following assumptions about the instrument:

1. The sum of percentages may be more significant than 100% in closed-ended questions with more than one response option

2. Use a Likert scale to understand respondents' opinions and attitudes. It is a survey scale representing a set of response options (numeric or verbal) covering opinions on a topic. It also uses a five or seven-point scale, sometimes called a satisfaction scale, ranging from one extreme attitude to another. The open-ended questions in Block 4 were followed by closed-ended questions using the Likert scale, from Highly Unlikely to Highly Likely. Quantitative data analysis was performed using a report obtained from Google Forms and Microsoft Excel spreadsheet, helping with data summarization.

3. We analyzed the quantitative data by generating a report in Excel format to summarize the data. First, we identified the relevant variables in your data set. We counted the number of responses for each category in each variable. Finally, we calculated the percentages of responses in each category about the variable's total number of valid responses. Numbers and percentages are put in organized tables for more precise visualization.

4. The answers to the open questions were analyzed using the coding technique (Yin, 2016) to organize and group the coded data into categories or families, sharing their characteristics (Sampaio & Lycarião, 2021). The first author carried out the coding, which was reviewed by the second and third authors, applying the codes and forming the categories.

Initially, we will present the general analysis of the respondents' profiles, the results, and a discussion of each level. Finally, a general discussion will correlate data across the three levels of education.

4.1 Respondents' Profiles

The analysis of the profile results of the 276 education professionals resulted in responses from 18 Brazilian states. Many responses came from the country's Northeast region, namely the states of Alagoas, Bahia, Ceará, Maranhão, Piauí, Sergipe, and Pernambuco, totaling 69.6% of respondents.

The respondents differed among states and public and private institutions where they teach (see Table 1). About 71.7% teach in public institutions; 36% work in the exact and earth sciences, and 21% work in the humanities. It is important to note that public schools and universities account for most educational institutions in Brazil, catering to many students nationwide. Moreover, professionals from the exact sciences, such as Mathematics, Physics, and Chemistry, are typically more familiar with technology and its applications than professionals from other areas. Because the survey is related to DTRs and teaching methodologies, education professionals felt more motivated to respond and provide valuable feedback about their context.

Regarding the DTR experience used in the face-to-face modality, there was a significant difference between the high school and college rates, as 54% of the respondents were from college and previously had had experience using DTR in their daily activities (see Table 2). 14.8% of the elementary school respondents used some DTR in the face-to-face modality, compared to 40.8% in higher education and 43% in middle school (see Table 3). In elementary school, the use of DTRs has lower percentages (see Table 3). This is probably because elementary school students are still developing their motor skills, visual perception, and cognitive skills. Simple tools such as pencils, paper, and books are still crucial for their learning and development at this educational stage (Borba et al., 2010).

Table 1: Knowledge Areas X Type of Educational Institutions.

	Public	**Private**	**Both**	**(%)**
Agricultural Sciences	10	2	0	4%
Biological Sciences	14	2	0	6%
Health Sciences	13	6	3	8%
Exact and Earth Sciences	74	15	10	36%
Human Sciences	37	14	7	21%
Applied Social Sciences	17	6	1	9%
Engineering	10	2	0	4%
Linguistics, Literature, and Arts	22	10	0	12%
Did not inform	1	0	0	0%
Total	**198**	**57**	**21**	**276**
Total (%)	**71.7%**	**20.7%**	**7.6%**	**100%**

Table 2: Knowledge Areas X Education levels.

	Elementary School	**High School**	**Higher Education**	**(%)**
Agricultural Sciences	0	5	7	4%
Biological Sciences	3	7	6	6%
Health Sciences	1	3	18	8%
Exact and Earth Sciences	5	22	72	36%
Human Sciences	19	25	14	21%
Applied Social Sciences	2	7	15	9%
Engineering	0	3	9	4%
Linguistics, Literature, and Arts	10	15	7	12%
Did not inform	0	0	1	0%
TOTAL (%)	**14%**	**32%**	**54%**	**100%**
Total (%)	**71.7%**	**20.7%**	**7.6%**	**100%**

Regarding the use of DTRs, 20.5% used personal computers at high school and 20.5% at college. We know that the curricula at high schools and higher education institutions are more complex and specialized than at elementary schools. These respondents have more technical experience and have become more comfortable and capable of handling more advanced DTRs (Villarreal et al., 2023).

The low rate of 0.9% shows that few education professionals needed to acquire skills and familiarity with DTRs to transfer pedagogical content from the face-to-face modality to classroom teaching (see Table 4). However, 7.1% of education professionals reported using VLEs, which should demonstrate a need for more familiarity with these virtual environments in face-to-face teaching. According to Table 4, Google Classroom (9%) was the most used software in all three levels of education, followed by VLEs (7.1%) and Google Meet (7%). This shows that the professionals needed more experience using DTR for teaching this modality. Castro et al. (2023) state that neither teachers, students, nor institutions knew how to work with the RT model since it requires its curricular organization support and evaluation materials.

This diversity of perspectives, previous experiences, and the rate of non-use of DTRs in

Table 3: DTRs X Levels of Teaching in the face-to-face modality.

	Personal Computer	**Smartphone**	**OHP**	**Tablet**	**Digital Whiteboard**	**Other**	**None**
Elementary School	4.90%	4.90%	0.60%	0.10%	3.70%	0.60%	0.60%
High School	20.50%	11.70%	2.50%	0.10%	7.60%	0.60%	0.10%
Higher Education	20.50%	9.60%	2.40%	0.10%	7.50%	0.70%	0.10%
Total	**46.00%**	**26.20%**	**5.50%**	**0.40%**	**18.90%**	**1.90%**	**0.90%**

Table 4: Software X Levels of Teaching in the face-to-face modality.

	Elementary School	**High School**	**Higher Education**	**Total**
Google Forms	0,00%	0.1%	0.2%	0.4%
Microsoft Teams	0.2%	0.5%	0.7%	1.4%
Zoom	0.6%	1.3%	1.7%	3.6%
Google Meet	2.1%	2.6%	2.3%	7.00%
Moodle (VLE's)	0.5%	2.1%	4.5%	7.1%
YouTube	2.5%	4.2%	2.3%	8.9%
Google Classroom	1.4%	4.4%	3.2%	9.00%
Other Apps	0.9%	8.2%	9.7%	18.9%
None	3.8%	22.4%	7.4%	33.6%

face-to-face education provides a valuable source to understand educators' challenges and the lessons learned in adapting to remote teaching.

4.2 Elementary School Results

14% of the respondents were elementary school teachers. These are from the following areas of knowledge: biological sciences, health, exact and earth sciences, humanities, applied social sciences and linguistics, literature, and arts.

Regarding their experience in RT, the collected data shows a 52.1% increase in the use of personal computers and a 37.1% increase in the use of smartphones compared to the face-to-face modality. 50% of respondents from elementary schools used personal computers, 38% for smartphones, and 9% for tablets. Many elementary school teachers had to adapt quickly to RT to continue teaching their students during the migration between face-to-face and remote modes.

With this, they started using more computers and smartphones to help the teaching process. For example, videoconferencing, such as Zoom or Google Meet, can be used to conduct virtual classes in real-time and create or send online activities to students, such as quizzes and interactive exercises. It also allowed teachers to communicate easily with students and parents or guardians through emails, text messages, and instant messaging applications to keep everyone informed about student progress and critical updates. Among the most used software are Google Classroom

(31%), Whatsapp (22%), YouTube (17%), and Zoom (13%).

These data show the little interaction of these professionals with Moodle (3%), which is widely used at the higher level as a leading platform to support activities in RT (to be discussed in 4.4).

4.2.1 RQ1:What experiences were lived by education professionals about teaching methodologies in the context of instructional design during remote teaching?

What were teachers' experiences about teaching methodologies in the context of instructional design in RT during the pandemic? Regarding the methodologies used in RT within the instructional design process, the most cited by elementary school teachers were lectures (22%). Theoretical classes are strategies characterized by the presentation of contents with the active participation of students, considering their previous knowledge, with the teacher acting as a mediator for students to question, interpret, and discuss the object of study (Borba et al., 2010).

Although 41% of the methodologies do not require student interaction (video-based lessons (19%) and lectures (22%)), we highlight the use of active methods, such as PBL (Problem-Based Learning) and flipped classroom, in the context of remote teaching, totaling 20%, involving the creation of meaningful and engaging learning experiences using the DTRs (see Table 5). Other teaching methods were also adopted, such as collaborative activities (16%); and gamification (13%) (see Table 5). PBL and Flipped Classrooms approaches allow students to participate in learning, interactivity, gamification, and collaboration activities, making the class more dynamic and motivating (Silva et al.,2022).

Table 5: Methodologies in Elementary Education in the Remote Modality.

Methodologies	**(%)**
PBL (Problem-Based Learning)	4%
Cannot give an opinion	10%
Gamification	13%
Collaborative Learning	16%
Flipped Classroom	16%
Video based classes	19%
Lecture classes	22%
TOTAL	**100%**

Despite highlighting active methodologies in Table 5, 10% of the education professionals did not give an opinion for a lack of knowledge in teaching methodologies. Many elementary school teachers were required to adapt quickly to remote teaching. As a result, they changed their pedagogical skills, including knowledge of teaching methodologies (Borba et al., 2010). RT requires specific DTRs, and not all teachers have access to these resources, limiting their ability to implement appropriate teaching methodologies in their pedagogical practices in RT.

4.2.2 *RQ2: How did education professionals deal with digital technological resources in their RT practices?*

DTRs played an essential role in supporting elementary school teachers. RT lessons, video conferences, and platforms allowed teachers to stay connected with students and provide quality educational materials even at a distance. In addition, DTRs such as personal computers (50%) and smartphones (37.9%), Google Classroom (31%), and Whatsapp (22%) helped enrich learning and make it more dynamic and interesting. However, challenges existed at the elementary school level.

Not all students had access to the necessary DTRs at home, and many teachers needed to adapt quickly to new tools and teaching methodologies, which was not always easy (Borba et al., 2010). In summary, only 5% of education professionals in elementary schools considered DTRs partially adequate to support practices in RT having inadequate infrastructure (32%). Moreover, 33% were inexperienced in the RT modality.

When analyzing the responses about inadequate support for conducting classes at RT, it was confirmed that the absence of an internet connection (a subcategory of *Inadequate Support* coding) was the main problem encountered for teaching activities. At elementary schools, most activities are carried out in a ludic way since the interaction between teacher and student is significant at this stage of teaching and learning (Machado et al., 2022). However, with the need to perform the RT modality, we noticed the need for more interaction and communication support tools.

As mentioned earlier, we used the coding technique to summarize the qualitative analysis of the five open-ended questions in the fourth block (see Table 6). As a result, five categories of codes express the main concerns about their lived experiences:

- **Inadequate support:** needed to receive sufficient support or resources to effectively use DTR in their teaching in face-to-face or remote settings, such as issues with training, access to technology, or other forms of support.
- **New adoptions:** reports on trying new tools or approaches for the first time in response to the shift to remote teaching.
- **Lack of Functionalities and Resources:** comments or feedback indicating that they found specific DTR tools or platforms needing more features or functionalities that they needed to teach their courses effectively.
- **Impacts:** refer to the positive or negative impacts when using DTR tools on their teaching, their students' learning, or other aspects of their work.
- **Future perspectives:** refer to thoughts or plans regarding the continued use of DTR in their teaching activities or their predictions of the future of educational technologies.

In Table 6, some examples of answers to open questions and related code.

Figure 2 summarizes our categories and subcategories for the elementary school answers.

Considering the New Adoptions responses upon returning to the face-to-face teaching modality, the use of interactive and audiovisual resources, forums and quizzes, infrastructure improvements, and activity management resources were the subcategories considered by the coding (see

Table 6: Examples of answers and coding of open-ended questions from Elementary School professionals..

Open questions	**Answer**	**Coding**
Support for teaching practices	"The school lacks the technological resources"	Poor Infrastructure
Lack of Functionalities and Resources	"I want to be able to have more interactive whiteboards on the computer screen; to be able to interact better at the time of the student's activities."	Interactivity
New adoptions	"Gamification tools, despite already using games in the classroom, this adaptation proved to be more attractive. As it is possible to use the computer/smartphone, it will be easier to use at other times"	Gaming Tools
General Impact	"They will be modified because it will be hybrid teaching, and we will need to continue to adopt the tools used in remote teaching."	Hybrid Teaching
Teaching for the Future	"Tablet, laptop, and how many more will be created"	Hardware Resources

Figure 2). As stated in Villarreal et al. (2023), teachers valued the opportunities offered by the internet through educational platforms, online resources, and social media to increase interaction in their RT classes. In the responses regarding the Lack of Functionalities and Resources, some respondents reported the importance of having more interactivity among the resources provided in the virtual environment in RT, such as video conferences. The VLEs have as main elements communication, so the platform must have available resources such as forums, chat, groups, and message boxes to interact with students and teachers (Silva, 2021). Among the answers, the absence of content tools and the quiz were also subcategories found in the respondents' answers.

12% of the respondents reported for the answers about the *Impacts* that their practices will suffer when they return to face-to-face teaching. The use of VLE, synchronous activities, and the inclusion of hybrid education, DTRs, or teaching methodology, led many teachers to reflect on their classroom behaviors, perceiving a need to search for new knowledge (see Figure 2).

Respondents provided information on what DTRs would be needed for *Future Perspectives* in education. 15% referred to connectivity, for better internet connection (considered as a subcategory for this coding) for students and education professionals; interactive communication (audio, video); hardware, with adequate equipment for quality remote classes; virtual reality with the use of holograms; activity management and evaluation; and collaboration tools (google classroom, VLEs, google drive). The prospects for remote teaching would relate to the respondents' answers about New Adoptions "What tools will possibly be incorporated into your teaching practice? How will it be done?". This question supplements the answers from multiple choice question

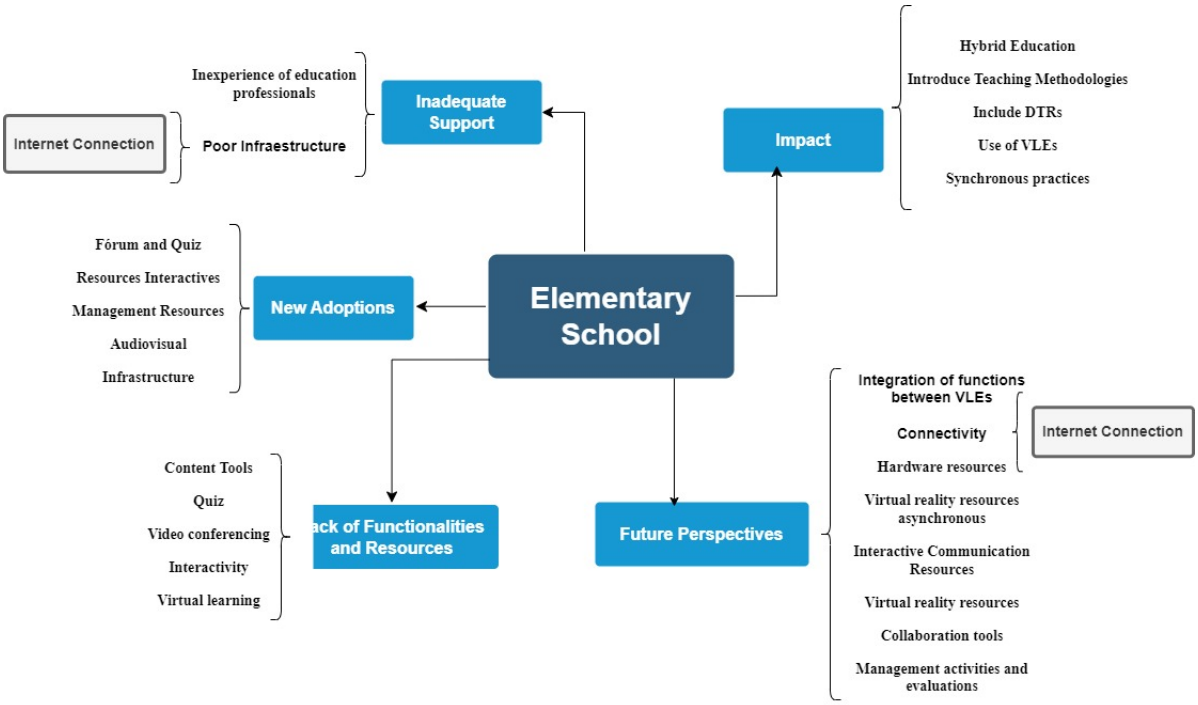

Figure 2: Coding related to DTRs for RT practices at elementary schools..

4.3, "When face-to-face classes resume, how likely are you to consider continuing to use the tools employed during non-face-to-face teaching?" Among the resources that might be adopted by more education professionals are: interaction resources, quiz or forums, management resources, and audiovisual, and infrastructure improvements, the latter already reported as one of the main problems being inadequate support for remote teaching.

The inadequate support for the DTRs used by these professionals, such as Google Classroom and Zoom, directly affected synchronous classes. Most of them had to learn to handle them by themselves to alleviate the situation and conduct remote classes in pedagogical practices. Professionals from public institutions reported this difficulty, while teachers from private institutions had better support for DTRs. However, they reported difficulties in getting children's attention in synchronized activities. They need more adaptation to the RT modality, where most of their classes are playful, and there is an active interaction between teacher and student. Other DTRs used during RT as methods in lesson preparation, Whatsapp and YouTube, helped to improve interaction with students. In contrast, VLEs were only used by 3% of teachers in elementary school, so they show low acceptance and a lack of adequate training for education professionals.

With the analysis of the open questions, we obtained significant results for elementary schools, indicating that the RT modality adopted required several adaptations by education professionals. One of these adaptations was using some teaching methodology, such as video-based or presentation classes, or active methodologies, such as the flipped classroom. The teaching strategies adopted at elementary schools can bring more quality to the teaching processes mediated by differentiated DTRs. The difficulties in planning, producing, and using methods, techniques, activities, or materials may contribute to a better acceptance of educational projects involving an instructional model (Mattar et al., 2022). Thus, elementary education institutions will undergo a

complex process of technological adaptation, and teachers see the possibility of recreating a new school scenario to meet the student's educational needs and demands.

4.3 High School Results

High school is the last elementary education level, comprising three years of schooling in Brazil. During this period, the skills, knowledge, and values acquired in the curricular components of general education are applied and contextualized in professional education practices.

Of the respondents,31% were from public institutions and 5% from private institutions, of which 13% were from Exact and Earth Sciences area, and the other areas of knowledge were Human Sciences, Linguistics, Literature and Arts, Applied Social Sciences, Agricultural Sciences, Engineering, Biological Sciences, and Health Sciences.

There are essential differences between face-to-face and remote teaching modalities at high schools. In the face-to-face modality, our results revealed among the most used DTRs are personal computers (20.5%), smartphones (11.7%), and Digital Whiteboard (7.6%) as resources for class preparation and as support for classroom teaching. The software YouTube (4.2%), Google Meet (2.6%), Google Classroom (4.4%), Whatsapp (2.6%), and Moodle (VLEs) (2.1%) were little used in this teaching modality since they prioritized a methodology of lecture classes and direct contact with the student in the classroom. However, when compared to the answers regarding the remote teaching modality, it was found that the use of smartphones (27%), tablets (5.9%), and personal computers (47.4%) increased significantly for pedagogical practices. According to the results obtained in the survey, most respondents said that they already use DTRs in their face-to-face teaching practices, making them a natural choice for small classes. These resources could be used to teach online classes, share resources, create activities, and interact with students in real-time, with the support of software such as Google Classroom (18.2%) and

4.3.1 RQ1: What experiences were had by about teaching methodologies in the context of instructional design during remote teaching?

Regarding the methodologies used in RT, the most cited by high school education professionals were video-based lessons (20%) and collaborative learning (19%) (see Table 7). Based on the experiences of these education professionals, the integration of DTRs has opened up new possibilities for teaching and learning, seeking approaches that meet the specific needs of each level of student. Video-based classes are strategies in which the content is presented in video format and can be previously recorded by the teacher, who delivers it to the students. Students can access the videos through online learning platforms (YouTube, VLEs, Google Classroom). 38% of the methodologies do not require student interaction (e.g., video-based classes (20%) and lecture classes (18%). However, active methodologies of PBL (Problem-Based Learning) and flipped classrooms (reported by 26%) were used, as shown in Table 7. As previously mentioned, in PBL, the teacher is a facilitator, guiding students in solving problems. On the other hand, the flipped classroom is an approach in which students watch recorded lectures or read didactic materials before face-to-face classes (Silva et al., 2022).

Other teaching methodologies have been adopted at high schools to make lessons more interactive: collaborative activities (19%); and gamification (10%) (see Table 7). Middle school

Table 7: Methodologies in RT at High Schools..

Methodologies	**(%)**
None	7%
Gamification	10%
PBL (Problem Based Learning)	10%
Flipped Classroom	16%
Lecture	18%
Collaborative Learning	19%
Video based classes	20%
TOTAL	**100%**

teachers have increasingly used both active methodologies cited in Table 7 as they provide a more engaging and practical learning experience for students. It is up to educators to choose the best approach to be used according to the teaching objective and the students' characteristics.

4.3.2 RQ2: How did education professionals deal with digital technological resources in their RT practices?

At high schools, DTRs were widely used by teachers to provide support in RT. 41 educational professionals at this level had intermediate or advanced RT skills; many could adapt their teaching skills to incorporate digital tools into their pedagogical practices. Among the DTRs that helped in this classroom support were online learning platforms such as Google Classroom (18.2%), Google Meet (9%), and Whatsapp (18.8%), as well as educational applications (Moodle (6.9%)) that help engage and motivate students in learning. However, these strategies require access to the Internet or technological resources, limiting the ability to learn in RT.

In summary, 13% of the respondents partially supported using tools to support their teaching practices in RT. 50% stated that VLEs have limitations and need to be adapted to RT (20%), generating as subcategories inexperience of professionals and interactive learning. 20% stated in the responses Inadequate Support for their teaching practices. Consequently, the subcategories of audio and video conferencing resource limitations were selected (See Figure 3).

Table 8 shows examples of responses collected to the open question 4.4.1. "In what ways will practices be modified?"Figure 3 summarizes the responses.

Considering the answers about the *New Adoptions*, 31% of the respondents did not indicate any tool to be incorporated when returning to face-to-face teaching. However, for the video-conference category (13%), we obtained a subcategory remote interaction, and for virtual environments (6%), subcategories remote interaction and organization of activities (6%) to be inserted on return to face-to-face teaching. In addition, content tools (34%) and audiovisual resources (10%) were the other categories for *New Adoptions* at high schools. In contrast to the *Lack of Functionalities and Resources*, respondents indicated that this absence of videoconferencing resources (82%), artificial intelligence resources (6%), and interactive resources (6%) - software that facilitates interaction between students and teachers were the categories defined for question 4.2. of the survey "What digital technology resource(s) do you miss and would you indicate for the computing environments and tools you use in your non-face-to-face teaching practice?"

Table 8: Examples of responses and Coding of open-ended questions from High Schools..

Open questions	**Answer**	**Coding**
Support for teaching practices	"Slow internet, free software without specification for teaching classes, sharing errors, access, screen or file sharing, etc."	Poor Infrastructure
Lack of Functionalities and Resources	"I want to be able to have more interactive whiteboards on the computer screen; to be able to interact better at the time of the student's activities."	Audiovisual Tools
New adoptions	"I would like to continue using tools like jam board, padlet, google forms, and interactive quizzes."	Interactive Resources
General Impact	"Use the resources that are currently being used permanently."	Include DTRs
Teaching for the Future	"All the resources indicated above and new technologies introduced."	Connectivity resources

In the answers about the *Impacts* generated by the use of resources in RT, at this level of education, the inclusion of DTR (30%), teaching methodologies (30%), and hybrid teaching (10%) was identified as modifying the pedagogical practices when returning to face-to-face teaching. 30% chose not to answer, showing that the practices in RT will remain the same since they had already used them before the change of modality. However, the DTRs cited as necessary for teaching in the future were hardware resources (35%), interactive communication (29%), connectivity (12%), integration of functions into VLEs (12%), and virtual reality (6%). These results suggest that in the classroom modality, RT will gradually enter pedagogical practices, but it will be necessary to adapt the institutions and their education professionals to meet the new student demand.

The respondents provided information about the DTRs needed for *Future Perspectives* in education. 25% referred to connectivity, improvements for better internet connection (considered as a subcategory for this coding) for students and education professionals; the integration of functions between VLES; improvements in hardware resources; virtual reality resources; and communication and interactivity resources, where the coding found in the education professional responses. The RT perspectives will be related to the respondents' answers about *New Adoptions* in open-ended question 4.3.1: "What tools will possibly be incorporated into your teaching practice? How will it be done?". This question complements the responses in multiple choice question 4.3, "When face-to-face classes resume, how likely are you to consider continuing to use the tools employed during non-face-to-face teaching?

With these qualitative results, a recurring statement from professionals is that the use of DTRs in RT needs more functionality to meet the needs of education professionals. However, all the DTRs mentioned have great potential to remain in the teaching and learning processes at high schools. It was observed that these processes would become more focused on active practices, where the teacher becomes a knowledge mediator, and the student becomes more active and responsible for his/her learning process.

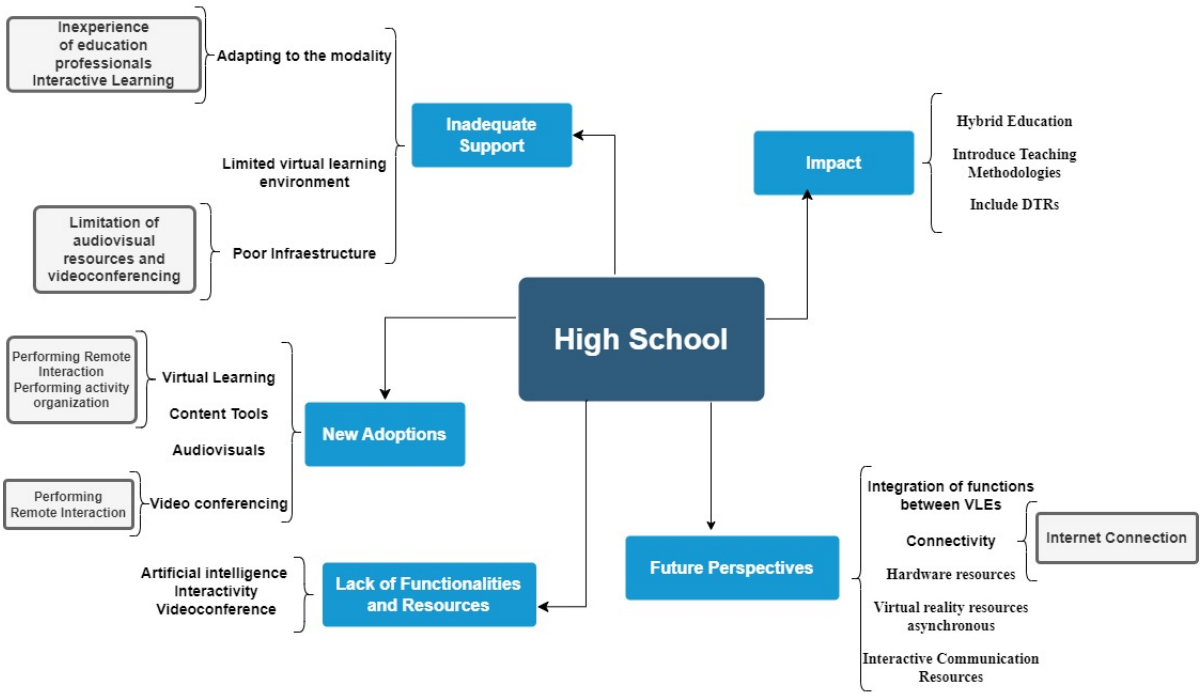

Figure 3: Coding related to DTRs for RT at High schools..

The answers to the open questions reported that the respondents used different DTRs in their classes. However, the student's lack of interest and interaction, computers, internet access, and licensed tools hindered teaching and learning at high schools. Private institutions, on the other hand, have better infrastructure but still reported difficulties adapting to RT and limitations with VLEs, such as unintuitive and confusing interfaces and difficulty in conducting assessments. Education professionals make an attempt to maintain the quality of education.

A possible explanation for these results may be the lack of training and adequate support for the DTRs that have been adopted, requiring adaptations by education professionals; here, 85.5% reported using active methodologies such as flipped classrooms and PBL in their teaching practices. These professionals used a diversity of DTRs to facilitate instructional design when preparing the plan of teaching activities, such as Google Classroom, Moodle, Google Meet, Zoom, video recordings for YouTube, and groups in WhatsApp, which assisted in the instructional design of the teaching practices. In addition, some respondents reported that they could not adapt to the practical activities and had to suspend them until they returned to face-to-face teaching. Thus, high schools have undergone technological adaptations, challenging education for the next decade, including features in functional integration between VLEs, connectivity, communications integration, and virtual reality.

4.4 Higher Education Results

Higher education courses are offered face-to-face, remote, and semi-attendance. 54% of the respondents worked at public and private institutions, and 36% had a degree in Exact and Earth Sciences. The other areas were: Human Sciences (21%), Linguistics, Literature, and Arts (12%),

Applied Social Sciences (9%), Agricultural Sciences (4%), Engineering (4%), Biological Sciences (6%), and Health Sciences (8%).

Initial observations in face-to-face teaching, block 02 of the survey, revealed the most used DTRs: personal computers (20.5%), smartphones (9.6%), and digital whiteboards (7.5%). Among the software used were YouTube (2.3%), Google Meet (2.3%), Google Classroom (3.2%), and VLEs (4.5%) in face-to-face teaching mode. One possible explanation for using VLEs in higher education, primary and secondary education, is the better implementation of virtual environments with adequate training for teachers and their students. In the data reported for the RT modality, we observed an increase in the use of personal computers (22.8%), smartphones (13.8%), and tablets (3.9%) in pedagogical practices. According to some higher education professionals, if there had been more support from educational institutions, it would have minimized the adaptation to RT.

Table 9: Methodologies in Higher Education in Remote Teaching..

Methodologies	**(%)**
Cannot give an opinion	4%
Gamification	6%
Video-based lessons	9%
PBL (Problem Based Learning)	14%
Lectures	16%
Flipped Classroom	21%
Collaborative Learning	28%
TOTAL	**100%**

4.4.1 RQ1: What experiences were had by education professionals about teaching methodologies in the context of instructional design during remote teaching?

Considering the methodologies used in higher education in RT, the most cited by respondents was the flipped classroom (21%). In the flipped classroom, the student previously studies the subject, and then the classroom becomes an environment for applying the content studied, solving problems, or developing projects (Serafim and Lopes, 2022). 25% of the methodologies do not require student interaction (video-based classes (9%) and lectures (16%)). However, we highlight the active methodologies of PBL (Problem-Based Learning) and flipped classrooms totaling 36%, as shown in Table 9. The other teaching methodologies adopted in higher education are collaborative activities (28%); and gamification (6%) (see Table 9). Higher education teachers have increasingly used both active methodologies to provide students with a more engaging and practical learning experience.

In the results of methodologies in higher education, synchronous and asynchronous classes were mentioned, but they are considered tools used in collaborative learning. It is up to these professionals to choose the best approach to use according to their teaching objectives and the student's characteristics. Synchronous classes are those in which teachers and students are present simultaneously in the same virtual or physical space, interacting in real-time. On the other hand, asynchronous courses are those in which the content is made available in advance, allowing students to access and study the material at their own pace and time. Such changes in RT activities demonstrate the search for continuous improvement and development of new teaching approaches

and strategies (Carvalho and Pimentel, 2022).

4.4.2 RQ2:How did education professionals deal with digital technological resources in their RT practices?

After the migration from face-to-face to RT, DTRs were widely used to support higher education. Classes conducted via video conferencing platforms, such as Zoom (8%), Google Meet (19%), and Microsoft Teams (5.6%), were live and interactive. They also used these platforms to conduct question/answer sessions and group discussions. Other online learning platforms, such as Moodle (13.5%) and Google Classroom (12.3%), host course content, assignments, assessments, and study materials. These are just a few ways the teaching staff used technology to support higher education. These resources will remain essential to higher education. In summary, 20% of teachers in higher education incorporate DTRs into their current teaching practices.

With the analysis of the coding for the *Inadequate Support*, we obtained as one of the categories the limitation of the VLEs (14%), which is subdivided into subcategories: support for classes and tools in the VLEs, resources for text corrections, and management of assessments. The other categories are inadequate infrastructure (12%) subcategories internet connection; irreplaceable practical classes in RT (10%); lack of mastery of the modality by professionals (8%); interactive learning (4%); adaptation to RT modality (4%), with the subcategories traditional methodology, gamification, and interactive learning; limitation of audiovisual resources (2%); limitation of video-conference resources (1%); and an excessive number of students in classes (1%) reported as the main problems to be supported in the DTRs (see Figure 4). The results show how DTRs have supported education professionals in their practices in RT. However, most of the answers reported that for the VLEs, access is limited to the functionalities made available in the environment, and they need adequate training on the tool (Mattar et al., 2022).

After using the coding technique on the higher education responses, Figure 4 summarizes the qualitative analysis of the open questions in block 4 of the survey. In Table 10, some examples of responses collected for each open-ended question are cited. Note, for example, that for open question 4.2, For example, for open question 4.2, “What digital technological resource(s) do you miss, and which environments or tools could be used in your remote practice? Feature or functionality of the software (system, application) adopted in your non-face-to-face practice.", the response regarding the *New Adoptions* of pedagogical practices would be in better monitoring activities and generating virtual learning tools as coded in the qualitative analysis.

However, 15% of the respondents did not indicate which tools could be incorporated when returning to face-to-face teaching. However, in the answers about *New Adoption*, 35% of the respondents said that content tools, videoconferencing, learning environments, quizzes, gamification, and simulation are the most cited tools that would be used when returning to face-to-face teaching.

Considering the *Lack of Functionalities and Resources*, 34% of the respondents indicated that collaborative components, artificial intelligence techniques, simulators, gamification, interaction, forum and quiz, infrastructure, audiovisuals, videoconferencing, function integration, management, and digital whiteboard are necessary resources to facilitate the teaching and learning processes and the interaction between students and teachers. These resources should be easier to use to improve activities when face-to-face classes resume.

Table 10: Examples of responses and coding of open questions from Higher Education..

Open questions	Answer	Coding
Support for teaching practices	"Difficulty in adapting lab practice content."	Adapting to the modality
Lack of Functionalities and Resources	"Greater integration between the online class environment (e.g., Zoom) and DE platform (e.g., Moodle) for dynamic group composition during classes."	Online environment integration
New adoptions	"Environment for group work, wikis, tests, and online polls"	Collaborative resources
General Impact	"Insertion of active methodologies in more stages of the teaching and learning processes"	Inclusion of active methodologies
Teaching for the Future	"Systems like SIGAA need to be better integrated with other EaD tools."	Resources for integration of functions between VLEs

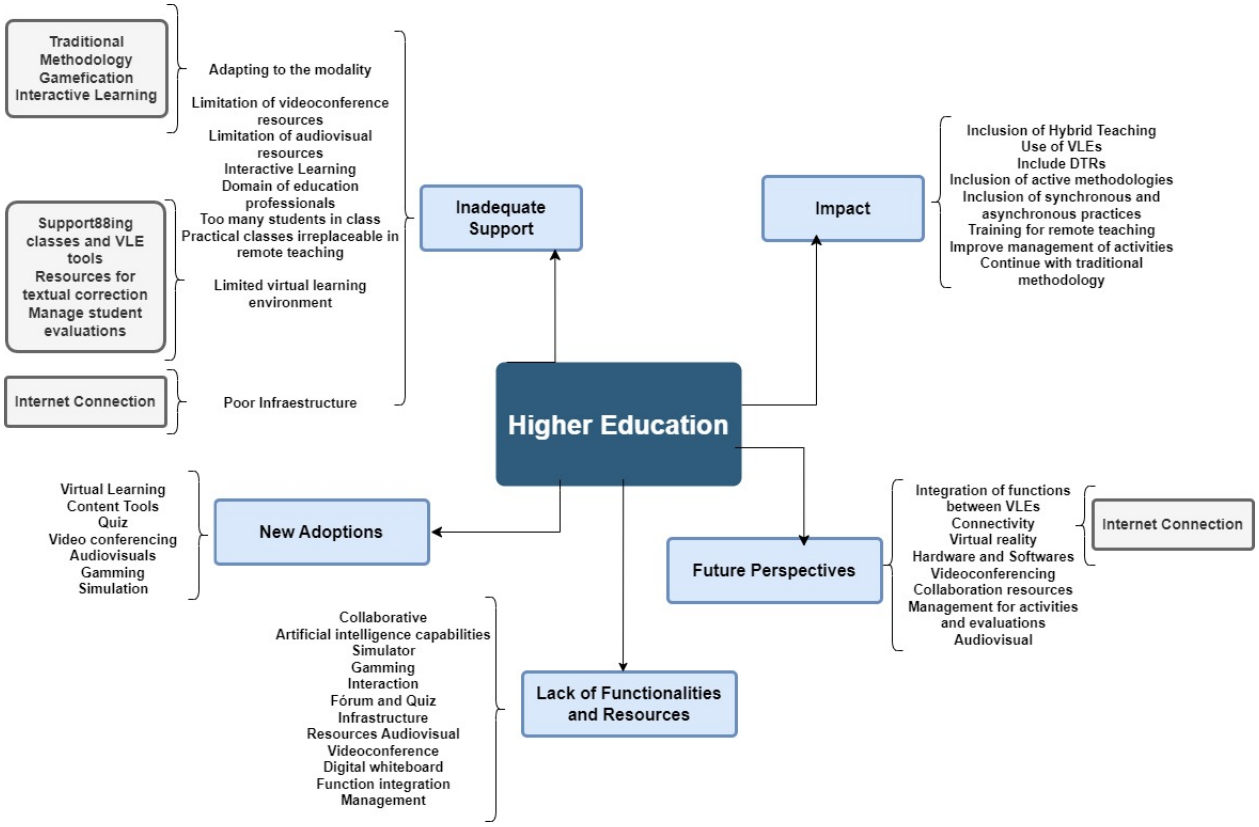

Figure 4: Coding regarding remote teaching practices in Higher Education.

Considering the responses of *Impacts* that may influence their teaching practices from their experience acquired in RT, they reported: that the use of traditional methodology (5%), the inclusion of hybrid teaching (5%), the inclusion of active methodologies (5%), improving activity management (5%); including more DTRs (5%); improving training for RT (5%); inclusion of synchronous and asynchronous practices (22%); use of VLEs (26%). 21% of respondents stated that their teaching practices would not be modified at all (Figure 4), as they had already been using some DTR or method before remote teaching was mandatory.

44% of the education professionals higher education reported that for *Future Perspectives*, software and hardware (12%); audiovisual resources (5%); software for managing activities and assessments (5%); videoconferencing resources (7%); collaboration resources (8%); virtual reality (14%); connectivity (16%) with subcategories internet connection; and integration 741 of VLE functions (18%), will be necessary for the continuation of pedagogical practices in RT. For these DTRs reported to the RT, *Lack of Functionalities and Resources* to meet the needs of educational professionals in VLEs and internet access were reported as ongoing challenges. However, all the mentioned DTRs have great potential to remain in the teaching and learning processes in higher education.

59% indicated that VLEs have limitations in supporting classes due to the lack of functionalities or integration with other tools (Figure 4). However, they reported that in adapting to the issues brought by RT, the traditional methodology for RT (1%), gamification (1%), and interactive learning (2%) were cited as minor problems. 80% of these teachers in higher education reported that some DTRS were missed in their RT practices, such as management resources (34%); role integration (16%); videoconferencing (7%); interaction (4%); simulators (2%); forum and quizzes (2%); collaboration (1%); artificial intelligence (1%); and gamification (1%) (Figure4). However, 22% reported that content tools were used when they resumed face-to-face classes, followed by VLEs (22%) and videoconferencing (12%) (Figure 4).

88% of education professionals claim to be intermediate or advanced-level users of DTR in the classroom, and 41% have used some teaching methodology. These results probably relate to various software tools that promote student interaction and video conferencing applications (e.g., Skype, Zoom). However, 65% of the respondents stated that it is a significant challenge to adopt such resources in the RT modality. Internet connection problems, poor infrastructure in the institutions, and lack of teacher training are some of the challenges for RT.

These results suggest that education professionals knew how to use these DTRs before they began the sudden migration from face-to-face and remote modalities. Thus, the research data indicate that these professionals adapted their teaching activities with the available DTRs to minimize the impact of the change to the RT modality in their courses, and this was reflected in the insertion of these technologies when they returned to face-to-face teaching.

5 General Discussion

The survey results revealed that educational professionals at all three levels of education, in public and private institutions, worked hard to adapt the instructional design of their classes from face-to-face to RT. In summary, the higher the level of education (elementary, high school, and

higher education), the greater the professional experience with DTRs and the diversity of strategies adopted during the pandemic.

Personal computers were the most used DTRs at all three levels of education. Smartphones were the second most used at the elementary and middle school level for teachers working in face-to-face education. An interesting finding is that over 50% of professionals claim to have an intermediate or advanced level of competence in using DTRs before RT. However, only 2.8% of elementary-level teachers in public institutions had less experience than others. In addition, VLEs were an underused DTR in elementary (0.5%) and middle school (2.1%) classroom teaching.

Education professionals used different teaching methodologies during the pandemic to adapt their teaching practices to RT, including video-based lessons, collaborative learning activities, and expository lessons. As a highlight, flipped classrooms were the most used methodology, even in elementary education. Less widespread than the flipped classroom, PBL is another active methodology adopted at all three levels of education.

The attempt by professionals to learn how to use different DTRs resulted in work overload, such as difficulties in working with groups of students during synchronous classes. DTRs of simulation, audiovisual, video conferencing, and content integration between different applications were desired but needed to be readily available in RT. Features like simulation functionalities and integrating applications and tools have generated new perspectives on application implementation requirements.

5.1 Answers to the research questions

This section summarizes the research questions presented (Section 3).

1. *What experiences were had by education professionals about teaching methodologies in the context of instructional design in remote teaching during the pandemic?* During the transition to remote teaching, education professionals had to adapt quickly, adopting various teaching methodologies. Initially, some of the experiences were the insertion of video-based classes and lectures as the most adopted teaching methodologies. Due to inadequate infrastructure, educational professionals employed active methodologies and strategies to streamline this. To assist with pedagogical practices in remote teaching, teachers began incorporating active methodologies such as Problem-Based Learning (PBL) or the Flipped Classroom approach. In this same context, Preuss and Lima (2023) also emphasize that active methodologies, gamification platforms, robotics, mediation, and online tools have improved teaching and have tried to overcome difficulties by facilitating the teaching of computer programming. Juli et al. (2023) also highlight the implementation of gamification in a lato sensu postgraduate course, where the results obtained indicate that most of the game elements implemented were correctly perceived by the course students. In this way, gamification has been adopted at different levels of education to improve student engagement. From this perspective, both teacher and student had to learn to work collaboratively to ensure the effectiveness of these new methodologies in remote teaching.

   The experience had several impacts on all three levels of education. The diversification of DTRs and pedagogical strategies tends to increase as one advances through the levels of education. However, it is necessary to consider that the barriers experienced by elementary

school teachers after migrating to RT will open up new opportunities. Students at this level of education have been exposed to the use of DTRs, which can drive the adoption of these technologies in the educational process. On the other hand, remote teaching has also provided opportunities for innovation in education, using various DTRs and improving chances to develop self-discipline, self-management, and independent learning skills.

2. *How did education professionals deal with digital technological resources in their RT practices?* The urgent need to insert pedagogical practices after the migration from face-to-face to remote teaching caused difficulties in teaching methodologies or DTRs. The study demonstrated the absence of interaction and communication difficulties between teachers and students. There needs to be more functionality in the applications and integration between different tools that support synchronous communication. On the other hand, active methodologies facilitated this transition to the RT modality, allowing educational professionals to search for methodologies that could help and improve remote classes, making them more interactive. These methodologies and DTRs helped education professionals, some with little experience or even needing more sophisticated equipment, use their smartphones.

   In this context, Souza (2020) emphasizes using different technological tools for remote teaching as contributions of remote training to spatial geometry. Classe et al. (2023) also highlights the use of metaverse as online learning based on virtual environments for hybrid teaching. However, the use of DTRs depends on teacher mediation, favoring the construction of meaning for student engagement.

   The lived experiences revealed several opportunities that educational professionals should incorporate. In RT, educational professionals were able to explore and use several DTRs in their pedagogical practices, such as video lessons, interactive applications (e.g., Kahoot, Google Classroom, Google Docs), VLEs (e.g., Moodle), and communication applications (e.g., Zoom, Meet). When they return to face-to-face teaching, teachers may incorporate their DTR experiences to enrich students' experiences and make classes more dynamic and attractive.

5.2 Open Issues and Research Opportunities

The following are the most urgent research topics for advancing the state of the art of adapting face-to-face modality for RT and inserting DTRs and methodologies into pedagogical practices:

- **New requirements for VLEs development:** Developing virtual learning environments (VLEs) now requires functionalities considering pedagogical perspectives. It is recognized that developing software for education is a challenging task, as Abreu et al. (2012) emphasized The survey results reveal no established development standard for educational software (ES), which may compromise identifying specific requirements for this domain. This issue is evident in the feedback from education professionals who report the absence of essential functionalities for pedagogical practices in remote teaching (RT). To address this challenge, it is essential to explicitly use learning theories in developing educational

software systems, as Abreu et al. (2012) explained. However, it is known that pedagogical aspects should be taken into account more during ES development. Based on the survey findings and related works, a catalog of software requirements to ensure appropriate settings in VLEs can be proposed as an initial step that should be continuously developed.

- **Interoperability of learning supporting tools:** Several different tools are essential in designing instruction for RT courses as a single or monolithic application aggregates all the necessary functionalities. Interoperability is a non-functional requirement addressed in several domains, such as health and public services (Deus et al., 2020). The usage of several non-interoperable solutions has led to educational professionals doing extra work. Regarding software development concerns, it is more effective to aggregate a set of systems or platforms, each one with its own specificity able to use and share information among them. Therefore, addressing interoperability specificity issues of the e-learning domains should enhance interoperability solutions (e.g., standards application interfaces, communication protocols, abstraction layers, software architectures) that the various platforms can use to communicate using common strategies.

- **Instructional Design Support:** Instructional design is crucial for adapting to the new demands and challenges that education professionals have faced while migrating modalities. Using various DTRs and teaching methodologies requires a well-planned and organized instructional design to ensure the effectiveness of remote teaching practices. Incorporating active methodologies and gamification elements can enhance student engagement and motivation, but it is essential to design instructional strategies that align with the learning objectives and outcomes. Moreover, effective assessment strategies are vital to measure remote teaching practices' effectiveness and students' learning progress. Therefore, tools and technologies for remote teaching should support instructional design effectively. As such, the instructional design offers a promising research opportunity to explore new and innovative ways to enhance the quality of remote teaching and learning experiences.

- **Interaction with technological resources and tools:** The online learning environment should provide opportunities for interaction, discussion, and access to content, but also for carrying out activities through additional tools, such as interactive exercises, simulators, or (self-) assessment systems. The student is considered to be at the center of the teaching and learning processes, i.e., he/she should take an active role in managing his/her activities, monitoring the learning performed, setting work goals with the support of teachers, and having at his/her disposal appropriate devices and tools for these activities. For this to occur, two necessary attributes are required: flexibility and extensibility, which are essential features in remote teaching tools, as they allow teachers to customize and adapt the tools to their specific needs. For example, a video conferencing tool should allow teachers to easily share documents, presentations, or other teaching materials. The tools should allow teachers to customize course resources and activities to meet the specific needs of their students.

- **Use and Application of Emergent Software Systems:** Emergent systems are technological artifacts or applications. These systems are not limited to messaging applications; they can be office suites, flash drives, wikis, social networks, and the most unlikely types of technologies. These artifacts have yet to be explored, especially when analyzing the potential of new technologies in different application areas, for example, health. These include the

Internet of Things, big data, artificial intelligence, robotics, and blockchain (Castro et al., 2023). There are countless challenges to be faced in this field of study. Therefore, it is necessary to seek new ways to understand the accelerated development of emergent software systems that have previously been neglected.

Open questions and research topics can help in developing functionality for VLEs. These research topics can guide academia and software developers toward more appropriate and complete solutions for evaluating configurable software requirements in learning environments.

In addition, many questions regarding usability, flexibility, interaction, and interoperability may not be expressly assigned to VLEs, but are quality attributes necessary in these learning environments. As in MOOCs, it is pertinent to use diversified resources and tools, adapted not only to pedagogical strategies but also to the subjects taught and skills to be instilled in students. As such, technology will be increasingly sophisticated in vocational education and training, driving the digital transformation of traditional education in conjunction with other factors, such as a sudden migration to RT.

5.3 Threat to the validity

Associated risks that may undermine the study were identified during its planning and execution. We present these risks and measures to mitigate possible effects.

- **Construct validity:** This risk refers to the participant's understanding of the questions presented, which may negatively affect the responses obtained. Thus, we made several refinements and inserted descriptions on the questions considered most sensitive to this factor. We also carried out pilot tests to certify the quality and objectivity of the questionnaire.
- **Internal validity:** The selected audience cannot represent the entire population of professionals who have been working during this period. However, responses were obtained from professionals working in 27 states, totaling 276 participants. Thus, we believe that this set is somewhat representative, thus minimizing this threat.
- **External validity:** Our survey respondents may not represent all education professionals. However, the survey was disseminated broadly to reach as many participants as possible, covering all or most Brazilian states. We used several digital means to publicize the questionnaire, such as e-mail lists, apps, and social networks, as presented above.
- **Reliability:** The control and integrity of the data obtained through the survey and distributed by Google Forms are beyond the control of the researchers as it is a private platform. The platform's security policy was reviewed, and the risk of data loss or exposure was considered. Respondents also had access to this policy and agreed to the additional terms expressed about their voluntary participation and possible risks in the research involved. As for the reliability of the researchers involved in the analysis of the qualitative data, the research process was well organized, planned, and based on an honest dialogue of participation assumed by each of the groups, which is critical to avoid interpretive bias.

6 Final Remarks

This study presents the results of a survey of the digital technology resources used before and during the migration of face-to-face and remote modalities in instructional design. The use of DTRs during the pandemic from March 2019 in Brazil boosted the RT and modified teachers'pedagogical practices. We obtained responses from 276 education professionals from different areas, including exact and earth sciences, biological sciences, health, linguistics, literature, and arts. Overall, 92% of the respondents favored using DTRs in classroom teaching, even after returning to classroom teaching. The results show a tendency for teaching practices to have been permanently modified due to this period that fostered the adoption of DTRs. The results analyzed demonstrate that most professionals use DTRs, especially smartphones, tablets, and laptops. It is essential to note the importance of mobilizing all stakeholders in the educational process (institutions, teachers, and students) to conduct and support RT and integrate these tools into their professional routines. This has stimulated the use of these resources in applying new teaching practices and building more collaborative knowledge.

Identifying which computational resources are most used in face-to-face teaching and the teaching methodologies these professionals use to seek support may help gather potential requirements for improving DTRs. Identifying new software requirements that bring such resources closer to teachers' daily work can also improve DTRs. This work is part of a broader research project to support the use of DTRs in instructional design and the use of tools for specific teaching methods. In future work, we plan to carry out interviews with teaching professionals to investigate in greater depth some remaining open aspects, focusing on more complex issues facing the aspects of adapting to RT to understand teachers' challenges and opportunities. We then intend to compile the results into a guideline of best practices for RT. These results help us understand the main problems education professionals encounter in incorporating technology into their teaching, such as the lack of adequate training for DRTs, functionalities already existing in the applications, and problems in the institutions' infrastructures. However, further investigation is needed into helping inexperienced users with DTRs in RT or challenges related to human-computer interaction. It is essential to remember the possible bias that after adapting to RT educational institutions, educational professionals and students should maintain the quality of face-to-face teaching.

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Appendix 1 - Table of Survey by Block

Table 11: Survey questions related to the Profile of the Education Professional.

Block 1: Educator Profile Objective: To identify the profile of the education professional, the type of work performed, and technical skills.	
Questions	Question Type
1.1 Training Area / Knowledge	Multiple Choice
1.2. Area of Professional Activity (e.g., Teacher, Director, Coordinator, etc.)	Short answer
1.3 Highest Degree Completed	Multiple Choice
1.4. Level of education in which you work? (You may choose more than one option).	Multiple Choice
1.5. Age	Single-answer questions
1.6. Gender	Multiple Choice
1.7 State	Multiple Choice
1.8. Type of institution where you work?	Multiple Choice

Table 12: Survey questions related to the face-to-face teaching modality.

Block 2: About face-to-face teaching practice Objective: Identity what face-to-face teaching practices have been adopted.	
Questions	Question Type
2.1. Are digital technological resources used in your face-to-face teaching practice?	Dichotomic
2.2 What is your skill level in using digital technological resources for education in face-to-face teaching?	Multiple Choice
2.3 What devices do you use in your face-to-face teaching practice? Please indicate other options if you cannot find them on this list.	Multiple Choice
2.4 What software/applications do you use in your classroom teaching practice? Please indicate other options if you cannot find them on this list.	Multiple Choice
2.5 What specific teaching method do you adopt in your classroom teaching practices? Examples: active methods, flipped classroom, PBL, etc.	Multiple Choice

Table 13: Survey questions concerning the Remote Learning modality.

Block 3: About remote teaching practices Objective: Identify what practices in remote teaching have been adopted.	
Questions	Question Type
3.1 How long have you been working in remote teaching?	Multiple Choice
3.2 What devices do you use in your remote teaching practice?	Multiple Choice
3.3 What software do you use in your remote teaching practice? Please indicate other options if you cannot find them on this list.	Multiple Choice
3.4. Does the curricular component (subject) you teach have any practical activity?	Multiple Choice
3.5 What adaptation(s) occurred in order to carry out your practical activity(ies)? Please tell us how.	Multiple Choice
3.6 Which method(s) has been adopted in your experience in remote teaching? Please indicate other options if not found on this list.	Multiple Choice

Table 14: Survey questions related to education professional's experiences perception.

Block 4: Professional Perceptions Objective: Point out the aspects perceived in this remote teaching modality. Indicate which tools adopted by the education professionals were missed: the main functionalities for the pedagogical practice	
Questions	Question Type
4.1. Do the virtual environments and tools used in your teaching experience adequately support your teaching practices?	Multiple Choice
4.1.1 If your answer was "No or Partially," what are the reason(s) you give for this?	Open-ended
4.2 What is digital technology feature(s) missing in your remote teaching practice? Please, cite any features or functionalities in the DTR you adopted in your remote teaching practice. Example: "I would like to see if the students performed the activities requested in my online class."	Open-ended
4.3. When face-to-face classes return, how likely will you consider continuing to use the tools adopted during remote teaching?	Multiple Choice
4.3.1 If your answer was "Highly likely" or "Likely", which tools might be incorporated into your teaching practice? How will this be done?	Open-ended
4.4 How likely do you think it is that your teaching practices will be modified by the practices currently exercised in remote teaching?	Multiple Choice
4.4.1 If your answer was "Very likely" or "Likely," how will the practices be modified?	Open-ended
4.5 Regarding future teaching, in the next decade, what digital technological resources do you imagine will be necessary for remote teaching?	Open-ended