*Journal on Interactive Systems, 2022, 13:1*doi: 10.5753/jis.2022.2004

Design and evaluation of a prototype of a children's educational application during and for the COVID-19 pandemic and beyond

Ingrid T. Monteiro [**Dell Lead / Federal University of Ceará** | ***ingrid@ufc.br***]
Edney L. de Q. Lourenço [**Dell Lead / Federal University of Ceará** | ***edneyqgp@gmail.com***]
Marcelo Q. de L. Brilhante [**Dell Lead / Ceara State University** | ***marceloqlb@gmail.com***]
Adriano T. de Freitas [**Dell Lead / Federal Institute of Ceará** | ***adriano.freitas@ifce.edu.br***]
Francisco C. de M. B. Oliveira [**Dell Lead / Ceara State University** | ***fran.oliveira@uece.br***]
Francisco E. B. de Castro [**Dell Lead** | ***edivaldobc@gmail.com***]
Ana C. B. de Oliveira [**Dell** | ***ana.oliveira@dell.com***]

Abstract Covid-19 pandemic affected virtually every sector of life, due to the need to avoid agglomerations and maintaining social isolation. In education, teaching-learning processes have changed drastically and now are in a state of fast transformation. Schools all around the world were closed and teachers and students had to migrate to online environments. In this paper, we present a whole design process of conceiving an educational mobile application that explores the students' houses as a source of knowledge through gamification and augmented reality. Field studies such as online surveys and user diaries were employed and resulted into the creation of eleven personas representing teachers, parents, and students. After a brainstorming session and the definition of the basic requirements, a low-fidelity prototype was created and evaluated by ten students aged 6 to 11 years old from both public and private schools. The results of the evaluation pointed to the potential of the app in keeping children motivated and interested in learning while at home. We highlight the challenges and lessons learned in doing user research involving kids during a pandemic.

Keywords: *home-based learning, pandemic, augmented reality, remote education, design for kids*

1 Introduction

At the start of the Covid-19 pandemic, schools were closed, and teachers and students were forced to migrate to online learning environments, due to the need of avoiding agglomerations and maintaining social isolation to decrease the risk of contamination.

Digital transformation, also known as the Fourth Industrial Revolution, will touch and deeply affect all fields of human activities. In 2015, the World Economic Forum (WEF) launched the Digital Transformation Initiative to serve as the focal point for new opportunities and themes arising from the latest developments in the digitalization of businesses and society. The Initiative has analyzed the impact of digital transformation across 13 industries and five cross-industry topics. According to the WEF report, digital transformation in education is partially described as: "personalized, automated learning services will help deliver a tailored, individual approach based on unique needs, with the ability to monitor how much a student has learnt more effectively" (WEF, 2018).

The Covid-19 pandemic has the potential to accelerate the digital transformation in Education. However, the emergency remote teaching brings considerable challenges of adaptation for teachers, students, and parents. This fast change in reality imposed a quick response to the community of practitioners and scientists. School teachers had to improvise in a desperate struggle to save the academic year. This is an important challenge for small children's educators. Suddenly teachers had to share their duties with overburdened parents, who are also at home (home office). Fortunately children even with minimal digital inclusion are very fond of technology, most of them spending hours in video-games, social networks, etc. Scientists should seize this opportunity and advance with the research agenda on producing and assessing engaging innovative educational technology that actually promotes learning.

Therefore, the current state of affairs raised the problem of how parents and teachers could keep the quality of learning, considering that "learning from home" may be very distracting. This loss of concentration affects the process of learning considerably, and the use of interesting and captivating technology such as games and augmented reality (AR) already applied in formal education can be used to help leverage learning outcomes for children and help parents to become more familiar with the forced home-based school.

Teachers, schools and institutions may use the new technologies in the learning process of children. Smartphones, tablets, smartwatches, headsets and other pervasive gadgets are also present in the daily lives of young people with access to these devices. These tools combined with technologies like augmented reality and virtual reality can be harnessed to convey concepts that would be very abstract or difficult to understand (Iftene and Trandabăt, 2018).

Specifically about AR, the use of this technology in education has increased in the last decade since it has the potential to enable new forms of learning for the benefit of the educational process (Geroimenko, 2018). The use of augmented reality is recognized by the New Media Consortium and the Educause Learning Initiative as one of the most promising technologies for both higher and K-12 education (Ibáñez and Delgado-Kloos, 2018). Some studies (Weng et al., 2020, Villanueva et al., 2020a, Villanueva et al., 2020b and Chen and Liu, 2020) have demonstrated that by applying AR in teaching chain leverage in learning outcomes for different situa-

tions, including abstract thinking and affective factors.

This paper describes the design process of conceiving and evaluating the prototype of an educational mobile application that explores the students houses as source of knowledge through gamification and augmented reality, considering as target users students from elementary education. We describe the whole process of designing the application prototype for children, presenting the methodology, step by step, centered on children, and considering their expectations. The first motivating problem was emergency remote learning, due to the pandemic and successive lockdowns that forced children to spend a lot of time at home. This state motivated us to create an app that involved the house and its elements, but in a way that lingers beyond the pandemic. In this paper we present the entire process of researching, designing and evaluating only a low-fidelity prototype of this application.[1]

We considered this paper suitable to JIS and its Special Call "Interactive Systems for the next 10 years", because it is aligned to the view that "the world is facing a pandemic situation that requires advances in terms of science and technology and their application. Therefore, we are at the beginning of a new decade full of challenges and demands, in a fast changing and unpredictable scenario."[2] This paper calls the attention to the current situation in one of the most important areas of society: education, which is impacted by another important area: healthy. More of this, it points out to the future, describing design practices aligned to the new realities and presenting a simple but powerful mobile application to support kids and parents in emergency remote teaching.

In the next section, we present the background and related work. In section 3, the applied methodology is presented, followed by the results. We end up with final considerations and future research works.

2 Theoretical Background and Related Work

In this section we address the theoretical background and related work considering the concepts of remote teaching, augmented reality and design for kids.

2.1 Emergency Remote Teaching

Daniel (2020) states that due to the exponential spread of Covid-19, institutions did not have enough time to prepare for a remote teaching regime. They had plans to better use technology in teaching, but these plans had to be put in practice in a few days instead of being implemented over months or years. The author affirms that the approaches to remote learning clearly differ between elementary school and tertiary education with specific needs for each one. Institutions have to improve their abilities to teach remotely. Teachers should use what they know and give special attention to reassuring the students when necessary. The author highlights the use of asynchronous learning. Many aspects of the learning and teaching process do not require participants to communicate simultaneously. Asynchronous learning gives flexibility to teachers to prepare their materials and also allows students to better deal with their home and study demands. It works best in digital formats. Teachers post materials for on demand access and check student participation periodically. Daniel (2020) also highlights that video lessons are more effective if they are short. Adjustments in the curriculum and in the student's assessment may be necessary too. However, especially at young age, pupils from elementary school resent more face to face contact than students from other ages, as core values such as discipline and commitment are still being forged in their characters.

Hodges et al. (2020) remind that there are differences between emergency remote teaching and traditional online learning. Many courses were offered online in response to the pandemic but they were not planned for that. The teams that usually help implement online learning cannot respond to the high demand of people needing assistance. Besides, online learning has the perception of being inferior in quality than in-person classes, despite research showing otherwise. The authors say that there is a lot of terminology to define each solution in this field and a completely understanding is not fully diffused among people. That is the reason they prefer to use the term emergency remote *teaching* instead of learning or education. According to the authors, effective online education has been studied for decades. There are a lot of studies, theories and models, standards, evaluations, and course design criteria.

Means et al. (2014) define nine dimensions of online learning: modality, pacing, student-instructor ratio, pedagogy, instructor role online, student role online, online communication synchrony, role of online assessments, and source of feedback. Each of these is completely different for emergency remote teaching which is happening in a hurry and with few resources. In these times of emergency different things need to be prioritized.

Focusing in the impact of emergency remote teaching, in a seminal paper (Zhao et al., 2020) conducted a survey with Chinese students, teachers and parents/guardians closely after the start of the coronavirus pandemic. In this study they found that a new type of homeschooling, different from the traditional was forced to emerge. The following data collection was performed: demographics, survey of students, survey of parents, survey of teachers, Strengths and Difficulties Questionnaire (SDQ), Self-Rating Anxiety Scale (SAS). A chi-square test was used to identify statistically significant differences between groups. As results, they found that 25.7% of teachers expressed concern that this style could diminish their students' interest in learning; the higher the grade, the more teachers are concerned. The study also found that 83.5% of the students, 95.6% of the parents and 83.8% of the teachers preferred classroom teaching to other styles. Authors found that 68.8% of the parents reported 3 hours and more of daily screen time for their children, and 82% of the students and 84.4% of the parents reported less than 2 hours of outdoor time. They found that 17.6% of students were suspected of having emotional or behavioral problems and lower grade students were considered more vulnerable.

[1] By the time of publication of this paper, new research was developed and part of the results (not reported in this paper) were published by Monteiro et al. (2021).

[2] https://sol.sbc.org.br/journals/index.php/jis/sc01

Finally, authors concluded that current homeschooling style was generally considered acceptable by students, parents and teachers in China during the Covid-19 pandemic, despite concerns raised by teachers that this style could diminish students' interest, focus and academic performance. In light of these recent studies, it is clear that developing and investigating new forms of mobile interaction and learning paradigms is important to keep young people motivated in their studies. This work supports efforts in the development of interactive media for learning at home, for example, demonstration experiments, animated videos and educational games.

There is another related concept that shall be considered here: homeschooling. Homeschooling is a parent-led home-based education more popular in USA but also present in other countries like Australia, Canada, France, Japan, Kenya, Russia, Mexico, South Korea, Thailand, and the United Kingdom (Ray, 2021). Families choose to homeschool their children for both academic and religious reasons (Isenberg, 2007). The biggest differences from traditional homeschooling and emergency remote teaching are that in the former parents choose for that modality and they must be academically and timely prepared to dedicate to children whereas in the latter, the homeschooling situation was forced by the pandemic and not in all the cases the parents are prepared or available to support the children in their academic activities.

In this project we address issues like: a) modality (the use of AR technologies); b) roles of the students, teachers and parents; c) online communication (to what extent learning activities can be held offline? - low/expensive 3G coverage in Brazil).

2.2 Virtual and Augmented Reality in Education

Azuma (1997) defines augmented reality (AR) as a variation of virtual environments (VE), or virtual reality as it is more commonly called. VE technologies completely imerse a user inside a synthetic environment. Therefore, AR can be defined as a system that fulfills three basic features: a combination of real and virtual worlds, realtime interaction, and accurate 3D registration of virtual and real objects. The use of augmented reality (AR) systems is well established in many fields. Specially in education it is widely used to enable new forms of learning and provide a learning experience for benefit of process education (Geroimenko, 2018). As an "ancient" technology with three decades of development, researchers in computer sciences and educational technology have defined AR diversely, for example, AR based on a broad approach and a restricted approach (Milgram et al., 1995) or based on its features, characteristics and materials (Hung et al., 2017).

With the project scope defined as around education in the pandemic, we start to investigate this issue in bibliography and similar products. We start from the premise that Virtual Reality and Augmented Reality technologies have the potential of motivating and arousing the students' interest. To understand a little on the state of the art and some metrics for evaluation and challenges involving AR/VR technologies in the learning process and their utilization in childhood to k-12 education we reviewed some interesting and inspiring studies. A systematic mapping of literature was done in the following scientific bases: Scopus, IEEE, ScienceDirect, Scielo, ACM, in addition to a manual search. The following search string was used: ((“augmented reality” OR “virtual reality”) AND (“educational technology” OR “digital media in education” OR “education”) AND (“teaching” OR “learning”) AND (“self-learning” OR “e-learning” OR “m-learning” OR “virtual learning” OR “ubiquitous learning”)). The initial survey generated a list of 587 works, of which 54 were selected and considered in the survey.

Some observations on the result of the literature mapping are: a) most of the works with education and virtual reality use devices such as hand-held displays, that is, cell phones and tablets; b) a very small number of works explores VR and AR in the context of elementary education, most of which apply to secondary, technical / training and higher education, showing themselves as a gap to be addressed. This mapping was important to understand how VR and AR technologies are applied in education. The results of the mapping motivated us to invest in a solution with a mobile application and focused on elementary education. From these relevant studies topics in computer-mediated reality we can highlight that marker-based techniques are the cheapest option, computationally speaking, and that usage of paper-based learning materials is advisable for AR-based educational technology. Algorithmic accuracy is impacted by lighting, and object recognition is a great challenge related to technical development even more in mobile PC hardware.

There is no doubt that AR and VR will be present in human interaction as touch screens actually are. But these two technologies, although came from the same root, present some differences that have to be exposed. A VR system often involves head mounted devices, and a programming 3D in stereoscopic environment which made this approach more expensive and time consuming.

In addition to the systematic mapping, we conducted a benchmarking in order to discover applications that explore AR resources for educational purposes or with the potential to be applied for didactic purposes. From the Google Play Store search, a set of 7 applications was selected and compared according to the following criteria: mobile device (cell phone and / or tablet); additional equipment (textbooks, own paper cards, surfaces); representation (2D or 3D); purpose (school use, entertainment). The applications found were: SAE RA[3], Positive Augmented Reality[4], ZOOM Augmented Reality[5], SketchAR[6], Mathematics RA[7], Quiver[8], Assemblr EDU[9].

We conclude that augmented and virtual reality technologies may be of great assistance both in promoting engagement among pupils and in creating new strategies for concept conveying through interactional affordances. One of the goals of this project is creating a digital product to help kids engaging in emergency remote learning and, as will be seen later, applying AR strategically.

[3]https://play.google.com/store/apps/details?id=com.sae.ra.livro
[4]https://play.google.com/store/apps/details?id=com.positivo.realidadeaumentada
[5]https://play.google.com/store/apps/details?id=digital.tenda.zoomar
[6]https://play.google.com/store/apps/details?id=ktech.sketchar
[7]https://play.google.com/store/apps/details?id=br.com.lionstudios.matematicara
[8]https://play.google.com/store/apps/details?id=com.puteko.colarmix
[9]https://play.google.com/store/apps/details?id=com.assemblr.education

2.3 Design for Kids

Design for kids has a large spectrum that need to be carefully defined in early phases of prototyping mobile application for kids, since there are significant differences according to the variation of ages and school levels. As explained by Gelman (2014), children change really quickly, especially in the early ages. In few months toddlers experience significant cognitive, motor, and technical growth, while adults remain pretty stable in such little time. It's important to keep these changes in mind as one develops digital products that can grow with the audience. In this project, the target users are children aged six to eleven, then such broad range brings even more challenges.

So, in general, when designing an interface aimed at children, the following elements must be observed: challenge, feedback, trust and change. These elements are considerably different when compared to the interaction design for adults (Gelman, 2014).

Another relevant difference between designing for kids and for adults is that while adults usually have a clear end goal in mind when they use an interface, kids are in it for the journey.

When we design for kids, other important point to be considered is engagement. Children are easily bored and lose interest in certain activities. Cash et al. (2020) are creating a tool that tries to generate a creative engagement in children, allowing them to create their own augmented reality content.

In conclusion, technology developers have a responsibility to design their products to meet the needs of children. Products should be designed to accommodate children' s size, strength, and dexterity (Markopoulos et al., 2008).

2.4 Game-based learning

Research on the adoption of game-based learning in the classroom shows a positive impact on aspects such as: student engagement and motivation, understanding of complex or abstract concepts, as well as on human skills and values such as empathy, systems thinking and problem solving (Voulgari et al., 2020).

Thus, recent studies describe GBL solutions aimed at children, focusing, for example, on teaching languages (Plecher et al., 2020) and science (Carpenter et al., 2021). There are even reports of the potential of common industry games in learning (Lin and Su, 2020). Other GBL studies address more specific aspects such as: teacher training (Lin and Su, 2020), students' reflection on learning (Carpenter et al., 2021), application of the flow state theory (Hsieh et al., 2016) and personalized learning Li and Wong (2021).

Focusing on mobile game-based learning (mGBL) for children, the work of Gouin-Vallerand et al. Gouin-Vallerand et al. (2018) describes the design and evaluation process of a serious mobile game for teaching math and English. The authors highlight the following design challenges and strategies in this process: maintaining student motivation and engagement; quest structure (investigation); and pedagogical pattern. Al-Razgan and Alshaarri (2019) present the development of a mobile game aimed at teaching spelling to Arab children in the literacy process. Some details were presented, such as: the use of genetic algorithms, the game design and the game's graphical interface. The research by Li et al. (2020) presents a mobile game that explores Augmented Reality in textbooks, aimed at elementary school students. The authors present the use of co-design with children in the construction of the game.

Other examples of research on mGBL for children are: game for teaching recycling Gaggi et al. (2020), a longitudinal study of systematic use of an educational game for iPad Sun et al. (2018) and authoring tools for educational mobile games Karoui et al. (2020).

Based on field research and ideation activities, it was decided to incorporate some mgbl principles in the development of the application presented in this paper.

3 Methodology

This section presents the research process used to construct the project, describing all the procedures including an online survey, user's diary, personas, brainstorming, prototype, and evaluation. The guiding problem of this research was: *"How to prototype an educational application following the user-centered design that would bring motivation and engagement to children during the pandemic?"*

In this project, we follow Lawson (2006)'s design vision. The authors describe the design process as a negotiation between problem and solution through three activities: analysis of the current situation, synthesis of an intervention and evaluation of the intervention.

In the analysis of the current situation, we seek to know the elements involved and the relationships between them, for example, people, artifacts, and processes. As a result, we get an interpretation of the studied reality, through a framework and a particular cutout of it. The analysis of the current situation points out the needs and opportunities for improvement for which an intervention is planned (Barbosa et al., 2021).

In the stage of synthesis of the intervention, one should consider, among other things, the knowledge acquired in the analysis of the current situation. Care must be taken with the experience that we intend to offer to users when using the designed system. Thus, the design of an interactive system must define an HCI solution with high quality of use to impact the current situation and the lives of users as intended. In this case, the HCI solution must comprise both the user interface and the interaction processes designed to support you in reaching your goals (Barbosa et al., 2021).

Once an intervention has been defined, it is necessary to assess whether it changes the current situation in the desired way. At HCI, the evaluation efforts focus on the experience of users during the interaction with the interface of an interactive system, that is, during the use of the system. An HCI assessment should check whether the interaction and the interface meet the quality of use criteria defined as priorities by analyzing the current situation. The HCI assessment can be done during the design process or after the finished product. Whenever possible, we must evaluate the quality of use from the beginning of the design process of the interactive systems, as the cost of correcting any problems will be lower (Barbosa et al., 2021).

Figure 1 shows all methodological procedures performed in this project so far following Lawson (2006)'s design vision.

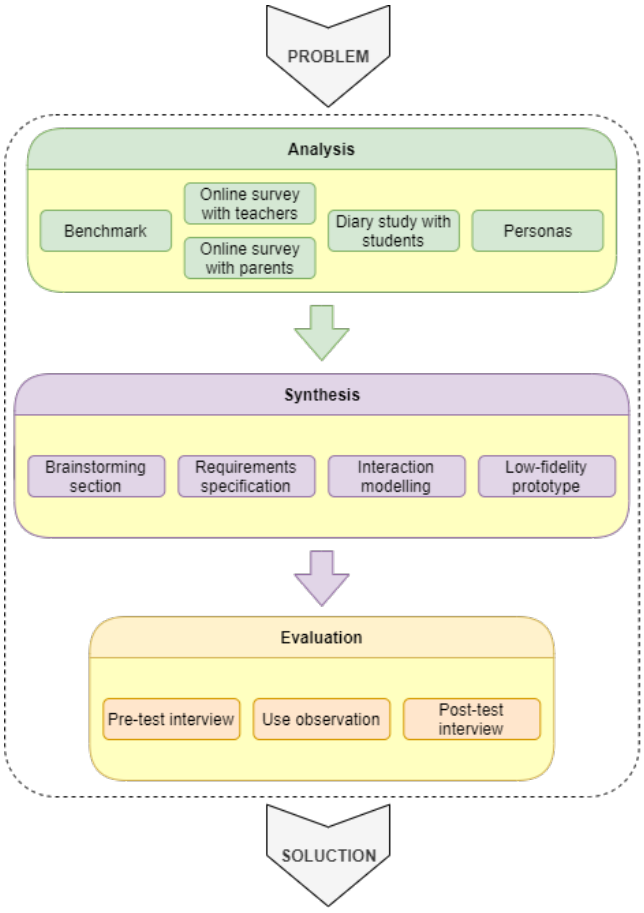

Figure 1. Methodological procedures. Adapted from Lawson (2006)

As presented, in this project, we collected data from multiple sources because, as pointed by Lazar et al. (2017), all research methods have strengths and weaknesses, and by using two or three different research methods, you can often get a much better understanding of phenomena than you would with only one research method. The participants were selected by convenience, we recruited the children we had access to test the prototypes and those who volunteered from the questionnaire (to be part of the diary study). The only exclusion criterion was school level. The inclusion criteria of teachers was opened, and the questionnaire was distributed as much as possible to diversify the sample to include teachers from public and private schools. With that we may obtain quality in data and variability.

3.1 Online Form Survey

In order to obtain a better knowledge of the actual context that we are living in, we decided to use online surveys to contribute to a more comprehensive vision. Teachers and parents from basic education (kindergarten to middle school) took part in the online research. Our goal was to know the profile of each group, to understand how remote classes are being approached and executed, and to find out how their experiences were unfolding in this new learning environment.

Two online forms were created: the first was directed to teachers of the primary education and middle school. The objective of this first form was to understand how the remote classes in the pandemic context were being provided, how has the adaptation process been, and how have interactions between students, teachers, and parents been established. The form was organized into a few sections: a) Participant profile, in which we get data about age, gender, city, state, academic grade, the type of school they work in, the number of schools they work in, their period of work experience, what subjects they teach, the quantity of classes and students they have; b) Experience in digital teaching, in which we collected data such as the start of remote education, the type of class, the frequency of classes, technological tools used to support remote education; and c) Planning, in which we questioned strategies and challenges of distance classes, strategies used to increase the participation level, educational software used, and feedback from the parents.

The second form, on the other hand, was addressed to the parents and guardians of kindergarten, elementary, and middle school students in order to find out about their participation in the student's life, how they were dealing with the new format of the classes and what their contributions were within that new learning environment.

The sessions present in the online form are: a) Student profile, to obtain information about age, school level, type of school, information about participation in classes and devices used in remote education; b) Profile of the respondent: age, gender, city, educational level, kinship with the student and his aptitude with technology; and c) Perceptions about emergency remote education, in this last session, we discussed the types of help that parents / guardians provided during remote classes, challenges encountered, the level of student attraction in remote classes, the parent's stress level and suggestions for improvements in remote teaching . At the end of the form, participants were invited to contribute to new stages of the research, letting an email address to contact them. The two forms were shared with the project members' acquaintances and posted on social networks related to remote education and were made available for a period of approximately two weeks.

3.2 User Diary Study

The choice of the diary as a method to do research with users in this project was due to the need to monitor the students' routine for a longer period and to obtain more solid data regarding emergency remote education. According to Lazar et al. (2017), in diaries studies applied to HCI, individuals are asked to record entries on a regular basis, record entries when events occur and note time information, or a combination of these elements. User diaries may help answer questions such as: How did users perceive a certain experience with the computer or device? How did they feel? How did they respond? How much time did it take them? How did it impact on their mood? When did they use it? How did it impact on their feelings of self-efficacy? The diary elicits this information in a way that neither outside observation nor automated data collection can (Lazar et al., 2017).

To recruit the participants for the diary study, we con-

tacted by email the 39 participants in the online form of the guardians who showed interest in continuing the research. In the email message, we explained how the method registration processes would take place and asked for confirmation to proceed with the study. At the end of the recruitment, 7 participants continued the user diary study.

For the registration of data, we prepared online forms separated by folders and dates to be filled in daily. The diary registration process took place over 5 days. During this period, one or two reminders (depending on the participant's choice) were sent to the participant with a message and the link to access the form for that day. The parent or guardian had to make daily diary entries about: the subjects that the student had studied, his/her behavior during the classes, duration of the class, the amount of time that the student kept interest in the class, the type of class that the student had, what the student liked and disliked the most in the class.

During the diary registration period, data were collected daily and inserted in a table to have better control of who was answering the forms and the number of days that were being recorded.

3.3 Personas

A persona is a description of a fictitious user, who does not exist as a specific person but is described in a way that makes the reader believe that the person could be real. A persona is based on relevant information from potential and real users according to Nielsen (2013).

With the objective of obtaining a more summarized analysis of the research and facilitating the visualization of the data, personas from the three user profiles were made: students, teachers and guardians. The creation process was carried out in three stages, in the first one, an analysis of the research data (online forms and diary study) was made and, during the study, similar characteristics were perceived among the respondents, thus being able to transform a group of people into a persona. With this, we proposed eleven personas, four to represent the groups of teachers, four for students and three for parents/guardians.

In the second stage, the information was separated and the most relevant data was selected, which should be used to represent the personas. Each group has different information. For teachers, profiles were created with the following data: A sentence that represents that group of teachers; the general data that inform about: age, type of school in which the persona teaches, in addition to the levels of classes he/she teaches; the goals and frustrations that the teacher had during remote classes; the type of classes (synchronous or asynchronous) and the technologies used; a small graph showing the level of his competences, which informs about: aptitude with technology, experience as a teacher and his ability to adapt to remote teaching; and finally, another graph on the experience in remote classes, classified by: level of participation of students, level of monitoring of parents/guardians and availability of the teacher for individual attention to students. For the students, the profiles were assembled with the following data: A sentence that represents the persona; the general data that informs about: age, type of school and grade; the objectives and frustrations encountered during the period of remote classes; characteristics of classes, such as: types of classes (synchronous or asynchronous), duration of the class and device used for remote learning; and a small graph of behaviors during classes, listed by: concentration, learning, disposition, anxiety and stress. Finally, the profiles of parents/guardians were listed with the following information: a sentence that represents the persona; the general data listed by: age of the parent/guardian, information about the child (name, age and grade) and type of school; the objectives and frustrations of monitoring in remote education; a chart about the challenges in remote education with information about: the parent's stress level and time dedicated to assisting students in class; and another graph in relation to the persona's competences related to: aptitude with technologies and his/her didactic level.

Finally, in the third stage, three graphical tables were produced, separated by the types of profiles, being: a table for teachers with four profiles, one for students with four profiles and another for guardians with three profiles, they contained all the information listed above and a fictitious photo to represent each persona's profile.

3.4 Brainstorming Session

In general, the brainstorming technique is used to raise requirements and to learn about new features that users would appreciate in a product, and provides more benefits when used during the conceptual stage of the product development as seen in Barbosa et al. (2021)

The session was held with the help of 7 professionals in the field of teaching, technology, design and research. From these participants, four were men and three women, and we point out that there was among them a teaching team leader, researcher of the immersive technology project and remote teaching specialist. At the beginning there was a presentation of the personas, with the intention of inserting and presenting to all participants the problem that had been identified with the research, so that it was possible to have a moment of ideas for the context presented.

The brainstorming moment took place in an online meeting held in the "Google Meet" platform, with the help of the "Mural" tool, a software that allows the creation of a whiteboard where several people can interact at the same time and take notes on cards.The virtual environment was previously organized to speed up the moment and not get out of the moderators' control. Yellow cards were predisposed for notes of ideas, red cards to evaluate against an idea and green cards to evaluate in favor. All participants in the first stage of brainstorming should make notes of ideas on the yellow cards, there was no limit on ideas, so everyone was free to write as much as they thought was necessary. In the second stage, the participants should read and analyze all the ideas to later make notes on the red and green cards, in order to analyze the pros and cons of each idea presented. And in the last step, all participants had to do an analysis of all cards, ideas with pros and cons. After checking all cards, the moderators enabled a voting moment, where each participant could spend at most 10 votes for the best ideas. This voting process was important to rank the brainstorming ideas.

For the analysis, all ideas were clustered in categories.

Most voted ideas and categories were the base for the definition of the requirements.

3.5 Interaction Modelling

After analyzing the brainstorming, the main requirements were defined to better serve the target audience. The interaction design was defined with the help of the Modelling Language for Interaction as Conversation (MoLIC). MoLIC allows us to represent human-computer interaction as the set of conversations that users can (or should) have with the designer's representative to achieve their goals. In these conversations, the designer's deputy (the interface) needs to communicate properly to users: what the system has done (or not done), what it is doing (or not doing), what it allows or prohibits users from doing, how and why . This communication is particularly important when an unexpected situation occurs, such as a breakdown in the communication (Barbosa et al., 2021) (Barbosa and da Silva, 2014).

Based on the requirements specified, the interaction modeling was done to idealize the solution, in order to meet all the problems regarding the research carried out within the project. Therefore, the main flows of the proposed solution were produced, namely: Login screen, Start screen, Game modes, Camera, Album, Profile and Settings. The MoLIC interaction diagram was created using the draw.io online tool.

3.6 Prototyping

When the interaction diagram was done, the creation of screens in a low-fidelity prototype, based on MoLIC, started. In this step, the main screens were produced using Figma software to define how the user's interaction and the arrangement of elements within the application would be.

3.7 Evaluation

The evaluation process was due to the need to consult the user and analyze their understanding of the proposed solution. The evaluation was made with the low-fidelity prototype, in order to analyze the children's understanding and possible improvements to be made according to what was perceived. Ten children from 6 to 11 years old participated in the evaluation.

To perform the prototype evaluation with the help of the pilot test, some steps were defined to be followed. In the first stage, a pretest interview was conducted to determine the child's data: a) Profile of the participant, where they were asked about age, school grade, type of school, subjects they like and dislike the most; b) Games: this session gathered data about the games that children play, how much time dedicated to games per day and the device used; c) Other hobbies, where the child was asked about games he likes, cartoons or movies they watch and other types of entertainment; and d) School, to find out how the classes are going nowadays, what they think of the remote classes, what they like and what they do not like. Right after the pretest interview, a presentation video about the "app" was shown, which was produced to assist in understanding and explaining the solution to the children[10].

For the evaluation, after the video, the child was informed that he would be filmed and received a brief explanation of what a prototype is, to help understand that he would not be using the final application directly in the mobile phone. After that, the child used the prototype, navigating the main flow, which are the screens: Login, Start, Surprise Mode, Surprise Mode 2, Question, Photo of the activity, Correction, Congratulations, Raffle and Camera with prize. With the completion of the main flow, the child was free to explore other features available in the prototype, such as: Modes, Profile, Album and Camera.

Finally, a posttest interview was made, in this stage they were asked about: a) The house, the part they like and dislike most, their opinion on what was possible to learn at home; and b) The prototype, where we asked what they understood, what they liked and disliked most, suggestions and whether they were interested in doing another test when the application was ready. The evaluations were carried out in two days, on the first day in the capital city of a Brazilian state and on the second day in a small country town in the same state.

3.8 Ethical Aspects and Procedures

This subsection aims to discuss the ethical aspects considered in the research described in this paper.

Resolution 466/2012 (Brasil, 2013), from the National Health Council of Brazil (CNS, its acronym in Portuguese), establishes: "Research projects involving human beings must comply with this Resolution." As described in this methodology section, the steps that involved humans in this project were: 1) online form survey; 2) user diary study; 3) brainstorming session; 4) prototype evaluation.

Resolution 466/2012 also establishes that "Respect for human dignity requires that all research be carried out with the free and informed consent of the participants, individuals or groups that, by themselves and/or by their legal representatives, express their consent to the participation in the research. The Free and Informed Consent Process is understood to be all the steps to be necessarily observed so that the person invited to participate in a research can express himself, autonomously, consciously, free and informed."(Brasil, 2013) This process contains two stages: 1) the initial stage is the clarification of the person invited to participate in the research; 2) the researcher in charge must present, to the person invited to participate in the research, or to his/her legal representative, the Free and Informed Consent Form (TCLE, its acronym in Portuguese) so that it can be read and understood, prior to the granting of free and informed consent. Additionally, the informed consent must be approved by a Research Ethics Committee (CEP, its acronym in Portuguese) to which the project was presented and by the National Research Ethics Committee (CONEP, acronym in Portuguese), when applicable.(Brasil, 2013)

However, in resolution 510/2016 (Brasil, 2016), which provides the rules applicable to research in the Human and Social Sciences, there is a set of types of research exempt

[10]The demo video is available here: https://bit.ly/3qyK1gp

from registration and evaluation by the CEP/CONEP system. Thus, we consider that two of our researches fall within this set. They are: 1) online form survey, which fits into item I of the resolution: "public opinion survey with unidentified participants"; and 2) brainstorming session, which fits into item VII of the resolution: "research aimed at theoretical deepening of situations that emerge spontaneously and contingently in professional practice, as long as they do not reveal data that can identify the subject". Regarding brainstorming, it was applied as a practical way to come up with ideas for solutions, involving only the people from the company (that's why it is characterized as "professional practice") and even so, all the records collected were anonymous, as established in this item of the resolution.

Unfortunately, there was not enough time in the project to submit the informed consents of our studies to the CEP. Therefore, in this section, we will detail the ethical precautions we take in light of resolution 466/2012.

According to resolution 466/2012, "research involving human beings must meet the relevant ethical and scientific foundations"(Brasil, 2013). Research ethics, according to this resolution, implies: "a) respect for the research participant in their dignity and autonomy, recognizing their vulnerability, ensuring their willingness to contribute and remain, or not, in the research, through manifestation express, free and clarified;" Consent to participate in the online survey was made before starting to fill in the form, after reading the research terms. Regarding the user diary study, the consent of the participants was collected via e-mail. And in relation to the evaluation of the prototype, the signatures were collected on paper, and the participant kept a copy of the informed consent signed by the head researcher.[11].

Resolution 466/2012 presents, in item III.2, some requirements that must be observed in research, in any area of knowledge involving human beings. We will comment on some of them, pointing out how they were addressed in our studies.[12]

- "a) be adequate to the scientific principles that justify it and with concrete possibilities to respond to uncertainties": It is part of the Special Call of this journal to consider the current moment of a pandemic, justifying, in itself, the scientific suitability of the project. In addition, throughout the paper, concrete answers to the various questions asked during the studies carried out will be presented.
- "c) be carried out only when the knowledge to be obtained cannot be obtained by any other means": The context of the pandemic, at the time of this research, was still very recent, with very few publications and even fewer focused on HCI and User-Centered Design. In addition, it is a UCD precept to collect data directly with users, so that the context of use and their needs are well known (Barbosa et al., 2021).
- "d) always seek to ensure that the expected benefits prevail over the foreseeable risks and/or discomforts": As explained in the TCLEs, the studies carried out had minimal risk, perhaps some discomfort or fatigue, when participating in the questionnaires, interviews and performing the tasks in the assessment. On the other hand, we also clarify the indirect benefit of collaborating to generate important knowledge about the reality of remote teaching in Brazil. Regarding the prototype evaluation, sanitary care was also taken, to reduce the risk of contamination of coronavirus, such as using a mask by all those present and cleaning the device before and after use.
- "e) use the appropriate methods to answer the questions studied, specifying them, whether qualitative, quantitative or quali-quantitative research": The methods chosen proved to be appropriate for what we wanted to discover: information about the reality of remote teaching, in addition to the first impression of children and guardians regarding the prototype.
- "g) obtain free and informed consent from the research participant and/or his/her legal representative, including in the case of researches that, by their nature, justifiably imply a posteriori consent": As previously mentioned, we requested consent to participate in all the studies that were applied, in addition to the online survey. Regarding the evaluation of the prototype, which was the only one with direct participation of children, the participation was authorized by the child's guardian through the signing of the consent term.
- "h) have the necessary human and material resources to guarantee the well-being of the research participant, and the researcher(s) must have adequate professional capacity to carry out their role in the proposed project": The researcher responsible for this project is a Doctor in Human-Computer Interaction (HCI) and has extensive practical experience in conducting HCI research with users. In addition, one of the contributors to this paper, who accompanied the entire research process, is also a researcher at HCI, having supervised numerous master's and doctoral research in HCI, accessibility and education. The other researchers who were directly involved in conducting the studies are 1) an undergraduate student at the end of a Digital Design course, with a solid background in HCI; 2) a Master's student in Computing, focusing on education and augmented reality. Regarding the well-being of the participants, speaking only on the prototype evaluation, all ethical precautions were taken, such as keeping the adult present throughout the session, keeping a child-friendly language and respecting the children's moments of shyness and silence.
- "i) provide for procedures that ensure confidentiality and privacy, image protection and non-stigmatization of research participants, ensuring that information is not used to the detriment of people and/or communities, including in terms of self-esteem, prestige and /or economic-financial aspects": Regarding the anonymity of the participants, in the online survey and in the brainstorming, the participants' names were not collected, guaranteeing anonymity automatically; in the user diary study, we had the identification of the person responsible (by e-mail), but there was no identification

[11] The texts of the TCLEs of the three studies (online survey, diary study and prototype evaluation) can be read here: https://bit.ly/3vK6WYA

[12] The resolution lists 21 requirements (from 'a' to 'u'). Here in the text, we highlight only 9 of them, as the others do not apply, such as items related to medical research in general, research in communities, research conducted abroad, etc.

of the name of the participating child; in the evaluation of the prototype, we had the identification of children and guardians (in the consent form); In these last two cases, anonymity was ensured in presentations and publications by the use of numerical identifiers. In addition, we only present images sent during the user diary study of participants who expressly authorized it (hiding faces and other information that could harm the privacy or anonymity of those involved). Considering confidentiality and privacy, only two people (the lead researcher and the trainee fellow) had direct access to research records and data and to communication and interaction with participants.

- "j) preferably be developed in individuals with full autonomy. Vulnerable individuals or groups should not be research participants when the desired information can be obtained through fully autonomous participants, unless the investigation can bring benefits to vulnerable individuals or groups": Even when researching the children's educational context, we only had direct contact with children, who are vulnerable individuals and without full autonomy, during the prototype evaluation. At other times (online survey and user diary study), we gathered information about the children reported by third parties: teachers and parents.
- "q) use the material and data obtained in the research exclusively for the purpose provided for in its protocol, or in accordance with the participant's consent": The data obtained in the research were used exclusively for the development of the prototype and later of the application and were only disclosed in internal presentations and in scientific publications, strictly following what was presented in the consent terms and following what was expressly authorized by the participants.

4 Results of "Analysis of the Current Situation"

In this section, we present the results of the field research done with teachers, parents and students.

4.1 Survey with Teachers

The first data source in this project was the online form answered by basic education teachers. Firstly, some demographic data:

- Gender: 88,2% (105) female and 11,8% (14) male, other genders were not mentioned.
- Age: 35% (42) of the respondents were between 41 and 50 years old and 21,8% were more than 50 years old
- Location: 10 Brazilian states were mentioned; 65,5% (78) were from Ceará; 21% (25) from São Paulo; 5% (6) from Rio de Janeiro; 8% (10) from 7 other states (Rio Grande do Sul, Paraíba, Piauí, Pará, Rio Grande do Norte, Paraná and Tocantins); there were no participants from the Center-West region.
- Type of school: 72,3% (86) taught in public schools; 20,2% (24) taught in private schools; 5% (6) in both; and 2,5% (3) neither (tutor, church, and NGO)
- School level: 58,8% (70) were Lower School teachers; 29,4% (35) were Kindergarten teachers and 32,7% (39) were Middle School teachers. [13]

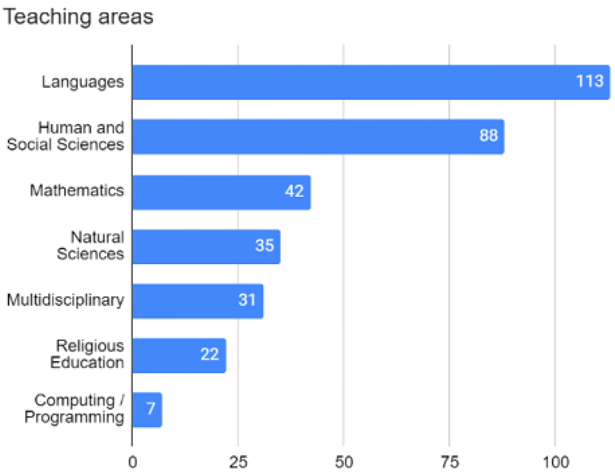

Figure 2. Teaching areas (absolute numbers)

Figure 2 shows that we had teachers from all knowledge areas, with most teaching Languages and Human and Social Sciences [14].

Now, focusing on the remote teaching context, figure 3 presents the answers to the question "Which tools do you use to support the emergency remote teaching process?". 68% (81) of the teachers affirmed to use messaging apps like WhatsApp and Telegram; 53,8% (64) use videoconference tools like Google Meet and Zoom and 35% (42) use teaching platforms like Google Classroom and Moodle. It is interesting to see the high number of teachers (23) who use phone calls. Still regarding the use of technology in remote classes, there was an open question "Do you use any educational software? If so, which ones?". The teachers mentioned 35 different tools. Google Classroom and Google Forms were mentioned 5 times; Kinemaster, Khan Academy, Geogebra, PowerPoint and YouTube were mentioned twice; 28 other tools were mentioned once, like Prezi, Candisa, Doodly, Speakpic, Scratch, Minecraft, Kahoot.

Regarding the problems faced by teachers, we selected two groups of information, related to the question "How often do you face the problems listed below, in remote synchronous classes, from the perspective of students?". Three problems are related to infrastructure and four problems are related to students' interest and attention. The respondents had five options of response: Ever, In most cases, In some cases, Rarely, Never and Not applicable. In order to simplify and stratify the analysis, figure 4 presents the data of infrastructure stratified by the type of school and figure 5 presents

[13] The sum exceeds 100% because there are teachers who teach in more than one level.

[14] The data were clustered according to National Common Curricular Base (BNCC)'s areas: 1) Languages (Portuguese, Foreign languages, Arts and Physical Education); 2) Mathematics; 3) Natural Sciences (Science, Physics, Chemistry); 4) Human and Applied Social Sciences (History, Geography, Philosophy, Sociology); 5) Religious Education. In the form, there was a "Other" field, where respondents answered things like "Pedagogical coordination", "Kindergarten", "Lower/middle school", so we grouped them as "Multidisciplinary". We decided also to keep Computing/Programming apart to highlight this area.

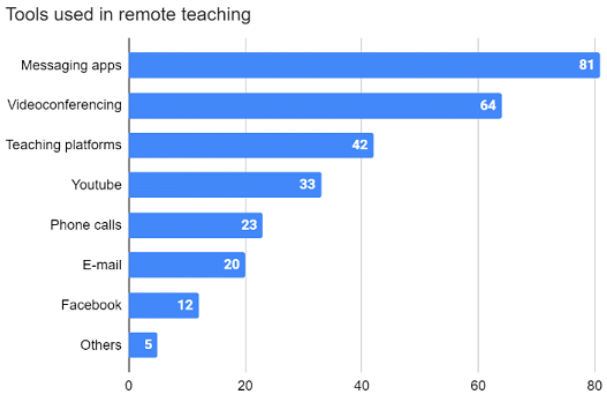

Figure 3. Tools used in remote teaching (absolute numbers))

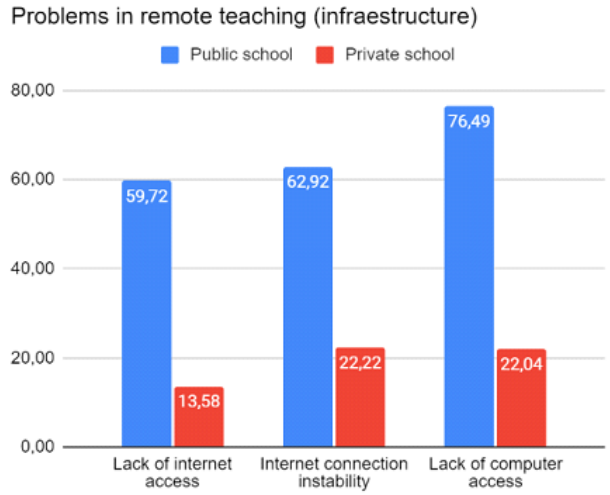

Figure 4. Students' problems of infrastructure (percentage)

the other problems stratified by level of teaching. In both charts, the numbers represent the percentage of the sum of responses corresponding to "Ever" and "In most cases". For example, regarding the "Lack of internet access", 59,72% of the responses of public school teachers were "Ever" or "In most cases", while only 13,58% of the private school teacher responses indicate it as an "Ever" or "In most cases" problem. In fact, there is no surprise in this data since infrastructure problems are more frequent to public school students.

Regarding figure 5, in Kindergarten, "Little participation" and "Realizing the moments of doubt" were the most frequent problems; in Lower School, "Attention retention" and "Realizing the moments of doubt" were more frequent; and in Middle School, "Little participation" and "Realizing the moments of doubt" were also more frequent. "Lack of interest" was the less mentioned problem in the three levels, although still remarkably high, especially in Lower and Middle School.

Figure 6 presents the challenges faced by teachers in remote classes. Note that 7 out of 9 listed problems were mentioned by at least 59 teachers (almost 50%). "Lack of adequate equipment" and "Lack of adequate work environment" were the most cited problems, with 70% (83 teachers) and 63% (75 teachers), respectively.

Besides the quantitative approach, we have also analyzed some open questions qualitatively. We have done content

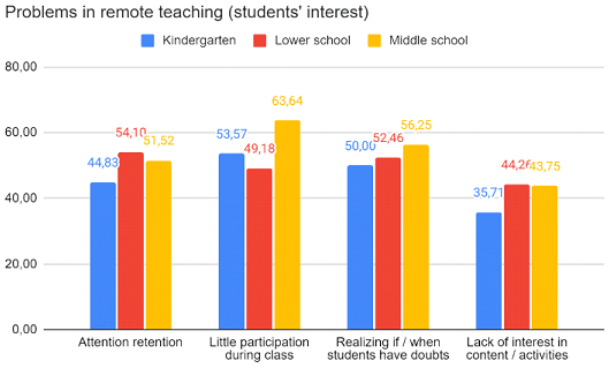

Figure 5. Students' problems of interest (percentage)

analysis, by carefully reading the answers, coding them into categories and after that grouping these categories in themes.

Regarding the open question "How do you plan emergency remote education classes and activities?, Figure 7 presents all categories and subcategories of coded segments of text. The numbers between parenthesis indicate the amount of coded segments. Teachers mentioned most use videos and search on the internet. They have also showed pedagogical concerns, such as:

- *"I plan [the lessons] taking into account the guidelines of the SBP (Brazilian Society of Pediatrics) regarding screen time, in such a way that the class has a didactic sequence that takes into account plugged and unplugged moments."*
- *"I always try to bring things that draw their attention beyond content."*
- *"I always look for something related to the ludic to pass the contents, with items that are possible to have at home even in the humblest ones. Creativity dominates in the creation of classes and activities. Remembering that less is more always."*

Many teachers reported the frequency of lessons planning. Most of them plan their lessons weekly. Some teachers also informed to follow official programs or documents, like BNCC, Mais PAIC [15] and "Trilhas de Aprendizagem".[16]

Now, let us see the results of the three final open questions of the form: "What positive feedbacks do you receive from those responsible for children about emergency remote education?", "What negative feedbacks do you receive from those responsible for children about emergency remote education?" and "What do you think could be done to improve remote education in your classes?". 92 teachers' entry on the form were analyzed, of which 70 from public schools, 17 from private schools, 3 both and 2 others. 91 codes were identified in 601 segments of text.

There are 21 different categories of codes related to "positive feedback", 37 categories related to "negative feedbacks" and 28 categories related to "suggestions. Table 1 presents information stratified by the type of teacher' schools. As more

[15] Government program "Learning Program at the Right Age" driven to public schools from Ceará (https://paic.se-duc.ce.gov.br/)

[16] A collection of books created by Education Office of São Paulo sent to families to be used during the emergency re-mote teaching (https://educacao.sme.pre-feitura.sp.gov.br/trilhas-de-aprendizagens/)

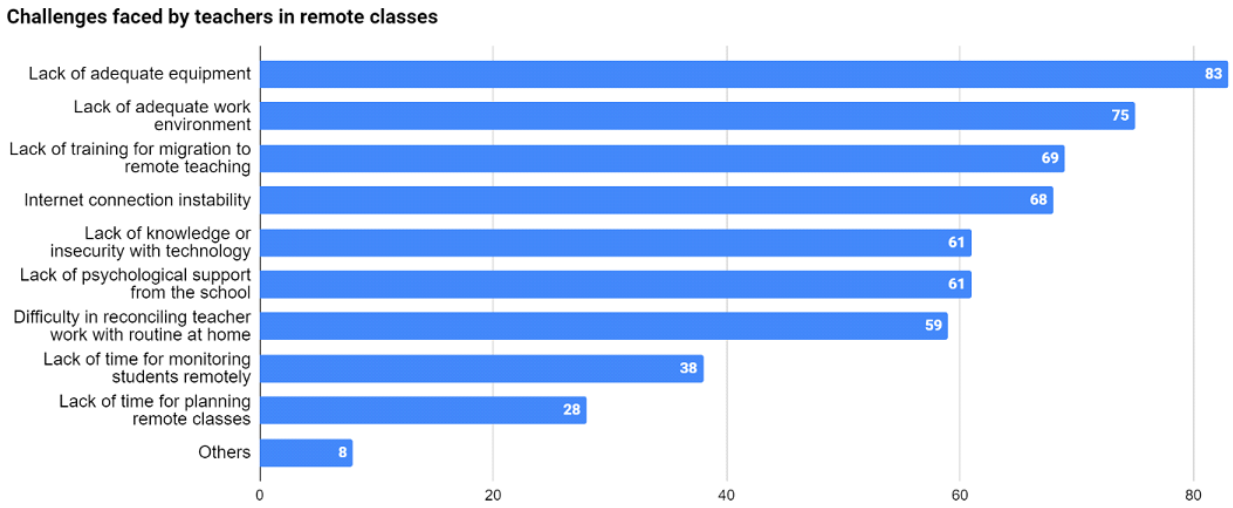

Figure 6. Challenges faced by teachers

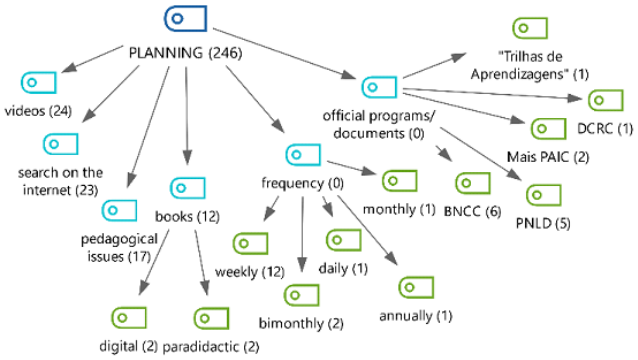

Figure 7. Categories and subcategories of coded segments

Table 1. Coded segments as categories of feedbacks

Category	Private	Public	Other	Total
Positive	15	77	7	99
Negative	29	96	9	134
Suggestions	10	97	6	113
No classification	0	13	1	14
Total	54	283	23	360

teachers were from public schools, there were more coded segments from this group. The number of negative feedbacks and suggestions were close to public school teachers, on the other hand, proportionally, private school teachers provided more negative feedback than positive or suggestions.

Figure 8 presents all categories identified during the content analysis. Regarding "positive feedbacks", 22 teachers reported that parents praised the attention of teachers with their children. Regarding "negative feedback", the most frequent complaints were "lack of internet connection" (16) and "lack of time" (11).

Regarding suggestions, the number of teachers who suggested that equipment and internet should be provide to students was significantly high. The open-ended questions allowed us to learn a lot about the real context of remote teaching, as can be seen in the selected reports bellow:

- *"They [parents] surprised me with compliments and congratulations for what I've been performing even with so many difficulties"*
- *"[The parents say] that the children did not learn in the in-person classes, imagine now [in the remote ones]."*
- *"Some illiterate parents complain that they cannot assist their children in their tasks."*
- *"I'd love to know how to improve this situation of students' lack of attention and minimal participation in the classes, but, unfortunately, I do not know how. It's hard to know what teenagers expect from a remote class."*

4.2 Survey with Parents

Besides the survey with teachers, we have also prepared an online form to be applied with children's parents or legal guardians. The main demographic data of the sample are:

- Gender: 88,7% (126) female and 11,3% (16) male, other genders were not mentioned.
- Age: 33% (47) of the respondents were between 36 and 40 years old; 33% (47) were between 41 and 50 years old; 18,3% (26) were between 31 and 35 years old; and 15,5% (22) were other age ranges.
- Location: 12 Brazilian states were mentioned; 62% (88) of the respondents were from Ceará; 17% (24) from São Paulo; 5% (7) from Paraíba; 16% (23) from the other 9 states mentioned in the survey (Rio Grande do Sul, Rio de Janeiro, Minas Gerais, Santa Catarina, Tocantins, Distrito Federal, Piauí, Rio Grande do Norte and Bahia).

Now, regarding the problems and challenges faced by parents, Figure 9 describes the kinds of support given by students' parents or guardians. The two most frequent answers correspond to low levels of support, however, the higher levels of support ("The child does not just stand still and I have to take him or her back to class" and "I stand beside or with the child on my lap for the whole class") were mentioned by 17% (24) of the respondents. Parents also reported the challenges, in their view, faced by the students (Figure 10).

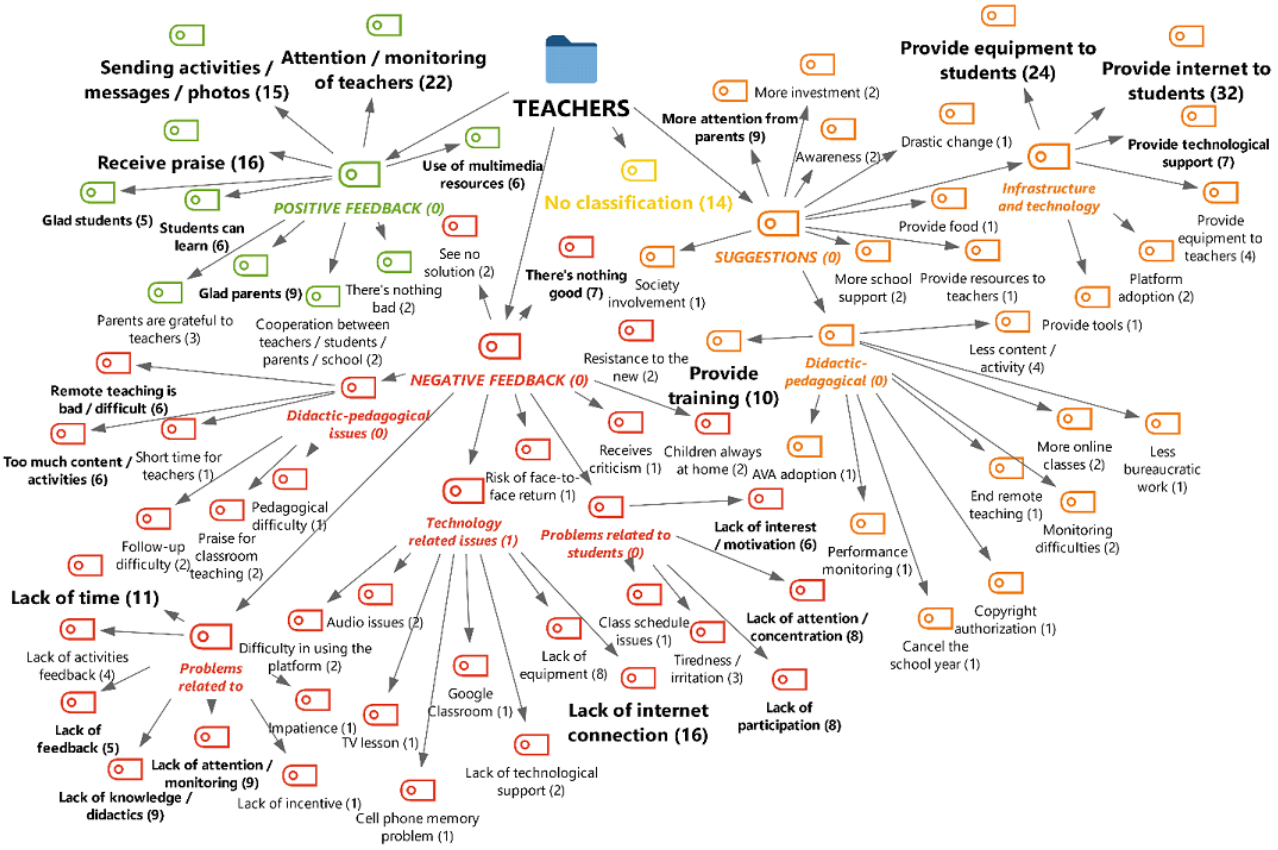

Figure 8. Categories of positive feedback, negative feedback, and suggestions. The items in bold highlight codes with at least 5 segments of text and items in bold larger text font highlight codes with at least 10 segments of text.

The most frequent problems were: "Lack of focus" (49%; 70), "Lack of interest" (37%; 53), "Tiredness" and "Stress" (32,4%; 46). Finally, in the parents' point of view, remote classes bring them high levels of stress (Figure 11): 24% (35) rated 4; 19,7% (28) rated 5; and 21% (30) rated 6, which is a total of 65% of people rating their stress in the three higher levels.

Now, regarding the open-ended questions "What do you think could be done to improve the remote teaching?" and "Leave here a comment that you think is relevant about the experience with emergency remote education", during the content analysis, 94 documents (individual form responses) were considered, 84 codes were created, and 1102 segments were coded. There are 30 different categories of codes related to "problems", 35 categories related to "suggestions" and 6 categories related to "comments". For the sake of space, Table 2 only presents codes with at least three occurrences. For suggestions, we highlight "more attractive classes" and "shorter classes". For problems, many parents reported the dependency of children during the class, complained about the remote teaching and the overload. For general comments, we highlight the high number of compliments for teachers, schools, and the remote teaching.

As with teachers, this survey with parents brought meaningful insights on the reality of Brazilian homes passing through remote teaching. The following parents' comments illustrate some of their positive and negative opinions:

- "Children don't focus even on in-person classes, much less in remote classes."
- "Simpler access tools [are needed], so that the child can access the class alone, thus removing the need for an adult to assist them every hour."
- "In general, I see teachers pretending to teach and students pretending to learn. It is not about difficulties with the technologies used, but a lack of interest, even in teaching a good class. […]. I feel like the whole responsibility has been transferred to the family and I don't see an approximation of school management or teachers in promoting an effective learning."
- "I feel like [it's] a lost year [in terms] of content but rich [in terms] of knowledge of life and family contact"
- "Teachers are reinventing themselves. This challenge can bring new ideas to the future. We should not demand that much, no one was prepared for such radical change so quickly."
- "Hopefully [this will] pass soon"

4.3 User Diary Study with Students

Seven children of different ages participated in the diary study, whose profiles are described in the Table 3.

The first interesting information gathered from the user diary study is related to the loss of interest in the classes. There was a light balance, since 12 out of 25 (48%) of the diary entries registered the loss of interest in less than 30 minutes of class and 10 out of 25 (40%) of the entries registered no loss of interest at all.

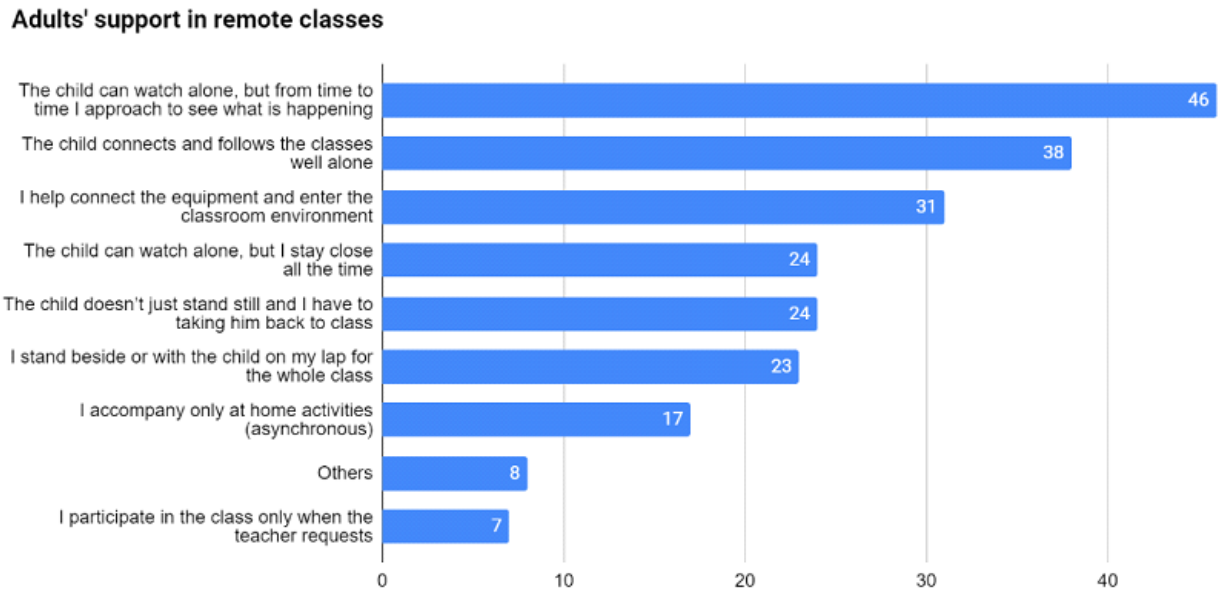

Figure 9. Support given by parents

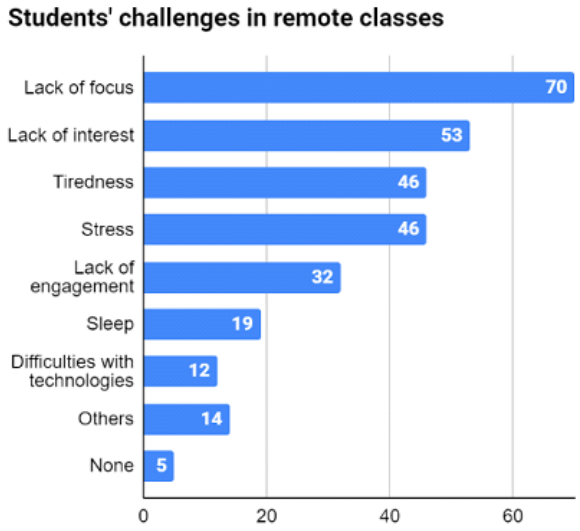

Figure 10. Students' challenges reported by parents

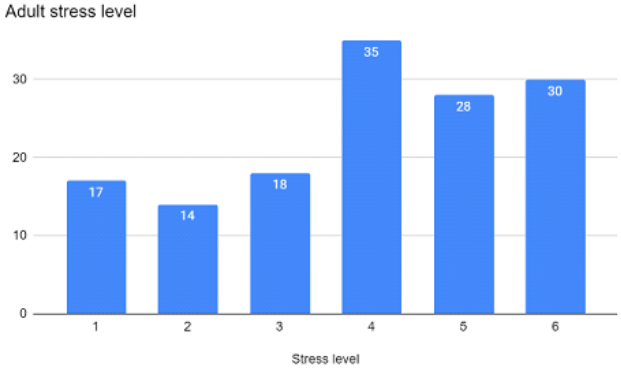

Figure 11. Parents' level of stress in remote classes

Table 2. Codes of the categories "suggestions", "problems", and "comments"

Code	#	Code	#
Suggestions		**Problems**	
More attractive classes	20	Adult dependence	11
Shorter classes	13	Remote is bad	7
Training	9	Overload	7
Support from school	5	Lack of concentration	6
More interaction	5	Too many activities	4
More preparation	5	Lack of learning	4
Radical change	4	No synchronous lessons	4
Audiovisual resources	3	Unsuitable for age	4
Access for everyone	3	Stress	4
Individual education	3	Children's tiredness	3
Equipment for teachers	3	Lack of time	3
More teacher support	3	**Comments**	
More organization	3	Compliment	19
Fewer activities	3	Face-to-face is better	4
There's nothing bad about it.	3	Better remote than nothing	4
		No classification	4

The participants of the study were asked to register the feelings and behaviors of students each day. Then, it was possible to relate positive and negative behaviors with the kind of classes and the subjects of the day.

Table 4 and Table 5 present the average grade of each behavior or feeling, considering all students' entries, according to class subjects and activities. The scores vary from 1 to 6, so the higher the score in positive behaviors the better, whereas the higher scores in negative behaviors the worse. The numbers between parentheses in the first column of both tables indicate the amount of diary entries that mentioned the given information. For example, 18 out of the 28 diary entries (64%) refer to Language classes (Portuguese, Foreign Languages, Arts and Physical Education), as seen in Table 4, and also 18

diary entries registered classes with exercises and practical tasks (Table 5).

Table 3. Diary study's participants profile

	Age	School	Entries	Pictures
S1	6	private	5	0
S2	14	public	5	1
S3	11	private	5	3
S4	8	private	5	0
S5	6	private	4	0
S6	9	private	2	2
S7	5	private	2	0

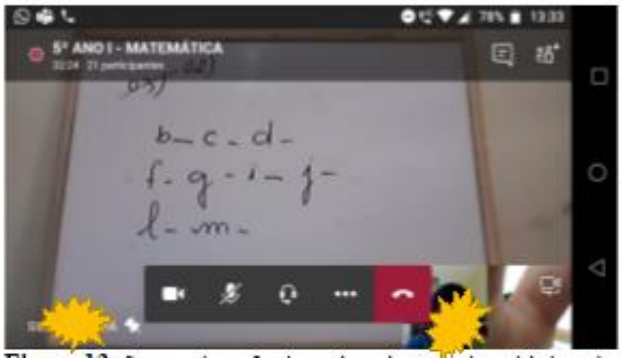

Figure 12. Screenshot of a class taught in an ordinary whiteboard, adapted to remote teaching

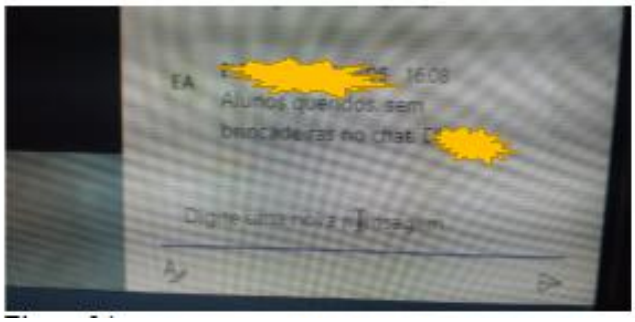

Figure 13. The teacher asked for the students' attention: "Dear students, stop playing in the chat."

In both tables, the values in bold are those with the best results for each behavior, and the values in italics highlight the worst averages. In general, the negative behaviors got low scores, meaning they were not so severe. In Table 4, the subject that scored higher in more positive behaviors was Natural Sciences with the best grades in Focus, Interest, and Concentration. On the other hand, Religious Education got the lower scores in all positive behaviors/feelings and the higher scores in the negative side of the table.

In Table 5, the type of class with the best scores was those that presented exercises and tasks to the students, surprisingly, it was this type of class that scored higher in Anxiety. Another not expected result was the low scores regarding the use of Music in class compared to the other items. Besides these quantitative data, the diaries brought additional qualitative information on the kids' study routine and problems. Some reports were extraordinarily rich and detailed. For example, S1's parent reported other types of behaviors that the child had during classes such as: performing other types of activities, frustration at not being able to perform the activity, restlessness, and need of communication. According to him, the only day that the child was more concentrated and did not request attention was the last day of registration.

Figure 14. Student following the lesson in the phone and taking notes in the notebook

S3's parent reported the kid liked most the classes about Brazil's History, about Amazon, and one class where he produced a poster on the importance of saving water. The same kid disliked a video lesson on Physical Education and a Math activity that was very tiring. In the last day, the participant reported that "the internet connection was lost and it was not possible for the math teacher to explain the whole subject."

S4 had a week of classes full of highs and lows. On the first day, according to his mother, "he answered that he didn't like anything about the class"; on the second day, he liked the exercises that he did alone and focused, and disliked the delay in correcting the exercises; on the fifth day, he liked drawing but disliked "having to talk during class".

Finally, the participants provided 6 pictures: 3 of the S3's online classes screens (Figure 12, Figure 13); 2 of S6's printed exams; and one of S2 studying through his phone (Figure 14). Despite this being a small number of pictures, they represent the reality of many homes in the emergency remote teaching.

4.4 Personas

From all the knowledge acquired from field research we defined eleven personas in the project[17]. The main information about them are described in Table 6.

In Figure 15, there are three examples of the personas cards, one to each group of personas. Leila Gomes is the teacher of Lucca Barbosa who is Cláudia Barbosa's son.

Bellow, we have the detailed description of these three personas:

Persona - Teacher

- Name: Leila Gomes
- Phrase: "Nothing replaces classroom teaching."
- Age: 42 years
- Type of School: Private
- School level: Preschool
- Goals:
  - Create playful content.
  - Successfully monitor the students.

[17] You can see the 11 personas here: https://bit.ly/3kEd5z9

Table 4. Positive and negative behaviors according to class subjects.

	Positive behaviors/feelings					Negative behaviors/feelings				
	Focus	Interest	Concen-tration	Motivation	Mood	Sleep	Stress	Tiredness	Anxiety	Embarrass-ment
Languages (18)	4.33	4.44	4.28	4.33	4.44	1.15	1.23	1.08	2.13	1.64
Mathematics (9)	4.11	4.33	3.89	4.56	4.56	1.13	*1.25*	1.50	2.50	1.50
Human Sciences (7)	4.57	**4.57**	**4.43**	4.43	4.57	*1.50*	**1.00**	1.17	**1.17**	1.57
Natural Sciences (7)	**4.86**	**4.57**	**4.43**	4.00	4.29	1.17	**1.00**	**1.00**	1.71	**1.00**
Religion (3)	*2.67*	*2.67*	*2.67*	*2.33*	*4.00*	**1.00**	**1.00**	*2.00*	*2.67*	*2.50*
Extracurricular (6)	3.83	4.17	3.83	**4.67**	**4.83**	1.25	*1.25*	*2.00*	1.83	1.25

Table 5. Positive and negative behaviors according to class activities.

	Positive behaviors/feelings					Negative behaviors/feelings				
	Focus	Interest	Concen-tration	Motivation	Mood	Sleep	Stress	Tiredness	Anxiety	Embarrass-ment
Exercise / tasks (18)	4.50	**4.50**	**4.33**	**4.33**	**4.56**	1.13	1.13	1.27	*2.12*	1.29
Theory (13)	**4.54**	4.38	4.23	4.31	4.46	1.38	1.08	1.31	2.08	**1.25**
Reading (9)	4.33	4.11	4.00	4.22	4.22	1.29	1.14	*1.57*	1.78	1.43
Drawings (7)	2.86	3.00	2.71	3.71	4.43	*1.57*	1.14	*1.57*	1.29	*2.14*
Music (6)	*2.83*	*2.83*	*2.67*	*3.33*	*3.67*	1.50	1.17	**1.00**	**1.00**	2.00
Physical activities (4)	4.00	4.00	4.00	4.25	4.25	**1.00**	*1.33*	**1.00**	1.25	1.33
Other activities (4)	3.50	3.50	3.50	3.50	4.00	**1.00**	**1.00**	**1.00**	1.25	2.00

Table 6. List of personas

Name	Age	School and level
Teachers		
Antônio Sampaio	51	Public, middle
Luísa Dias	37	Public, elementary
José Alberto Leão	29	Private, elementary
Students		
Lucca Barbosa	6	Private, kindergarten
Ana Clara Santos	8	Public, 3rd grade
Iury Azevedo	9	Private, 4th grade
Alana Rodrigues	11	Public, 6th grade
Parents / guardians		
Cláudia Barbosa (mother)	32	Private, elementary
Vicente Alencar (father)	29	Public, elementary
Caio Rodrigues (brother)	20	Public, middle

- Frustrations
  - Children's lack of interest in the classes.
  - Frequent complaints from parents.
- Class type: Synchronous, use of games and use of music
- Technologies: WhatsApp, YouTube, Google Meet
- Skills (from 1 to 10):
  - Aptitude with technology: 6
  - Teaching experience: 7
  - Adaptability: 4
- Remote classes (from 1 to 10):
  - Student participation: 5
  - Support from parents: 8
  - Individual support: 6

Persona - Student

- Name: Lucca Barbosa
- Phrase: "Loves music and dance classes."

Figure 15. Personas Leila Gomes, Lucca Barbosa and Cláudia Bar-bosa

- Age: 6 years
- Type of School: Private
- School grade: Kindergarten
- Goals:
  - Learning to read and write.
  - Play ball on the playground again.
- Frustrations
  - Need his mother support to attend the classes.
  - Learning literacy remotely.
  - Spend the entire class sitting.

  - Being away from friends.

- Class type: Synchronous
- Class time: 2 hours
- Used device: Notebook
- Behaviors (from 1 to 10):
  - Concentration: 3
  - Learning: 8
  - Disposition: 4
  - Anxiety: 3
  - Stress: 2

Persona - Parent:

- Name: Cláudia Barbosa
- Phrase: "The children did not learn with in-person classes, imagine now."
- Kindship: mother
- Age: 32
- Responsible for: Lucca, Kindergarten; and Lunna, fourth grade
- Type of School: Private
- Goals:
  - She really wants the return of in-person classes, because the children don't learn and she gets very tired.
- Frustrations
  - Lucca can't be alone during class.
  - I can't keep up with Lunna's activities.
  - Teachers demand a lot of activities.
- Challenges of remote teaching (from 1 to 10):
  - Stress level: 8
  - Time to support children: 5
- Skills (from 1 to 10)
  - Aptitude with technology: 4
  - Didactics: 3

5 Results of "Synthesis of the Intervention"

After the field research and the creation of personas, we move on to the next step, which is to conceive a digital solution proposal. In this step, we performed a brainstorming session, identified the requirements, modeled the interaction and built a first low-fidelity prototype.

5.1 Brainstorming

The brainstorming session, even with relatively few participants (7), was very productive. They created 67 different ideas cards. After analyzing these cards, we identified 47 different ideas, and organized them in 8 big categories. Table 7 presents the list of generated ideas with the number of cards they were suggested in, and the total of votes each idea has received by the participants. Many of the most voted ideas became requirements to the project.

Table 7. Categories of ideas, cards and votes.

Categories of ideas		Cards	Votes
Pedagogical aspects	Micro classes	5	11
	Active methodologies	1	2
	Meaningful learning	2	1
	Language	3	1
	Goals	2	1
	PBL	1	1
	"Hand in pocket" pedagogy	1	1
	Not tiring learning	1	0
	Formative evaluation	1	0
	Planning	1	0
	Total	18	18
Features	Augmented reality	2	6
	Animation	1	3
	Repositories	1	3
	Customization	2	2
	Teaching plan	1	2
	Video call	2	2
	Pomodoro	1	1
	Automation	1	0
	Chat	1	0
	Total	13	19
Social interaction	Collaboration	3	7
	Interaction	1	5
	Socialization	2	3
	Group work	3	1
	Total	10	16
Interface and interaction	User-friendly interface	3	4
	Playful interface	1	4
	Simple interface	3	2
	Fluid interaction	1	0
	Total	8	10
For tech lay people		1	1
For parents		6	4
Technical aspects	Online	4	6
	Offline	1	3
	Hardware	1	0
	Total	6	9
No classification		3	3
Content type	Gamification and games	10	13
	Everyday life contents	4	6
	Practical	1	5
	Interactive	2	3
	Playful	3	3
	Simulation	2	3
	Asynchronous	1	1
	Interdisciplinary	1	1
	Environment	1	1
	Activities	4	0
	Concrete	2	0
	Music	1	0
	Total	32	36
TOTAL		97	115

5.2 Project Requirements

The field research with teachers, parents and students and the brainstorming session were the main sources of requirements to the digital solution proposed in this project. After these steps and taking advantage of a gap in the application of Augmented Reality in educational software drive for children, we defined the general requirements that guided the next steps. Table 8 presents the list of these requirements and identifies their source.

The design concept for the solution is a mobile application that allows kid students to explore their own houses as a source of knowledge of various fields. We, as designers, aim to make the kids "get up from their chairs" and "walk around", carrying out the challenges proposed by the app and receiving rewards in augmented reality in return.

In order to involve the parents, most of the challenges are supposed to be verified by them, and after that, if everything is ok, the kid will receive a virtual object as reward. Table 9 presents details about content and information that will be explored in the app. To make things clearer, consider this example of a simple challenge: "Find a cylindrical object in the kitchen". The kid must find it, take a picture, and send to evaluation. She may ask a parent in the house to check her response or may send a link to a teacher (or another adult) and ask him or her to check it. In both cases, the app will verify if he/she is an adult and allow the verification. After the activity is verified, the kid will receive a random virtual object to be projected by augmented reality in the real environment. For example, she may receive a boat and virtually put it in the kitchen sink, take a picture and share it to friends and family.

5.2.1 Interaction Modelling

After defining the requirements, we defined the interaction or, in other words, to the modelling of the navigation and interaction flows.

We employed the MoLIC (Modelling Language of Interaction as Conversation), which is useful to represent diagrammatically all the possible dialogues between the user and the designers' proxy during the interaction.

We have created the entire conversation to the entrance in the app to the application, sharing and exchange of rewards. Figure 16 shows all the main flow of the app.

5.2.2 Low-Fidelity Prototype

The next step was to design a low-fidelity prototype following the established conversations in the MoLIC diagram.

The prototype works as follows:

- the user performs a basic registration, informing the name, grade and age
- the user chooses a game mode (surprise, by story or by the house part)
- the user spins the roulette wheel and a challenge is drawn.
- the user performs the challenge as requested in the statement. (in the case of the prototype, you are asked to take a photo of a cylindrical object in the kitchen)
- the system simulates the correction of the challenge and the user is taken to the prize draw screen (in the prototype it is a helicopter)
- the user simulates the application of the figure in the kitchen
- the user can visit the album screen (where he can see the possibility of changing the sticker)
- the user can visit the profile screen (where he can follow the progress in the game)

The prototype was developed with 33 screens[18]. The screens relative to the activity review and the exchange of rewards were not developed, because the design team has not decided yet how to present these features. The prototype, being of low fidelity, was made in shades of gray, with icons and illustrations only of the basic functions or essential for understanding. There is also an indication of non-implemented screens or with elements not yet defined.

In this version of the prototype, it was possible to apply the following initial requirements (see the complete list of requirements in the Table 8):

- 2. The system must display gamification elements or games
- 4. The system should have a playful, simple, user-friendly interface
- 7. Content with short, specific themes.
- 8. Practical content and related to student's day-to-day.
- 9. Content that explores people, environments, and objects from the house.
- 10.Content that explores augmented reality as awards.
- 11.Contents for elementary school (1st to 5th grade).

Figures 17, 18 and 19 present three of the prototype's screens.

6 Results of "Evaluation of the Intervention"

The prototype was evaluated by ten children in November 2020, in two Brazilian cities, Fortaleza, capital of Ceará, and Quixadá, an inland city with about 80,000 inhabitants.

Before that, we performed a pilot test with a 9-year-old boy. The main contributions of the pilot were the thoughts on how to explain what a prototype means, the way of conducting the prototype demonstration, and the anticipation of the first part of the interview to be performed before the interaction with the prototype.

Table 10 presents the children profile. Only C1's classes had already gone back to school. All the children from public schools were not having synchronous or video classes, they only receive materials and exercises by the teachers by WhatsApp few times a week.

C7 explained how it works: *"I'm not going to school; I'm studying on my cell phone. The teacher sends the task, then he waits for people to copy, then as soon as you finish copying you answer and after you answer, then you send [it back to*

[18]Here you can see a pdf with all the screens developed for the test: https://bit.ly/3wJxnw6

Table 8. Initial application requirements.

#	Requirements	FR	BS	LM
1	The system must be a native mobile multi-platform app	x	x	
2	The system must display gamification elements or games.		x	x
3	The system should allow collaboration and interaction between students and the teacher.	x	x	
4	The system should have a playful, simple, user-friendly interface		x	
5	The system should allow offline operation (online for synchronization and interaction only).	x		
6	The system should contribute to increasing children's motivation and engagement in classes/activities.	x		
7	Content with short, specific themes.		x	
8	Practical content and related to student's day-to-day.		x	
9	Content that exploits people, environments, and objects from the house.	x	x	
10	Content that explores augmented reality as awards.		x	x
11	Contents for elementary school (1st to 5th grade).	x		x

FR = Field research | BS = Brainstorming | LM = Literature mapping

Table 9. Information and content of the App

Activities		**House elements**
Subjects		rooms
Languages		people
Mathematics		objects
Natural Sciences		**House rooms**
Human and Social Sciences		*Living room*
School levels	*Format*	objects
1º year	video	characteristics
2º year	picture	*Bedroom*
3º year	audio	objects
4º year	text	characteristics
5º year		*Kitchen*
Users		objects
Students		characteristics
performs activities		*Bathroom*
delivers activities		objects
receives reward		characteristics
apply rewards		*Outside*
shares rewards		objects
Teachers		characteristics
check activity by link		**Rewards**
release reward		virtual objects
Parents		customization of rooms
check activities by password		characters
release reward		animations

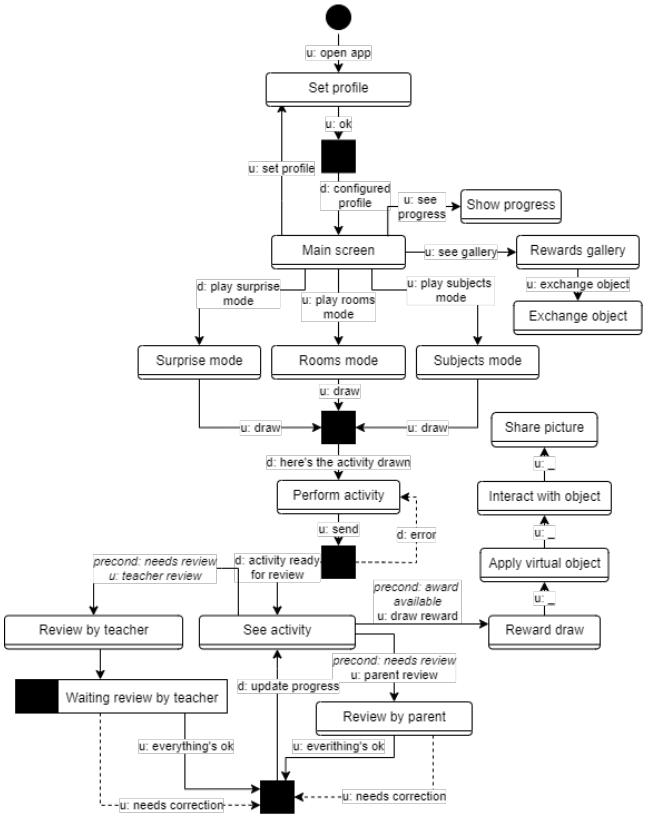

Figure 16. MoLIC diagram of the APP

him]. I copy in the notebook, [do the homework]and then take a photo and send."

During the first part of the interview, participants informed the subjects they like and dislike the most (Table 11). Math and Portuguese were the most cited subjects. There were few subjects cited as disliked (Math, English, and Religion).

C1 and C3 mentioned to like all subjects; C9 affirmed to not like neither subjects; C2, C3 and C4 affirmed to not dislike either subjects. C5 affirmed to like text composition but dislike grammar.

We also asked the children about how they spend time. Table 12 lists all their answers on the preferred plays, cartoons, and movies and Table 13 lists the preferred videogames and how much time they pass playing a day. Among us, Minecraft and Talking Tom were mentioned by two or more children.

Table 14 presents the house rooms and spots that children spend more and less time. Living room and bedroom are the preferred rooms whereas the kitchen and backyards are the spots less frequented by children. C3 explained why he did not spend time in the kitchen: *"Kitchen, I'm not going much [there]. My parents say the stove is dangerous because the house can burn."*. C7 said: *"My bedroom, because my bed is a bunk bed and I stay at the top and it is very hot there."* C9 dislike the bathroom *"because it is very horrible"*.

We asked children what they liked and disliked in the remote teaching. Some of the speeches are: (C1) *"I did not like [the remote classes], because we might not do anything, we just stood there watching [the teacher]. It's better at school."*; (C2) *"It's been a long time with these video classes. I like it, but I think I prefer to go to school.[...] I miss my friends,[I*

Figure 17. Surprise mode: in roulette, the drawing of the level (medium), the room (kitchen) and the subject of the activity/challenge (Maths)

Figure 18. Activity/challenge: "Take a picture of a cylindrical object in the kitchen"

Figure 19. Applying the AR object (reward) in the kitchen

Table 10. Participants profile

ID	Gender	Age	School	City	Classes
C1	F	6	Private	Fortaleza	At school
C2	F	10	Private	Fortaleza	Remote
C3	M	8	Private	Fortaleza	Hybrid
C4	M	8	Private	Fortaleza	Remote
C5	F	9	Private	Quixadá	Remote
C6	M	8	Private	Quixadá	Remote
C7	M	11	Public	Quixadá	WhatsApp
C8	M	9	Public	Quixadá	WhatsApp
C9	F	6	Public	Quixadá	WhatsApp
C10	F	7	Public	Quixadá	WhatsApp

Table 11. Subjects children like and dislike most

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Mathematics	X		X	X	O	X	X			O
Portuguese		X	X		XO		X	X		
Art		X			X					X
Science			X		X					
English	X	X				O				
Geography			X							
Religion							O			
All	X		X							
Neither		O	O	O					X	

X = like | O = dislike

Table 12. How children have fun and spend time.

ID	Plays	Cartoons or movies
C1	swing	Barbie.
C2	doll, cooking, tag, hide-and-seek	The Amazing World of Gumball.
C3	Lego, Hot Wheels, Monster trucks, doll	Spiderman, Teen Titans, and Aquaman.
C4	—	"I watch more YouTube"
C5	hide-and-seek, freeze tag, tag	Umbrella Academy, How to train your dragon, and Imperfect dancer.
C6	ball, sword, bicycle	Ben10.
C7	—	"I watch on television."
C8	doll, cars, football	Woody Woodpecker.
C9	doll	Peppa Pig, Tom and Jerry, and Chucky.
C10	hide-and-seek, Barbie	Mia and Me .

Table 13. Preferred games and time playing.

ID	Games	Time
C1	Barbie, Peppa Pig	3
C2	Talking Tom, BK-XD	2
C3	"little snake game", "blocks game"	1
C4	Among us, Minecraft	1
C5	Among us	1
C6	Among us, Bad wars, Dragon city	3
C7	Among us, Minecraft, Free fire	3
C8	Minecraft, "car games"	3
C9	Gwen, "make hair game"	2
C10	Talking Tom, "little cat game"	1

Time playing games: 1 = little; 2 = moderate; 3 = a lot.

Table 14. Preferred spots at home.

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Living room		X		X	X				X	X
Bedroom	X		X			X	O	X		
Terrace							X			
Kitchen			O					O		O
Backyard		O			O					
Stairs	O									
Bathroom									O	
Neither				O		O				

X = more time | O = less time

miss] talking to the teacher."; (C3) *"I like to go to normal school, but the annoying thing is to wear a mask."*; (C5) *"I prefer school a thousand times. The other students get in the way of online classes."*; (C6) *"[I don't like] people screaming when the teacher is explaining."*; (C7) *"[In remote, I like] only the exams [with Google Forms], because the rest is tiring. [I don't like] to solve the activities by myself. [I miss] the classroom lessons, and classmates too"*; (C9) *"I studied only once by cell phone. I didn't get the books from the school and I'm not doing the homework because I don't like to study. I don't like to study, I'm very angry, I don't have a clean sheet [in the notebook]. I don't like the new school."*

Participants also talked about what was possible to learn from home or what they have already learned inside home. C5, C7, C10 mentioned how to cook; C1 learned *"words in the bathroom with the syllable game"*; C2 learned *"translate English words on Kindle"*; C3, C4, C8 and C9 did not know how to answer. About cooking, the answers were: (C5) *"Yes, food recipes, I've learned 4."*; (C7) *"[I can cook] beans, rice, pasta, fish... My grandmother taught it."*; (C10) *"I learned how to make mousse"*. Crossing this information with Table 14, we see that C10 mention the kitchen as a place to learn (to cook) even it is the spot in the house less frequented by her.

Regarding the children's' experience with the prototype, Table 15 details how each child interacts with the prototype in terms of support given by the evaluator. C2, C5, C6 and C7 interacted with all screens without difficulties and support. C8 and C9 needed support in almost all screens. In all screens, there were at least one child who needed support. The screens that demanded less support were "activity photo" (the user take a photo of a cylindrical object found in the kitchen), "surprise" (the first screen to start the surprise mode of game), "congrats" (a pop up congratulating the user for the achievement) and "award draw" (the user see the helicopter drawn as award). The screens that demanded more support were "login" (a form with the fields name, school year and age) and "correction" (a pop up explaining that this feature was not done yet).

Other useful information is the level of comprehension of the prototype screens (Table 16). We defined a scale of 1 to 6 for little to high comprehension, set according to the facial expressions, behaviors, doubts, and ways of interaction observed in each participant. According to the table, 5 children showed good levels of comprehension; three of them showed moderate level and two of them (C8 and C9) poor level of comprehension. These two last ones also needed support to interact with the prototype (Table 15). The screen "activity photo" get the best average of comprehension and all the other screens get moderate levels of comprehension. The "review" screen got the lower level of comprehension.

Table 15. Interaction with prototype.

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Login	P	N	N	N	N	N	N	T	T	T
Home	N	N	N	P	N	N	N	P	P	P
Surprise	N	N	N	P	N	N	N	N	P	N
Surprise 2	P	N	N	P	N	N	N	P	N	P
Question	P	N	N	P	N	N	N	P	N	N
Activity photo	N	N	N	N	N	N	N	N	P	N
Review	N	N	P	P	N	N	N	P	P	P
Congrats	N	N	N	P	N	N	N	P	N	N
Award draw	N	N	N	N	N	N	N	P	P	N
Award applied	N	N	N	N	N	N	N	T	P	N

N = no help | P = partial help | T = total help

Table 16. Levels of comprehension

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	Av.
Login	1	6	5	5	6	6	6	1	1	3	4
Home	3	5	5	5	5	6	6	3	4	2	4.4
Surprise	5	5	2	1	6	6	6	5	1	3	4
Surprise 2	2	4	5	4	6	6	6	1	5	4	4.3
Question	2	6	6	3	6	6	6	1	2	5	4.3
Activity ph.	5	6	6	5	6	6	6	4	3	5	5.2
Review	3	6	5	2	6	5	6	1	2	2	3.8
Congrats	6	6	6	4	6	6	6	1	3	4	4.8
Award draw	3	6	6	5	6	6	6	2	2	3	4.5
Award ap.	4	6	6	5	6	6	6	1	4	4	4.8
Average	3.4	5.6	5.2	3.9	5.9	5.9	6	2	2.7	3.5	

By watching the recorded interaction video was possible to note the emotions and feelings that came through during the interaction with the prototype (Table 17). Most of the participants seemed to be interested or indifferent in the most part of time. One exception was C8, who was embarrassed and apprehensive during all the time. The children showed more confused and apprehensive in "Home" and "Review" screens. Four children showed thoughtful in the "Question" screen.

After participants follow the main flow (draw, question, award), they were invited to freely explore other app features. Five children tried first the other game modes and two ones tried first the album screen. Other screens tested by them in different orders were Profile, Camera and Review.

Finally, regarding the suggestions to improve the app, the most frequent ones were: to change the app color (7x), to provide more awards (4x), to use images to decorate the game modes (4x), to provide more characters options (3x). Some of the participants' ideas of awards were: a car, an airplane, frames to decorate, changing wallpapers, a teddy bear, a heart, a flower, a pen, a helmet, a chair, a table. C7 suggested *"Avatars could be some kind of superhero, says Captain America, Wonder Woman... Just add more superheroes so that the person doesn't get bored*. Other interesting suggestions were: to provide house decoration awards; to show the

outline of the awards that was not won yet; the name of the app (C3 suggested "House explorer game"). As a sample of the richness of suggestions, take C5's speech: *"It must be improved first. The panel changing colors, very colorful; The avatar must have a boy, a girl; [You may] put the roulette wheel to illustrate the surprise mode, in the subjects [mode] there could be several blocks with the subjects, in the room [mode], put the living room because it is the first thing in the house; I like colors, it has to be colorful."*

Table 17. Participants' emotions and feelings

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	R
Login	😨	😐	🙂	😐	🙂	🙂	🙂	😨	😵	😵	🙂
Home	😨	😐	😳	😨	😳	🙂	🙂	😳	🙂	🤔	🙂
Surprise	😐	🙂	😐	😐	😐	🙂	🙂	😨	🙂	😐	😐
Surprise 2	😐	🙂	🙂	😐	🙂	😐	😐	😨	🙂	😳	🙂
Question	😵	🙂	🤔	😨	🤔	🙂	🤔	😨	😵	😵	🤔
Activity ph.	😐	😐	🙂	😐	🙂	🙂	🙂	😳	😐	😐	😐
Review	😵	🙂	😐	😨	😳	😳	😐	😨	😐	😐	😐
Congrats	😐	🤔	🙂	🙂	🙂	🙂	😐	😨	🙂	😐	🙂
Award draw	🤔	🤔	🙂	😐	🙂	🙂	😐	😳	🙂	🙂	🙂
Award ap.	🙂	🙂	🙂	😐	🙂	🙂	🙂	😨	🙂	🙂	🙂
Recurring	😐	🙂	🙂	😐	🙂	🙂	🙂	😨	🙂	😐	

🙂 Interested 😵 Distracted 😨 Apprehensive 😳 Confused
😐 Indifferent 🤔 Thoughtful 😳 Embarrassed

7 Contributions and Conclusion

In this paper, we described the whole process of the design of an educational mobile application, in the form of a low-fidelity prototype, from the field research to the prototype evaluation.

The field research was crucial to learn a few about the reality of teachers, parents, and children in the current remote mode of teaching due to the Covid-19 pandemic. By the surveys and diaries, we learned the importance of internet and computer infrastructure, specially to public school students. We noted that in some cases, teachers blame the parents (for not giving attention to students) and the parents blame the teachers (for too much content). Students stand "in the middle of the crossfire", distant from the classmates and teachers, having to deal with ways of learning they were not used to. The field research resulted in the creation of the nine personas who inspired the creative and collaborative work done during the brainstorming session.

The lessons learned from the field research and brainstorming session allowed us to conceive a digital product to reframe the process of learning at home, by giving a new meaning to the children's own houses[19]. The prototype evaluation showed us the potential of exploring the house as source of knowledge and fun. All participants (except C8) demonstrated excitement in wining prizes that can be applied in their houses' rooms. The positive points of the prototype were: the use of awards; the use of the camera; the application of virtual objects in environments; and the exploration of home environments. The negative points were: use of text in the interface; grayscale interface; login and progress screens.

Some challenges in performing the evaluation were: explain to children what a prototype means; have a productive dialog with younger and shy children.

As contributions we highlight firstly the richness of the collected data, informing about the reality of teachers, parents and students that took part in this study. We did not intend to work with a statistically significant sample, however, there is no doubt that much of what we found here faithfully represents most part of Brazilian people with similar profiles.

The second contribution is a real example of how to make user-centered interaction design even in the middle of a pandemic. Children were considered throughout the project, from by studying design for kids to field research: indirectly, through the reports of parents and teachers, and directly, in the study with use diaries and with the evaluation of the prototype. We have applied remote user research techniques like online forms, user diaries and online brainstorming, besides all the research and design teams intensively working fully remotely for about six months.

The third contribution is the research methods and findings around designing for kids. We had to adapt the way of conducting the study according to the participants' ages. We also learned the importance of the presence of the parent during the study to encourage kids to speak and complete missing information. We could put in practice the respect to the limit of each kid, according to his/her level of interest and shyness.

We have already started the development of the app, following all the lessons learned until here. Besides that, it will be necessary to involve basic education specialists to create the app content according to the school levels and subjects. We will also need designers to develop the app visual identity, user interface, and virtual objects. We plan to develop a fully functional proof-of-concept to be evaluated in the next months by parents and children [20]. We also plan to incorporate accessibility features such as audio description of images (in the challenges content), auto-contrast and font adjustment, and Libra translation. A future possibility is to create a platform in which teachers will be able to create their own content to be accessed by students through the app.

Finally, even though the app was conceived in the context of Covid-19 pandemic, we believe it has the potential to be fully used in the post-pandemic scenario, mainly because of its design concept of learn by home and with home.

Acknowledgements

We thank the volunteers that took part of the study.

References

Al-Razgan, M. S. and Alshaarri, S. (2019). Design and development of a mobile spelling game for elementary stu-

[19]The first version of the application was described by Monteiro et al. (2021)

[20]See more information in (Monteiro et al., 2021).

dents using genetic algorithms. *Proceedings of the 2019 11th International Conference on Education Technology and Computers*.

Azuma, R. (1997). A survey of augmented reality. *Presence: Teleoperators Virtual Environments*, 6:355–385.

Barbosa, S. D. J. and da Silva, B. S. (2014). Design da interação humano-computador com molic. *Livro dos Tutoriais do XIII Simpósio Brasileiro sobre Fatores Humanos em Sistemas Computacionais*, pages 109–138.

Barbosa, S. D. J., Silva, B. S. d., Silveira, M. S., Gasparini, I., Darin, T., and Barbosa, G. D. J. (2021). *Interação Humano-Computador e Experiência do Usuário*. Autopublicação.

Brasil (2013). Resolução nº 466, de 12 de dezembro de 2012: Dispõe sobre diretrizes e normas regulamentadoras de pesquisas envolvendo seres humanos. Diário Oficial da República Federativa do Brasil, Brasília, DF.

Brasil (2016). Resolução nº nº 510, de 07 de abril de 2016: Dispõe sobre as normas aplicáveis a pesquisas em ciências humanas e sociais cujos procedimentos metodológicos envolvam a utilização de dados diretamente obtidos com os participantes ou de informações identificáveis ou que possam acarretar riscos maiores do que os existentes na vida cotidiana. Diário Oficial da República Federativa do Brasil, Brasília, DF.

Carpenter, D., Cloude, E. B., Rowe, J. P., Azevedo, R., and Lester, J. C. (2021). Investigating student reflection during game-based learning in middle grades science. *LAK21: 11th International Learning Analytics and Knowledge Conference*.

Cash, W., Howland, K., Echavarria, K. R., and Samaroudi, M. (2020). Exploring children's everyday journeys with user-generated ar. In *Proceedings of the 2020 ACM Interaction Design and Children Conference: Extended Abstracts*, pages 308–313.

Chen, S. and Liu, S.-Y. (2020). Using augmented reality to experiment with elements in a chemistry course. *Comput. Hum. Behav.*, 111:106418.

Daniel, S. J. (2020). Education and the covid-19 pandemic. *Prospects*, pages 1–6.

Gaggi, O., Meneghello, F., Palazzi, C. E., and Pante, G. (2020). Learning how to recycle waste using a game. *Proceedings of the 6th EAI International Conference on Smart Objects and Technologies for Social Good*.

Gelman, D. L. (2014). *Design for kids: Digital products for playing and learning*. Rosenfeld Media.

Geroimenko, V. (2018). Augmented reality art. In *Springer Series on Cultural Computing*.

Gouin-Vallerand, C., Ferreira, S. M., and Hotte, R. (2018). Towards a mobile serious game environment for children self-learning. In *Goodtechs '18*.

Hodges, C., Moore, S., Lockee, B., Trust, T., and Bond, A. (2020). The difference between emergency remote teaching and online learning. *Educause Review*, 27.

Hsieh, Y.-H., Lin, Y.-C., and Hou, H. T. (2016). Exploring the role of flow experience, learning performance and potential behavior clusters in elementary students' game-based learning. *Interactive Learning Environments*, 24:178 – 193.

Hung, Y., Chen, C.-H., and Huang, S.-W. (2017). Applying augmented reality to enhance learning: a study of different teaching materials. *J. Comput. Assist. Learn.*, 33:252–266.

Ibáñez, M. B. and Delgado-Kloos, C. (2018). Augmented reality for stem learning: A systematic review. *Computers in Education*, 123:109–123.

Iftene, A. and Trandabăt, D. (2018). Enhancing the attractiveness of learning through augmented reality. *Procedia Computer Science*, 126:166–175.

Isenberg, E. J. (2007). What have we learned about homeschooling? *Peabody Journal of Education*, 82(2-3):387–409.

Karoui, A., Marfisi-Schottman, I., and George, S. (2020). Jem inventor: a mobile learning game authoring tool based on a nested design approach. *Interactive Learning Environments*.

Lawson, B. (2006). *How designers think: The design process demystified*. Routledge.

Lazar, J., Feng, J. H., and Hochheiser, H. (2017). *Research methods in human-computer interaction*. Morgan Kaufmann.

Li, J., der Spek, E. V., Yu, X., Hu, J., and Feijs, L. M. G. (2020). Exploring an augmented reality social learning game for elementary school students. *Proceedings of the Interaction Design and Children Conference*.

Li, K. C. and Wong, B. T.-M. (2021). Features and trends of personalised learning: a review of journal publications from 2001 to 2018. *Interactive Learning Environments*, 29:182 – 195.

Lin, X. and Su, S. (2020). Motivating learning by playing animal crossing new horizons: A trending game during the covid-19 pandemic. *eLearn*, 2020.

Markopoulos, P., Read, J. C., MacFarlane, S., and Hoysniemi, J. (2008). *Evaluating children's interactive products: principles and practices for interaction designers*. Elsevier.

Means, B., Bakia, M., and Murphy, R. (2014). *Learning online: What research tells us about whether, when and how*. Routledge.

Milgram, P., Takemura, H., Utsumi, A., and Kishino, F. (1995). Augmented reality: a class of displays on the reality-virtuality continuum. In *Other Conferences*.

Monteiro, I. T., de Lima Brilhante, M. Q., dos Santos, J. M. Á., de Mattos Brito Oliveira, F. C., and de Oliveira, A. C. B. (2021). Mobile game-based learning with opi app: Lessons learned with a children usability evaluation. In *Proceedings of the XX Brazilian Symposium on Human Factors in Computing Systems*, pages 1–11.

Nielsen, L. (2013). *Personas-user focused design*. Springer.

Plecher, D. A., Herber, F., Eichhorn, C., Pongratz, A., Tanson, G., and Klinker, G. J. (2020). Hieroquest - a serious game for learning egyptian hieroglyphs. *Journal on Computing and Cultural Heritage (JOCCH)*, 13:1 – 20.

Ray, B. D. (2021). Research facts on homeschooling. homeschool fast facts. *National Home Education Research Institute*.

Sun, Z., Yao, X., You, J., Du, W., and Luo, L. (2018). Detecting the correlation between mobile learning behav-

ior and personal characteristics among elementary school students. *Interactive Learning Environments*, 26:1023 – 1038.

Villanueva, A., Zhu, Z., Liu, Z., Peppler, K. A., Redick, T., and Ramani, K. (2020a). Meta-ar-app: An authoring platform for collaborative augmented reality in stem classrooms. *Proc. of the 2020 CHI Conference on Human Factors in Computing Systems*.

Villanueva, A. M., Kotak, H., Liu, Z., Mehta, R., Li, K., Zhu, Z., Torres, Y., and Ramani, K. (2020b). Arbits: Towards a diy, ar-compatible electrical circuitry toolkit for children. *Proceedings of the 2020 ACM Interaction Design and Children Conference: Extended Abstracts*.

Voulgari, I., Lavidas, K., Komis, V., and Athanassopoulos, S. (2020). Examining student teachers' perceptions and attitudes towards game based learning. *International Conference on the Foundations of Digital Games*.

Weng, C., Otanga, S., Christianto, S. M., and Chu, R. (2020). Enhancing students' biology learning by using augmented reality as a learning supplement. *Journal of Educational Computing Research*, 58:747 – 770.

Zhao, Y., Guo, Y., Xiao, Y., Zhu, R., Sun, W., Huang, W., Liang, D., Tang, L., Zhang, F., Zhu, D., and Wu, J.-L. (2020). The effects of online homeschooling on children, parents, and teachers of grades 1–9 during the covid-19 pandemic. *Medical Science Monitor: Int. Medical J. of Experimental and Clinical Research*, 26:e925591–1 – e925591–10.