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Emergency Remote Teaching Based on Education 4.0: an Experience Report about the Methodology adopted in the Experimental HCI Class

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Abstract

In Education 4.0, the professor is challenged to teach more than curriculum content, prompting the development of 21st-Century competencies and skills. Thus, this paper presents the Emergency Remote Teaching (ERT) methodology used in the Experimental Human-Computer Interaction (HCI) classes during the COVID-19 pandemic, based on Education 4.0. This class was taught to final year students of the undergraduate courses in Computer Science and Biomedical Informatics and graduate students in Informatics at a University. The teaching methodology adopted in this discipline sought to develop skills considered relevant for a researcher, such as recognizing research problems and learning new processes. The classes were guided by the Flex learning model, which consisted of synchronous and asynchronous classes. Thus, the schedule of classes needed to be adapted, including collaborative and diversified activities. We collected the student's opinions about the teaching methodology and the skills developed in the class and analyzed the results qualitatively. The results showed the difficulties and problems faced by students with the resources and materials in ERT, such as students having internet connectivity problems. However, the teacher made the recorded classes available, and this problem was overcome. The results also show that the deficit of skills, such as autonomy, initiative, and independence, hampered students' performance in ERT. The findings can help other teachers to improve the remote teaching of this class and indicate the possibilities of ERT in the Education 4.0.
Keywords: *Education 4.0, Teaching Methodology, Emergence Remote Teaching, Experimental HCI*

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1 Introduction

Faced with the COVID-19 pandemic, educational institutions adopted Emergency Remote Teaching (ERT) to continue classes. During the pandemic, research related to the experience in the ERT started to be carried out frequently. This knowledge is necessary due to the possibility of future pandemics, incidents, and other situations that could harm academic activities (Whittle, Tiwari, Yan, & Williams, 2020). Research on ERT is important and challenging, especially in universities in developing countries, where the Information and Communication Technologies (ICTs) infrastructure is precarious, there are few financial resources, technical support, and skills for the use of ICTs (El Said, 2021). Thus, information on how teachers adapted their classes to ERT can be very useful in improving teaching and learning processes. Moreover, understanding the human factors that influence students' ERT experience can provide insights for researchers and teachers about adapting learning, approaches, and tools (Martinelli & Zaina, 2021).

The ERT brought several challenges to professors who had to adapt and involve students in online learning environments (Whittle et al., 2020). This adaptation of face-to-face teaching to the remote uses the resources of e-learning. For Butola (2021), e-learning is defined as a network that facilitates sharing knowledge and skills and provides education for several people simultaneously or at different times. In this sense, some researchers highlight the difference between the terms e-learning and ERT. In e-learning, teaching has been designed and is pedagogically effective to meet the needs of students and future professionals (Bonfield, Salter, Longmuir, Benson, & Adachi, 2020). At ERT, teaching had to be adapted and improvised. Moreover, into ERT, the ways of teaching and evaluating have been completely changed to online. This change required training in a short period and support for professors and students in digital technologies (Hack, 2020).

One of the ERT challenges perceived in the literature is the students' few skills to deal with digital technologies in their activities (El Said, 2021). In this context, online training and skills improvement workshops are suggested to compensate for previously face-to-face activities (Martinelli & Zaina, 2021). Thus, it is necessary to provide in the course methodology the encouragement and development of skills required in the 21st-Century, such as investigative, analytical, and communication skills (Martinelli & Zaina, 2021). For HCI students, for example, the skills will allow a better perception of the needs of their users, identifying causes or problems in the use and creation of new technologies (Martinelli & Zaina, 2021). Thus, materials must to be reformulated into smaller learning units to be easily reused and updated. And, classes need to be carefully monitored by the teacher through emails, video calls, and chats (Martinelli & Zaina, 2021).

In this context, Martinelli and Zaina (2021) applied a questionnaire to identify students' experiences in the remote period, using a Flipped Classroom approach. The questions about the experience followed the non-verbal pictographic scale of the Self-Assessment Mannequin Technique (SAM). Subsequently, data collection was complemented with interviews. There were no specific questions about 21st-Century skills and competencies in the questionnaire and interviews, even though students commented on them. Unlike Martinelli and Zaina (2021), we prepared a questionnaire to assess 21st-Century skills and competencies focusing researchers in training. Similar to Martinelli and Zaina (2021), we use a flipped-classroom approach to encourage active learning, even in the face of difficulties brought about by the Covid-19 pandemic. In turn, El Said (2021), analyzed the effect of the sudden change from face-to-face distance learning to online. The author evaluated student performance by comparing the differences in grades between online and

face-to-face teaching. El Said (2021) identified that student performance in terms of grades was not affected. However, the lack of skills is the main challenge for the adoption of online learning. Even though the author recognizes the importance, he does not investigate these skills in his work.

Given this context, this paper presents a methodology adopted during the ERT in the Experimental Human-Computer Interaction (HCI) class with 6 final year undergraduate students in Computer Science, 3 final year undergraduate students in Biomedical Informatics, 15 master's students and 12 Ph.D students of the graduate program in Informatics from the Federal University of Paraná (Brazil). This class followed the resolution Nº 65/2020-CEPE approved in June 2020 by the University Council on Education, Research and Extension (CEPE) (UFPR, 2020). This resolution regulates academic activities in the ERT modality, calling it a special period. The resolution sought to advance the curriculum that had been paralyzed since March 2020. It is noteworthy that the provision of disciplines was optional for professors into ERT, and students were also free to decide whether or not to take disciplines during that period. In the professor's lesson plan, the means of interaction with students should be presented, such as virtual platforms and other digital means to allow communication and access to information about the class. In addition, the professor could adapt the didactics, assessment, bibliography, make the weekly workload more flexible, and make the activities available to students, considering possible access problems (Silva, Corrêa Sobrinho, & Valentim, 2020).

From this resolution (UFPR, 2020), the Experimental HCI professor looked for possibilities in the Education 4.0 literature to support students in ERT. Education 4.0 aims to prepare young people for the challenges of the 21st-Century (Silva et al., 2020) and develop lifelong learning (Bonfield et al., 2020). Thus, online teaching and learning can be considered one of the challenges of Education 4.0, where professors need to relearn how to use technological resources to conduct their classes. Besides, students need to develop autonomy to search for tools, complete a group task, upload activities, use cloud storage, and maintain effective communication with professors and classmates (Hussin, 2018). We chose Education 4.0 as a background to compensate the difficulties that would be faced by students due to the sudden shift to online teaching. Therefore, the discipline reduced theoretical classes and emphasized practical classes.

Other features of Education 4.0 that were part of the teaching methodology adopted were student-centered learning with practical, collaborative, and diverse activities (Silva et al., 2020). The Experimental HCI classes followed the Flex learning model, which consisted of online classes (synchronous approach) and offline tasks (asynchronous approach). In the Flex model, the learning base is online teaching, with students being protagonists and professors being mediators (Dakhi, Jama, Irfan, & Ambiyar, 2020). In this way, the professor helped students with their doubts, guided them in their studies, and motivated them to discuss the contents in synchronous classes. For offline tasks, the professor used Flipped Classroom practice (Bergmann & Sams, 2012), where students had to carry out the work and read asynchronously, based on the instructions received. Besides, students discussed their difficulties, learned lessons, good practices, and doubts in the synchronous classes.

Therefore, this work sought to develop skills and competencies considered important for a researcher in training, such as Critical Thinking, Problem-Solving, Decision-Making, Collaboration and Teamwork, Proficiency in Information, and Learning to Learn. As part of the results, it was identified that the students positively evaluated the methodology adopted in the ERT, taking into account the feedback received in the self-assessment questionnaire. Moreover, we noticed

that students developed competencies and skills such as Critical Thinking (students questioned about their research problem), Collaboration (students committed to carrying out the activities necessary for group work), and Learning to Learn (students said they learned new content).

Our contribution consists of sharing how to adapt the experimental HCI class from traditional teaching to ERT. The teaching methodology was focused on Education 4.0. Therefore, we seek to develop not only the curriculum of the discipline, but the 21st-Century skills and competencies. The teaching methodology allowed individual and collaborative practical work to be carried out using digital technologies, even in the face of difficulties caused by the Covid-19 pandemic. Our teaching methodology includes aspects of Education 4.0. Therefore, it can be reused and adapted for other learning contexts, such as blended learning, face-to-face, and e-learning. In this way, the methodology allows including activities that the student can do alone or in a group, being at home or school/university, online or offline, varying according to the course load, context and learning objectives. In short, the proposed methodology allows students to learn at their own pace, and teachers to identify skills that could be improved.

This paper is organized into Sections. In Section 2, the Background and some Related Works on Education 4.0 and their opportunities for ERT will be shown. In Section 3, the teaching methodology of the Experimental HCI class will be presented. In Section 4, the competencies and skills developed in the class will be presented. In Section 5, qualitative results on the teaching methodology will be presented. In Section 6, the data will be discussed. In Section 7, some limitations of this experience will be presented. Finally, in Section 8, conclusions and future work will be presented.

2 Background

This experience report is related to Education 4.0, as it aims to develop 21st-Century skills and competencies, being one of the main characteristics presented in the literature on the topic (Alda, Boholano, & Dayagbil, 2020). In this sense, e-learning presented itself as one of the learning trends of the 21st-Century, evidenced in the period of the Covid-19 pandemic (Butola, 2021). There are signs suggesting that these practices could have a lasting impact on the trajectory of innovation and digitalization of learning (El Said, 2021), which may allow the advancement of Education 4.0 (Silva et al., 2020). As the term is recent, not yet a standard and single definition used in the literature, with much of it being abstract and theoretical studies (Bonfield et al., 2020); (Himmetoglu, Ayug, & Bayrak, 2020). In this sense, researchers searched for works those present characteristics and definitions to understand what is expected from Education 4.0.

From the industry's perspective, Education 4.0 can be considered a general approach or trend to prepare a future workforce for Industry 4.0 (Bonfield et al., 2020). Furthermore, Education 4.0 is an answer to the needs of Industry 4.0, where humans and technologies are aligned, which may allow for new possibilities (Hussin, 2018). From an educational perspective, Education 4.0 can be characterized by virtual courses composed of interactivity in Blended Learning and resources driven by Artificial Intelligence and other technologies (Ciolacu, Tehrani, Beer, & Popp, 2017). Education 4.0 aims to train individuals with skills to be creative and innovative (Puncreobutr, 2016). The definition of Education 4.0 from an industry point of view may not be considered adequate by some specialists in education. Because the context of Education 4.0 can go beyond

the purposes of the industry, allowing to prepare young people for the contemporary world.

Due to the difficulty of having a precise definition of the term, one definition of Education 4.0 based on aspects perceived in the literature was identified. Education 4.0 is understood as a student-centered learning vision that seeks to prepare young people for the challenges of the 21st-Century, including the use of technological resources and processes and the development of 21st-Century skills and competencies (Hussin, 2018; Maria, Shahbodin, & Pee, 2018; Mourtzis, 2018; Ciolacu et al., 2017). In Education 4.0, it is expected that the learning process allows flexibility for students to be responsible for the construction of knowledge, having the freedom to achieve the desired goals (Hartono, Kosala, Supangkat, & Ranti, 2018). Furthermore, in Education 4.0, a dynamic mindset is sought so that students can solve real-world problems collaboratively and creatively, develop innovative and technological solutions, being active and participative subjects (Angrisani et al., 2018). Therefore, Education 4.0 seeks to teach more than didactic content, prompting the development of skills and competencies of the 21st-Century (Silva et al., 2020).

The European Center for the Development of Vocational Training (Cedefop, 2018) defines skill as the ability to perform tasks and solve problems in a specific context. In comparison, competence is the ability to apply learning outcomes in different contexts, such as school, university, work, whether for personal or professional development. In this way, it is understood that skill is contained into competence. In the words of Angrisani et al. (2018), competence can be defined as a combination of knowledge, experiences, and skills. However, competence is not limited to cognitive elements but covers functional aspects (technical skills), interpersonal attributes (social and organizational skills), among others (Ananiadou & Claro, 2009).

2.1 Education 4.0 Opportunities for ERT

As well as skills and competencies, it was observed that e-learning technologies are also interesting for Education 4.0. In this sense, the internet can allow interaction and creative thinking in the classroom, either in person or remotely. Interaction can encourage skills, such as teamwork and collaboration, that are necessary for working in society. Moreover, creative thinking can enable students to think outside the box to solve problems (Maria et al., 2018).

Therefore, e-learning technologies can offer opportunities for ERT. The possibility of working online is considered one of the trends of Education 4.0, as it allows learning to occur anywhere and at any time (Hussin, 2018). Another trend in Education 4.0 that is interesting for ERT is the possibility of working on hands-on activities (Hussin, 2018). As a result, students get involved and apply their knowledge and skills over time, which will be useful in their future careers (Hussin, 2018). In Education 4.0, the technologies of Education 2.0 (Web 2.0 and Blended Learning) and Education 3.0 (Social and Virtual Learning and Massive Open Online Course - MOOC) (Maria et al., 2018) are now being rethought and reassessed, as before the professor acted as a source of knowledge. However, in Education 4.0, the professor becomes a mediator, giving all the necessary conditions for students to build and personalize their learning (Alakrasha & Razak, 2020). Table 1 presents nine contributions of digital technologies to the ERT modality.

Table 1: Contributions of Digital Technologies to Remote Education (Butola, 2021).

Contribution	Description
Availability of resources online	Online learning allows students to access several material possibilities, including books, PDFs, test papers, among others.
Provides fun	Educational games can change the face of education. The implementation of gamification in learning can help to increase the level of student involvement.
Promotes distance teaching	Students have access to research, materials, and tools. Besides, online education can offer students the autonomy to study at their own pace.
Offers personalization	The platforms offer a personalized way of teaching and learning to meet the needs of students.
Cost-effectiveness	The technology of online teaching is much more economical than most other methods of education. The student can have access to the platform, regardless of their educational and economic context.
Portability	In online education, the student can learn in a cozy and relaxing environment, requiring a good connection to the internet.
Sustainability	The online teaching method is sustainable as it does not require paper. Therefore, students and professors only need to download the documents.
Report on real-time performance	Online teaching allows students to assess in real-time. This contribution provides students with a faster and more complete review of their performance at school.
Live streaming seminars	The applications allow students to participate in online classes by professors and professionals. In addition, students can also benefit from solving their doubts through the use of specialized technologies.

2.2 Related Work

In this subsection, we present some works identified in the literature on ERT in the context of the COVID-19 pandemic. As mentioned earlier, ERT was the solution found by educational institutions to maintain classes during social distance. Several studies on the ERT have emerged to contribute to this challenge. Six studies that present ways of adapting face-to-face classes to ERT, showing the challenges, care, and possibilities of work were selected and presented below. These studies were selected through a manual search on google scholar and in the proceedings of RBIE (Brazilian Journal of Computers in Education).

Whittle et al. (2020) proposed a generalized conceptual framework to facilitate understanding and support online teaching in emergencies. The ERTE framework has three stages: (a) research (to identify the basic needs of professors and students, taking into account health, time, access, and familiarity with technology); (b) classification of available resources into constants

(factors shared by all students and teachers) and variables (factors shared by some students and teachers). In this way, several teachers were able to identify social variables such as students who undergo basic needs, such as food, internet access, or technical devices; and (c) design of educational experiences (to guide professors in collecting information to create a coherent design that makes it possible to maximize students' learning from their individualities and needs). For the authors, the professor need frequently reevaluate his project to realize the current approach's effectiveness and identify the necessary adjustments.

In sequence, Mohmmed, Khidhir, Nazeer, and Vijayan (2020) presented the application and evaluation of a model designed for the ERT. The adaptation to the ERT consisted of two steps: (a) transformation of the curriculum to allow students to have access to information anywhere: in this stage, classes started to be conducted through digital platforms, where students could discuss and take their doubts about the content. Furthermore, these classes were recorded and made available on Moodle and social networks to facilitate access later, in case there were any unforeseen events related to the internet connection. Also, professors need to provide materials with concise tips in slides they use during online classes. Thus, if students cannot download the video classes, they may still have access to the content; and (b) professor personal development: due to the pandemic, a massive professor training program was established for the use of technological resources in remote education. In short, for the authors, asynchronous activities are more rational and should be given special attention, as it facilitates access for students who do not attend online classes.

Butola (2021) shared that several platforms help to maintain online education in India in the pandemic period. These platforms offer online courses that allow students to learn and complete their studies. In addition, professors use digital platforms for asynchronous activities, providing materials in PDF and PPT presentations, tasks, simulation tests, among others; and, synchronous activities through virtual rooms. During the COVID-19 pandemic, studies in India were not affected, mainly in Higher Education as Medicine course, as technological resources are used frequently, being considered one of the skills and knowledge to be developed in students. Through e-learning, the professor becomes the learning facilitator, being supported by a variety of online resources (e.g., interactive patients, medical video games, e-books, e-atlas, and digital editions of online journals) that can be used to support all fields of learning, such as cognitive, psychomotor and affective. The authors reflect on the need to familiarize students with technological resources, as this can help with professional growth given the number of subjects in the academic curriculum, the shortage of time, and the overburdened routine.

Martinelli and Zaina (2021) presented a virtual flipped classroom-based approach to teaching HCI. The approach adds elements to moments inside and outside the classroom. Thirty-three undergraduate and ten graduate students from the HCI course participated. Before class, students interacted alone with the HCI course materials. For each week of class, students focused on learning one unit of HCI. During classes, students participated in a synchronous meeting in an online room. After the class, the students were organized in different online rooms to carry out the practical exercise in small groups. The authors carried out two data collections. The first was after the 5th week of classes through a questionnaire about their experience with the different formats of materials and activities in the classroom, following the Self-Assessment Mannequin Technique (SAM). The second data collection was from the interviews with each group at the end of the HCI course. A semi-structured script was used to encourage students to report their experiences in the interviews. The study contributes to the HCI community by introducing a new configura-

tion of active learning online classes that can support teachers in encouraging students to work collaboratively, even in times of COVID-19.

El Said (2021) analyzed the effect of switching from face-to-face teaching to online teaching due to the COVID-19 lockdown at one of the universities in Egypt. The study assessed the variation in students' academic performance in the spring 2020 semester and the previous semester and collected student satisfaction. A hybrid investigation technique that combines quantitative and qualitative tools was used. First, student performance was quantitatively evaluated by comparing grade differences between online and face-to-face teaching. Second, an online survey quantitatively assessed student satisfaction with the university's distance education portal during the COVID-19 lockdown. The study shows that student performance in terms of grades was not affected, even with the scarcity of infrastructure and lack of practice in online education. The results provided specific recommendations for the future application of online distance learning to cut costs, reduce student density, among others.

Oliveira, Lima, Carvalho, and Fonseca (2020) adjusted a teaching model to meet the needs of remote classes of an Artificial Intelligence discipline. The study presented the use of a combination of different active methodologies such as flipped classroom, project-based learning, group work, and gamification to support a fully remote teaching environment. The teaching model was organized into six stages. In stage I, lectures take place through a virtual room. Among the available software, they chose to use Google Meet. At this stage, the teacher prepared six lectures and the student profile identification form. In stage II, students used Directed Studies to guide their theoretical studies. In this stage, students used books, articles, and videos. In stage III, the teacher used Google Meet to connect with the class. In this stage, the teacher used some gamification techniques. Among the solutions found, they chose to use Google Jamboard, a platform on which it is possible to adapt a card game. In stage IV, students used the Google collab platform to store the coding, and encourage collaboration and visualization of the implementation of the computational model by the group members. In stage V, the groups continued to use the communication channels and carry out the writing of the report. In stage VI, the groups present and deliver the document with the solution to the problem.

We observed that most studies report the combination of asynchronous and synchronous approaches to support the teaching and learning processes in the ERT period. Furthermore, we identified that professors who are not in the field of Computing start to receive massive training about the use of digital technologies, to continue the academic calendar (Whittle et al., 2020). However, even with more than one year of pandemic, there are still some difficulties in applying these approaches in practice. The difficulties may be due to the short period to design a class entirely online, the adaptation of professors in digital technologies, lack of focus and interest of students, difficulties accessing virtual rooms (Mohmmed et al., 2020). Therefore, it is pertinent to continue investigating ways of teaching and learning at ERT to support teachers and students (Martinelli & Zaina, 2021). Studies about ERT show the need of students to develop skills for using digital technologies and carrying out their activities (El Said, 2021) (Martinelli & Zaina, 2021). Thus, it is believed that e-learning along with active methodologies can help students to improve their learning (Butola, 2021; Oliveira et al., 2020), being characteristics of Education 4.0. Autonomy allows students the opportunity to Learn-to-Learn, being an important 21st-Century skill for students' future professional careers (Martinelli & Zaina, 2021). Thus, the following section presents details on the planning of the methodology used in the Experimental HCI class in

the context of ERT, focusing on the characteristics of Education 4.0.

3 Teaching Methodology

The Experimental HCI class offered had a 60-hour workload into ERT. The Flex model guided the classes to encourage the active participation of students to develop 21st-Century skills and competencies based on the context of Education 4.0. Therefore, the class was organized into online classes (synchronous approach) and offline tasks (asynchronous approach), considering students' diversity of conditions and access time. The classes were transmitted through the BigBlueButton [1] (BBB) platform, and the specification of the class with the tasks and support materials were made available in Moodle [2]. The teaching methodology was also inspired by the Flipped Classroom. Before classes with the professor, the students read the materials (PDFs, slides and instructions) and self-prepared for the classes. After the teacher's guidance, the students did practical work. In the synchronous approach, in addition to the exposure of the class, the professor acted as a mediator of the learning process. Thus, the professor motivated the students to discuss the contents learned, a sketch about their difficulties in carrying out the weekly practical work, ask questions about the work to be delivered in the subsequent class, among others. In the asynchronous approach, students carried out individual or collaborative activities, depending on the work specification. For collaborative activities, students could organize themselves into pairs or trios. The professor guided them to meet by video call and exchange messages about practical activities during the week. Students had the autonomy to choose communication tools, work dynamics, and the distribution of tasks among them.

The classes covered the following topics: Introduction to Experimental HCI and Systematic Mapping Study (SMS) (1st week); Planning and Execution of the SMS (2nd and 3rd week); Experimental Studies (4th week); Quantitative Analysis of Experimental Studies (5th week); Qualitative Analysis of Experimental Studies (6th week). The classes lasted two hours a week. However, students received enough materials and activities to work on during the week, such as reading scientific papers, book chapters, and practical work. Among the practical work, the students carried out the first two individually and the later four collaboratively, having the challenge of carrying out the works within five days. Students were evaluated through formative assessment, based on practical work about topics of experimental HCI. Thus, students received feedback from the professor through dialogue and comments, not just grades. These works were delivered in the SBC article format [3]. The purpose and activities of each practical assignment are described below.

Practical Work 1 (PW1) aimed to enable the students to plan an SMS protocol. This protocol could be prepared based on the students' research. Thus, it was advised that the students should talk to their advisors about the activities to reuse the works for their research. PW1 had the following activities: (a) Define the application context, showing the need to carry out an SMS on the topic; (b) Define the objective and the research questions; (c) Define the search scope, presenting the selection criteria for the choice of data sources. Moreover, the students should identify the restrictions associated with the SMS; (d) Define and justify the languages used in the

[1] https://bbb.c3sl.ufpr.br/b/
[2] https://moodle.c3sl.ufpr.br/
[3] https://bit.ly/3ABNtsf

research to select publications; (e) Define the search method for publications as a search string and the procedure used in each data source; and (f) Carry out a pilot study to test and retest the search string until it is refined. Also, students should observe the results achieved and report their experience in this pilot study. PW1 was performed individually by each student.

Practical Work 2 (PW2) aimed to allow the students to perform a partial SMS on their researches. PW2 was performed using the planning protocol defined in PW1. PW2 contained the following activities: (a) Define the publications selection criteria (inclusion and exclusion criteria); (b) Define the procedures (1st filter and 2nd filter) adopted for the selection of publications; (c) Define a form for data extraction, considering items that need to be extracted to help answer the research questions defined above; (d) List the first 50 papers returned in the search performed in the digital library with complete references of each publication; (e) Conduct the 1st filter (suggestion of reading the title and abstract) of the first 50 publications returned by the digital library, making it clear which of them passed or not, and by what criteria they were included or excluded; (f) Conduct the 2nd filter (full reading suggestion) of the papers that passed the 1st filter, indicating the selection criteria and justifying the reason for inclusion or exclusion; and (g) Extract data of 5 papers that passed the 2nd filter. PW2 was also performed individually by each student.

Practical Work 3 (PW3) aimed to enable the students to plan a controlled experiment. PW3 should contain the following topics: (a) Definition of the objective of the experiment according to the GQM paradigm; (b) Formulate null and alternative hypotheses; (c) Select the dependent and independent variables and define how the dependent ones will be collected and/or calculated; (c) Specify the design of the project in between-group or within-group; (d) Select the participants and the environment where the experiment should be carried out; (e) Define the instruments as supporting and instructional materials, including the Informed Consent Form (ICF), questionnaires to characterize the participants and a self-evaluation questionnaire to collect the opinion of the participants. In addition, students should define measurement procedures; (f) Present how threats to validity, biases that may be caused by measurement instruments, experimental procedures, participants, researcher, and environmental factors can be mitigated.

Practical Work 4 (PW4) aimed to enable the students to carry out a pilot study of the experiment planned in PW3. In PW4, students should invite at least two people to participate in their pilot study. In the end, students should submit a report of the study. PW4 should contain the following topics: (a) Describe the characteristics and previous experience of the participants; (b) Show how the pilot study was prepared, including training and instructions given to participants; and (c) Present the pilot study procedure, as well as all the steps performed by the participants.

Practical Work 5 (PW5) aimed to allow the students to reproduce the quantitative analysis of an experiment. PW5 contained the following activities: (a) Identifying a scientific paper close to the research theme of study that students planned in PW3. This paper should have sufficient quantitative data for students to reproduce the statistical tests; (b) Study about the statistical tests of the experiment identified in the selected paper. Students should reproduce the tests using statistical software such as SPSS[4] or R[5]; however, students could use any other quantitative analysis tool; and (c) Make a report containing the reproductions of the tests. Students should describe each step performed during tests on the software and show the result achieved.

[4]https://www.ibm.com/br-pt/analytics/spss-statistics-software

[5]https://www.r-project.org/

Practical Work 6 (PW6) aimed to allow the students to reproduce a qualitative analysis of an experiment. The qualitative analysis software Atlas.ti[6] was suggested for this work, but students could use any other qualitative analysis tool. PW6 had the following activities: (a) Choose qualitative data obtained through an experiment related to its research. For PW6, data from the pilot study carried out on PW4 or from an experiment with access to raw data could be used. If students had neither option to analyze, they could collect qualitative data by conducting an interview, questionnaire, or observation concerning the topic of your research; (b) Analyze and code the qualitative data, identifying, naming, and recording recurring content in the complete set of data; (c) Examine the result achieved in item b, finding more abstract categories where codes can be grouped. Students should maintain the systematicity and rigor of their analysis; and (d) Write a report describing (i) their conduct of analysis, (ii) the results, and (iii) their conclusions about PW6. The conclusions could be linked to the product achieved or the process carried out.

The professor of this class received support from two teaching assistants (Ph.D. students) who had the function of helping students to remove doubts, assisting in the preparation of materials for classes, and helping in the evaluation of the activities carried out. For this, the professor and the assistants communicated via Whatsapp. To remove doubts about the contents and activities, the students communicated asynchronously in Moodle through the message and discussion forum's resources and synchronously during online classes. Besides, Moodle served as a material repository, activity manager, environment for delivering the results of activities, and communication between professor, students, and assistants. At the end of the classes, students were asked to answer the self-assessment questionnaire[7]. This questionnaire was composed of two parts: a) closed questions related to the competencies and skills developed through practical works (shown in Section 4); and b) open questions related to the teaching methodology used in the class (presented in Section 5).

The discipline was taught to two groups during the ERT. In the first class, 28 students participated, and in the second, 8 students participated, totaling 36 participants (P1 to P36). Of this total number of students, 6 (17.00%) are Computer Science undergraduates (P20 to P25); 3 (8.00%) are Biomedical Informatics undergraduates (P26 to P28); 15 (42.00%) are master's students (P01 to P04, P06 to P08, P12, P13, P16 to P19, P33 and P36), and 12 (33.00%) are Ph.D. students (P05, P09 to P12, P14, P15, P29 to P32, and P34). Moreover, of these 36 students, 10 (28.00%) are female and 26 (72.00%) are male.

Through her first experience with the ERT, the professor felt the need to have more time to serve students on the content of Secondary Studies. Therefore, the professor slightly adjusted the discipline schedule from the first to the second class, making six weeks of classes. In the discipline, students received the same content. The classes given to the first class were recorded and later transmitted to the second class. At the end of each class, the professor made the video classes available at the BBB for students. In this way, the students could attend classes as often as necessary to assimilate the content and/or recall important details of the professor's explanation.

[6]https://atlasti.com/

[7]https://bit.ly/3fXq391

4 Development of 21st-Century Skills

The 36 students answered the self-assessment questionnaire on the competencies and skills developed. For the first part of the questionnaire, four skill groups were presented by (Binkley et al., 2012) related to research skills considered important to be developed. The skills were organized as follows: (a) Critical Thinking, Problem Solving and Decision Making (Ability to read and write critically, Recognize research problems, Recognize relevant studies, and Conduct research on a scientific path); (b) Collaboration and Teamwork (Networking and Teamwork); (c) Proficiency in Information (Academic writing/documentation and Use of information sources), and (d) Learning to Learn and Metacognition (Learning from new processes). Twenty-five sentences were used in the questionnaire as evidence and are represented in Figures 1 to 4, being (i) The Critical Thinking, Problem-Solving, and Decision-Making skills (Figure 1) have 10 sentences; (ii) the skills Collaboration and Teamwork (Figure 2) have 5 sentences; (iii) the Information Proficiency skill (Figure 3) has 6 sentences; and (iv) the Learn to Learn and Metacognition skills (Figure 4) have 4 sentences. The sentences were answered on a five-point Likert scale, with Totally Disagree, Partially Disagree, Neither Agree Nor Disagree, Partially Agree, and Totally Agree.

One class assistants (expert in Education 4.0) prepared the questionnaire. The questionnaire was submitted to two rounds of reviews by two other researchers who know about Experimental HCI (second class assistant and the professor). The three researchers discussed until reaching a consensus on the adequacy of the questionnaire. Adequacy concerns the refinement of sentences about skills to reflect the experimental HCI activities that students performed in the classes.

After the end of classes and delivery of the work, the students answered the self-assessment questionnaire. The professor explained to the students that they were not being evaluated for the class. In this way, students could feel free to provide feedback, or not, about their experience in class. The questionnaire was answered anonymously and, therefore, there was no influence from the professor on the students' answers. Data analysis was conducted by an assistant of the class and was later peer-reviewed by the professor.

4.1 Critical thinking, Problem-Solving, and Decision-Making

Regarding the skill to read and write critically (Figure 1 – sentences CT1 and CT2), we identified that no student totally disagreed with the sentence CT1 "I endeavored to read critically the material made available (papers and book chapters)". On the other hand, 52.78% believe that they could critically read the support materials needed to understand the contents and carry out the work. In sequence, in the sentence CT2 "I managed to write my opinions, criticisms, and decisions in the requested activities", we observed that the students were more positive than in the sentence CT1. Thus, 66.67% of the students fully agreed on writing their work critically. There is a higher concentration of total agreement in the sentence CT2 than in the CT1. This higher concentration occurs because the students were evaluated by the delivery of their reports. Therefore, we believe that students had to put even more effort into writing than reading. They had other sources of information such as the internet and the professor who taught the content and removed doubts synchronously to understand the content. In writing, they needed to have greater independence and autonomy, which may have collaborated to develop criticality in what they were producing.

Regarding the recognition of research problems (Figure 1 - sentences CT3, CT4, and CT5),

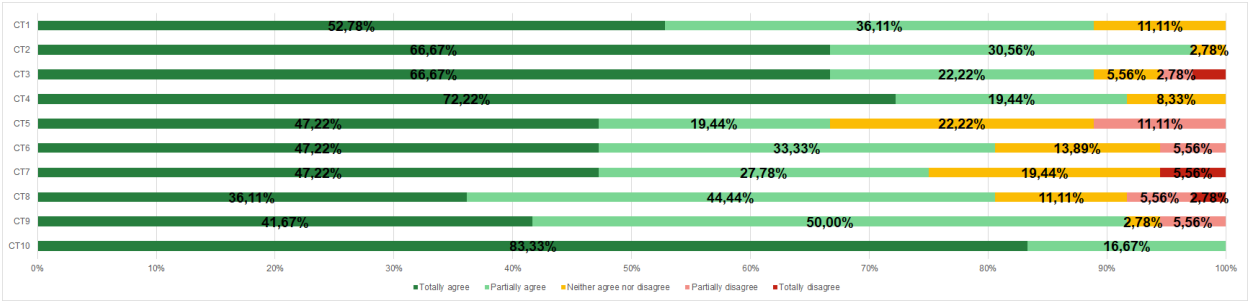

Figure 1: Agreement level of the Critical thinking, Problem-Solving, and Decision-Making skills.

we noticed that 2.78% of the students totally disagreed with the sentence CT3 “I tried to better understand my research problem during the activities of the class”. Even though 66.67% of the students agreed, we noticed that some students could not understand their research problem so well. This difficulty may be linked to the little knowledge about their theme and the new arrival to the postgraduate program in Informatics. Then, in the sentence CT4 “I asked myself about my research problem during the activities”, the students were positive. 72.22% of the students totally agreed, having no total or partial disagreement. Thus, it was observed that even some students having difficulties understanding the research problem, they asked questions, which can have helped them in the learning process. Subsequently, in the sentence CT5 “I was able to identify gaps in my research theme during the activities”, even though there was no total disagreement, a greater variation in the students’ responses was identified. 47.22% of the students totally agreed with the sentence CT5. Therefore, we identified that some students had difficulties finding the research gap, possibly, because they were unable to understand their research problem, causing a second difficulty. Thus, if these students do not develop skills such as problem-solving and critical thinking, it is believed that they will have serious problems throughout their master’s/doctorate, which can culminate in the delay in delivering the master’s dissertation or doctoral thesis.

Regarding the Recognition of Relevant Studies (Figure 1 - sentences CT6 and CT7), we observed that 47.22% of the students totally agreed with the sentence CT6 “I chose and organized the articles I needed to read about my topic”, no total disagreement. However, we noticed that not all students could find papers that were useful for their research. This problem can have been one factor that led some not to understand the research problem and find the research gap. Thus, it is still necessary to work with students to help them find relevant literature that contributes to the construction of knowledge and theoretical support for research. In sequence, in the sentence CT7 “I looked for other interesting studies, in addition to the studies that I had already identified before the class”, a greater distribution of responses was identified. The results showed that 5.56% of the students totally disagreed, and 47.22% totally agreed. Thus, we verified that some students had limited themselves to the support materials made available in the class, such as papers and book chapters. This limitation indicates that some students need to be helped to become autonomous and independent in their learning. Also, the lack of interest in other materials can have contributed to not having identified the problem and the research gap. The support materials of the class were about general topics in the area of HCI; therefore, the students needed to look for specific materials for their research theme.

Regarding the conduct of research in a scientific way (Figure 1 - sentences CT8, CT9, and

CT10), in the sentence CT8 “I managed to learn to perform and interpret statistical tests” we found that 36.11% of students totally agreed with the sentence, with a total level of disagreement of 2.78%. In contrast, in the sentence CT9 “I managed to learn how to perform an adequate qualitative analysis”, even though there was no total disagreement, 41.57% of the students totally agreed with the sentence. Thus, we observed that students had more difficulties performing the quantitative analysis than the qualitative analysis. However, this aspect is understandable, as they had little time to learn how to use the analysis software. We believe that learning required commitment and organization with activities and needing autonomy to learn new tools for carrying out practical work. Finally, in the sentence CT10 “I consider it important to carry out an evidence-based survey”, we noticed that the students were positive. 83.33% of students totally agreed and 16.67% partially agreed, being the only sentence among the groups of investigated skills to have no negative (total and partial disagreement) or neutral answers (neither agree nor disagree). Thus, we believe that students recognized the importance of conducting evidence-based research, improving the quality of their master’s and doctoral dissertations.

4.2 Collaboration and Teamwork

Regarding Networking (Figure 2 - sentences CO1 and CO2), in the sentence CO1 “I managed to have time to help my team during the activities”, we noticed that more than half of the students (66.67%) totally agreed and 2.78% totally disagreed, with no partial disagreement. Thus, we identified that not all students could contribute with their colleagues as they would like. Low collaboration can mean that they had problems with time or even an internet connection to meet with colleagues online to carry out practical work. Subsequently, in the sentence CO2 “I met new people and exchanged experiences throughout the classes” there was a greater variation in the responses concerning the sentence CO1. Moreover, we noted that there was a significant level of total disagreement (11.11%). Thus, through sentence CO2, we identified that some students had difficulty networking at ERT. In this sense, what may have helped some to relate more than others in the class were the collaborative works. Even so, they were free to do the practical work alone or stay with the same group in all activities. Finally, we believe that shyness can have limited the interpersonal relationship of some students in the class.

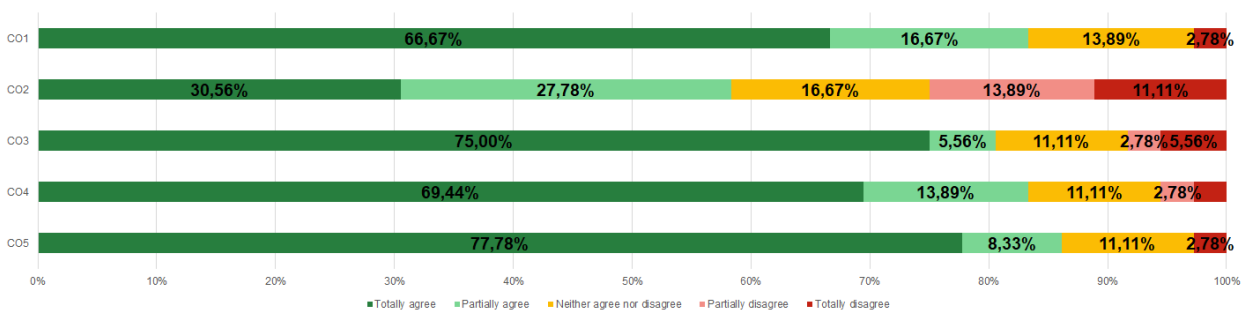

Figure 2: Agreement level of the Collaboration and Teamwork skills.

About Teamwork (Figure 2 - sentences CO3, CO4, and CO5), in the sentence C03 “I enjoyed working together with my colleagues to do the activities”, most of the students were positives, 75.00% totally agreeing. Therefore, we found that a good part of the students demonstrated that they enjoyed working together. This collaboration may have helped them learn from each other,

making it possible to exchange experiences with colleagues in the group and find more than one idea/solution to conduct the practical work of the class. In this way, it is always interesting to allow students both individual and collaborative activities, to provide several experiences and knowledge exchanges. In sequence, in the sentence CO4 "I managed to organize and plan the activities done in a group" we noticed that more than half of the students (69.44%) totally agreed. However, 2.78% totally disagreed, indicating that they had difficulties organizing and planning the work collaboratively. Besides, we observed that the same level of total disagreement of sentence CO4 is the same as that of the CO1 sentence of the Networking skill (2.78%). Thus, we believe that students could not organize and plan teamwork due to a lack of time to help colleagues in activities. Subsequently, in the sentence CO5, "I pledged to do the activities necessary to achieve the group's common goal" the students were positive. In this sense, 77.78% of students totally agreed, and 2.78% totally disagreed. We believe that the 2.78% represented in the total disagreement were the participants who had more difficulties in Networking and Teamwork skills due to the same level of disagreement presented in other sentences of this nature. Thus, we find it necessary to work with undergraduate Computer Science and Biomedical Informatics, and graduate Informatics students to improve their Collaboration and Teamwork skills.

4.3 Information Proficiency

Regarding academic writing/documentation (Figure 3 – sentences PR1, PR2, and PR3), in the sentence PR1 "I read the papers and chapters of books and understood the content treated" there was no total disagreement. However, we noticed that students' highest concentration of responses is in partial agreement (61.11%). These responses can indicate that reading material alone was not enough for some students to understand the content of discipline fully. However, there was a reserved time in each class to clarify doubts and outline difficulties faced. Also, the professor taught the class about the contents after previous readings of materials by students. Furthermore, at the end of each class, the professor made the video class available so that students could watch as many times as necessary to understand the content. We believed that for this reason, there were no disagreements concerning the sentence PR1. Then, in the sentence PR2 "I was able to argue and describe my opinion in the class activities", the students showed themselves to be positive, and there was also no disagreement. Some students totally agreed (55.56%), and others partially agreed (41.67%) with the sentence. We realized that not all students could argue and write their opinions as they would like, but they believe that they delivered good work within the time set by the professor. Finally, in the sentence PR3 "I took care of the texts I wrote for the class, before handing it over to the professor", 69.44% totally agreed, with no disagreements. Thus, we observed that the students were diligent in preparing and writing the reports delivered in each practical assignment. We believe that two situations can have influenced the agreement of this sentence: (a) the students needed to discuss the activity in each class, including their participation and learning, and (b) they were evaluated according to work sent.

Regarding the Use of Information Sources (Figure 3 – sentences PR4, PR5, and PR6), in the sentence PR4 "I managed to find the necessary information to do the activities of the class" half of the students (50.00%) totally agreed, while 2.78% totally disagreed. We believe that as some students limited themselves to the subject's support materials (as seen in the sentence CT7 on Recognition of Relevant Studies in Subsection 4.1), they found it difficult to obtain information to do the activities. These problems may have happened, as each student had a line and research

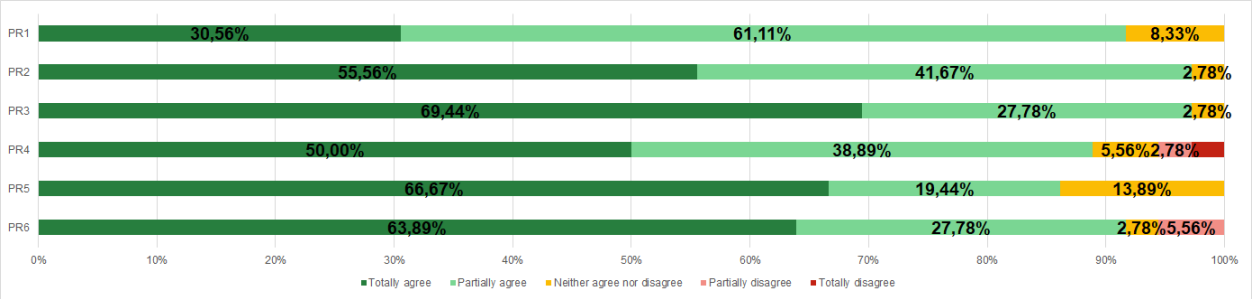

Figure 3: Agreement level of the Information Proficiency skill.

theme different, making it necessary to look for other materials related to their context to do the work. One of the professor's tips was for the students to ask for their advisors' suggestions. In this way, the students could reuse the class's works for their research, in addition to answering specific questions about their research topic with their advisors. In the sentence PR5 "I analyzed whether an information was reliable or not, before using it in the class", the students were positive with no disagreement. Some students totally agreed (66.67%), and others partially agreed (19.44%) with the sentence. Thus, we identified that some students had concerned about using reliable information in their work. This attitude shows their commitment to present something truthfully, demonstrating the students' maturity and ethics. Lastly, in the PR6 sentence "I changed my opinion depending on how much I learned more about the subject", more than half of the students totally agreed (63.89%), with no total disagreement. Thus, we identified that some students had the flexibility to change their opinion as they learned content. Others chose to remain with their initial ideas but sought to improve their works in some way.

4.4 Learn to learn and Metacognition

About the Learning of New Processes (Figure 4 - sentences LL1, LL2, LL3, and LL4), in the sentence LL1 "I planned how I would study the contents of this class (which activities I will do in which day/time)", we identified that there was no total disagreement. Some students totally agreed (36.11%), and others partially disagreed (8.33%) with the sentence. Thus, we noticed that some students had difficulties planning and studying the class contents during the ERT. In this sense, we believe that resilience needs to be worked on the students, especially in a pandemic context. Resilience is considered one of the 21st-Century skills and can help students deal with their studies even in the face of problems, changes, and adverse situations such as stress, fear, and anxiety. In the sentence LL2 "I dedicated more study time to the class, especially when I was having difficulties with a specific content" more than half of the students (52.78%) totally agreed. However, we observed that 2.78% of the students totally disagreed. We believe that the time factor, or lack of organization skills, has impaired some students in their learning process. Thus, we found that the same number of students who did not have time to work as a team (sentence CO1 as shown in Subsection 4.2) was the same as those who did not have time to devote to studies (2.78%). Later, in the sentence LL3 "I liked to learn new content with this class", they were very positive. They totally agreed (83.33%) and partially agreed (13.86%), with no disagreements on the part of the students. Therefore, students liked to learn the class contents, mainly because they could deal with subjects that could directly contribute to their academic research. Finally, in

the sentence LL4 “I managed to stay focused during the activities”, a greater distribution of the students’ responses was noticed. In this sense, the higher convergence of responses is in partial agreement (41.67%), with a level of total disagreement of 2.78%. Thus, we identified that some students were unable to concentrate during activities. The lack of concentration can be related to the lack of a quiet and peaceful environment to study during the pandemic.

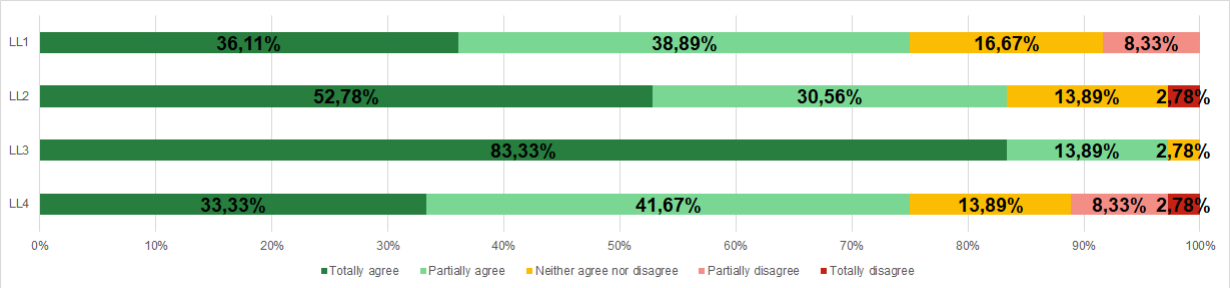

Figure 4: Agreement level of the Learn to learn and Metacognition skills.

5 Qualitative Results

For the qualitative analysis of the data from the second part of the self-assessment questionnaire, we used a subset of the coding phases of the Grounded Theory (GT) method (Strauss & Corbin, 2014), which are open coding (1st phase) and axial (2nd phase). In both phases, coding was performed by one researcher and, later, peer-reviewed together with the professor. This procedure was adopted to resolve discrepancies and disagreements in coding. The 1st phase consisted of separating the data (participants’ citations) into codes, which helped compare the phenomena and make it possible to find the similarities between them. We sought to read the data provided carefully to identify interesting issues at this phase. Each analysis code was named with a phrase that expresses its meaning to the researcher. The 2nd phase consisted of data categorization, where all codes belonging to the same phenomenon were grouped, giving them a greater meaning. In this 2nd phase, the identification and definition of the relationships between the codes were carried out. This process was iterative and allowed the construction of an understanding of the data. In this study, we did not carry out the 3rd phase of the GT (selective coding), which seeks to create a theory, because the rule in the GT is the circularity between the stages of collection and analysis until theoretical saturation is reached (Strauss & Corbin, 2014), being necessary multiple data collection and analysis. This study was the 1st of this research. In our study, the qualitative analysis aimed to identify the benefits of the methodology used in ERT to support the teaching and learning processes and skills development of the 21st century. Students in the first class are represented by codes P1 to P27, and students in the second class with codes P28 to P36. Of these 36 students, P20 to P25 are Computer Science undergraduate students; P26 to P28 are Biomedical Informatics undergraduate studens; P01 to P04, P06 to P08, P12, P13, P16 to P19, P33 and P36 are Master’s students; and P05, P09 to P12, P14, P15, P29 to P32, and P34 are Ph.D. students. In open coding, we identified 149 codes. In the axial coding, 4 categories emerged.The categories identified in axial coding and described in this article are i) Methodology Adopted in the ERT; ii) Support Materials and Resources Used in the ERT; iii) Difficulties and Problems Faced in the

course; iv) Developed Skills.

5.1 Students' Opinion on the Methodology Adopted in ERT

Regarding the methodology of the class defined by the professor, a student commented that it was possible to exercise protagonism through the proposed activities (see a quotation from P25). Another student believes that practical activities were necessary to understand and assimilate the content of the class (see a quotation from P27). In addition, a student shared that the practical activities made it possible to associate and apply the contents of the class in the context of his research (see a quotation from P18). Regarding the class to be carried out remotely, a student said that it was possible to maintain the same experience as the face-to-face classes through technological resources (see a quotation from P21). In sequence, a student said that he had the opportunity to attend the recorded classes several times, which helped his learning (see a quotation from P12). In addition, a student commented that he was able to take advantage of online classes to make the necessary credits for his academic training without having to leave his city or leave his job (see a quotation from P28).

- "*We, students, experience protagonism in the teaching and learning processes. The classes were very well organized, structured and explained [...]*" (P25).
- "*The activities proposed in the class were determining factors for understanding and retaining the content. I had the opportunity to put into practice and experience all the activities*" (P27)
- "*All the works proposed were entirely linked to the content discussed in the synchronous classes, and this facilitated the development of the activities. The learning gain was very significant mainly due to the possibility of associating all activities with the context to which we were already working in our research or at least they were close to our reality [...]*" (P18).
- "*The concepts were well explained in the online class. In my opinion, it was not much different from taking face-to-face classes. The only possible difference would be the feedback and exchange of ideas between students, but this was done through chat on the BBB platform and also, in the case of group activities, through our group on WhatsApp and video calls*" (P21).
- "*Unlike the face-to-face class, the online class made it possible to review as many times as necessary. Therefore, this helped with [remove] doubts during the execution of activities*" (P12).
- "*I entered the doctorate this year already knowing that I could not move to [program city] because of work. I am a professor [at a university] and I need authorization and a replacement for me to go away. As there are no distance classes in the program, I was sure that this year I could get no credit [of discipline]. Unfortunately, we had a pandemic, but the positive thing, which I have removed from the situation, is that I can take important classes for my training*" (P28).

In this sense, we observed that the professor managed to work on some characteristics of Education 4.0 that are important for the development and learning of students. Through the results, we noticed that the students were able to exercise the protagonism, being responsible for their learning. In this way, students could expose their ideas and doubts about the contents and activities with the professor and colleagues during the synchronous class. In addition to practical work, they should prepare before each class. Therefore, they should read supporting materials such as papers and book chapters before the class. In addition, they knew what the professor would teach in subsequent classes. Thus, they could highlight the doubts of the previous readings and ask the professor. In this class, we sought to integrate the contents into the students' research proposals. In this way, learning could be used in addition to classes, helping them with their master's and doctoral researches, or even graduation work. Subsequently, we identified that the class in the ERT allowed students to develop autonomy to learn at their own pace. Therefore, they could revisit the video classes as often as necessary to consolidate knowledge or retrieve valuable information for carrying out their activities. The use of the internet and mobile devices also enabled interactivity and collaboration between them, contributing to receiving feedback and exchanging students' ideas with each other and with the professor. Finally, the classes at ERT brought portability to students, collaborating so that they could reconcile the discipline classes with other work, even being in a different city from the city where the professor teaches the class.

However, we found that some students experienced problems in the ERT modality. Others gave their suggestions to improve the methodology of the class for future classes. Regarding the issues identified, one of the students said that synchronous classes were difficult to follow due to the low internet connection (see a quotation from P3). In sequence, a student said that it was a challenge to focus on synchronous classes due to external distractions, such as websites and family members at home (see a quotation from P1). Moreover, a student believes he does not have the skills to study in the ERT modality (see a quotation from P26). Regarding the suggestions given, one student shared that he would like to have his work evaluated before starting another one (see a quotation from P20). Another student would like to have more weekly classes to answer his questions (see a quotation from P22). Finally, a student suggested adding exclusive synchronous classes to remove doubts (see a quotation from P14).

- "*The classes themselves were difficult to follow due to the quality of my internet, unfortunately. But the availability of classes to attend afterward solved this problem well*" (P3).
- "*It was a challenge to follow the class online, since it is very easy to be distracted by other sites, by the people at home, or by going to the kitchen to get a snack. [...]*" (P1).
- "*Particularly, I don't have the profile to be an ERT student. I have difficulties in organizing my routine. Above all, I now have a good basis for improving my studies. The materials made available will be fundamental for this*" (P26).
- "*I just felt a lack of feedback on the work delivered. I believe that there is a link between the work proposed by the class and that it would be enriching to have feedback on each work before starting the next one, to learn from the mistakes and successes of the previous one and apply it to the next one*" (P20).
- "*I believe I was able to learn the content satisfactorily, but I would like there to be more classes to answer questions about the work. The pace ended up being very busy*" (P22).

- "*Some classes were too long; I believe that there could be a period to clear doubts out of the class period so as not to impact so much*" (P14).

Based on the results, we noticed students with problems with internet access during synchronous classes. However, the availability of video classes helped to mitigate this issue, as they could attend classes later. In addition to the classes taught, students were instructed to look for other information sources and extra readings available on Moodle. Subsequently, doubts could be resolved during synchronous classes (via the BBB platform) or asynchronous classes (via e-mail/chat in Moodle). In sequence, we found that there were students with concentration difficulties. Thus, the variations of practical work allowed active learning, where they could apply and understand the contents practically. On the other hand, we observed students with little autonomy, initiative, and independence in the learning process. We believe that the deficit in these skills ended up hampering the performance of some students in the ERT modality. This deficit reinforces the need to teach students skills and learning to learn to be autonomous and responsible for building their knowledge.

Moreover, we identified that some students would like to have received an immediate assessment of each work before starting a new activity. Even acknowledging the benefit of this action, the speed in delivering grades was not possible for the professor because she had other classes and disciplines in parallel to this discipline and other research and extension activities. The professor also had the support of the assistants who helped in the correction of the practical works. It is worth noting that the assistant was a graduate student who was doing his teaching internship in this discipline. Therefore, the professor corrected the practical works separately and compared them with the corrections made by the teaching assistants, taking more time to make corrections to the students' work. Additionally, the suggestion to add exclusive classes to answer questions was considered interesting. In this way, students could ask questions and perform activities, and be accompanied by the professor during these moments. Even though this did not happen in practice, students could ask questions at the beginning of each class and through the asynchronous approach. We believe that students who had greater communication and participation in the learning process could better use the Experimental HCI class.

5.2 Students' Opinion on Supporting Materials and Resources Used in ERT

Regarding the support materials used, a student said that reading the texts before classes helped him better understand the professor's explanation (see a quotation from P18). Another student said he could dedicate time to reading the texts and carrying out practical activities (see a quotation from P36). In sequence, a student shared that the support materials and questions helped to remove doubts about the contents (see a quotation from P6). Regarding the recorded classes, another student commented that the video classes served as consultation and support for carrying out the work (see a quotation from P4). However, a student believes that video classes should not be transmitted during synchronous classes, as they remove dynamism and decrease the interaction between professor and student (see a quotation from P33).

- "*I believe that the strategy used during the classes has a lot of similarity with the Flipped Classroom, allowing us to read and understand the texts before they were presented in synchronous classes, which helped a lot to make better use of the professor's speech and answer*

questions that they were already better elaborated. All the proposed works were entirely linked to the content discussed in synchronous classes, which facilitated the development of activities" (P18).

- "*[...] for each class ended on Tuesday, I spent time reading the studies suggested for the next class to produce handwritten abstracts that could help me absorb knowledge. I tried to solve all the activities in the most planned way possible. On Wednesday, I met with my co-supervisor to discuss the topics spent in class and how I would carry out the activity, relating it to my research project*" (P36).

- "*I managed to have a very good performance in the class because all the doubts I had I was able to solve by different means: consult the video class, the slides and other extra materials made available. I managed to ask the professor questions via Moodle message. I was able to understand the content of the classes and apply what I learned in my activities*" (P6).

- "*The lessons that were recorded were excellent for me. I managed to do all the work during the week by accessing the classes. As they were very well administered, practically all doubts were resolved. The doubts that remained, I could get in touch at any time via Moodle, and they were answered*" (P4).

- "*I believe that showing the videos takes away much of the dynamism of the classes. The videos could be complementary but not an integral part of the classes. In my view, we could use the face-to-face space for more productive discussions*" (P33).

The classes sought to make the students responsible for their learning with the flexibility to achieve their goals. Thus, the support materials were available for consultation in the Moodle, where students could prepare themselves before the synchronous class, reading and making notes on doubts and curiosities. The communication channels used in the classes were BBB, Moodle, and e-mail. Therefore, students had the option of taking classes asynchronously as well, if preferred. They received video classes, support materials, work instructions, and their questions were answered through the channels. The possibility of the asynchronous approach was helpful for those who did not have a stable internet connection or those who could not attend the day and time of the classes for personal reasons. However, we recognize that the asynchronous approach requires students to have skills such as autonomy, independence, communication, and the ability to learn. Based on the results, we found that students were able to carry out activities normally just by watching video classes. They could revisit the recordings as many times as needed, which may have helped assimilate the content. The doubts that arose were asked by the communication channels without the need to be in the synchronous class. The classes taught for the first class were transmitted in the second class for all students to have the same experience in the class. For some students in the second class, this strategy was not interesting, as they believe that the dynamism of the classes was removed. However, the professor and the assistants were online to answer and address the problems that were arising during the transmission. Before and after the video classes' reproduction, the professor gave orientations and conducted discussions with the students.

5.3 Students' Opinion on Difficulties and Problems in ERT Classes

Regarding the difficulties faced, a student said that it was challenging to collect data for qualitative analysis work due to the time spent in the class, but that he managed to reuse the raw data from a previous work to carry out the activity (see a quotation from P36). Another student commented that it was difficult to carry out the work individually. However, with the help of his colleagues, he became more relaxed about working and delivering the reports (see a quotation from P4). Besides, a student said that his lack of experience with research slowed the process down (see a quotation from P1). Regarding the problems faced, another student shared that the classes could last for a semester so that the works would have more maturity and fewer errors (see a quotation from P16). In sequence, a student commented that there was a short period to carry out the activities (see a quotation from P13). Another student believes that the class was intense and tiring (see a quotation from P3).

- "*I found it difficult to prepare activity of qualitative analysis, I was thinking about how to collect qualitative data in a short time, and that could be meaningful for the activity, and it was at this point that the idea of rescuing qualitative data from a work that I developed in 2017 came up, and thus carry out the qualitative analysis. All the topics presented in the class, meaning in some way. I clearly state that I dedicated myself to all the axes that covered the class, readings, activities, watching and interacting with the classes, really a class that motivated me to rediscover and redo studies that I had declared as completed, as well as the example of the activity of qualitative analysis*" (P36).
- "*I dedicated the weekends to the paper, and it even worked. In week one, it was very difficult. But in the others, when I was in a group, it was calmer, with each one doing their part*" (P4).
- "*I was unable to read all the recommended materials, and the lack of experience in research made the development of activities slower, always requiring periods of reflection and comparison to see if what I was making made sense. But despite these difficulties, I consider that I learned a lot with the class, mainly in the theoretical part, leaving now to exercise more the practical part*" (P1).
- "*Although I feel an evolution in knowledge through practice and experience with activities. I felt that my activities have flaws, that if it were in a normal semester, they would be smaller, as we would have more time to mature and more discussions with the class*" (P16).
- "*The activities were a great opportunity to learn in practice the content presented by the professor. Even though it was a short period for the development of activities (5 days), it was possible to learn by doing and to discover the obstacles related to the development of research, confirming the importance of using a correct methodology*" (P13).
- "*Doing a class intensively is always more tiring than over a semester. Even so, I leave the subject satisfied because I learned a lot and used concepts from the systematic review/mapping of literature for my master's research*" (P3).

In this sense, we observed students who had difficulties in data collection, mainly for qualitative analysis (P36). Due to the pandemic, it became difficult for students to find people to

participate in their pilot experiments. A suggestion from the professor was to apply the study with family members at home or among colleagues remotely to obtain data to simulate qualitative analysis of an experiment. As a solution, some students took the opportunity to re-analyze old works using the techniques and concepts learned in the class. In addition, we identified that some students found it better to work collaboratively, as they could divide tasks, making the experience more profitable and productive. Therefore, the problems identified in the class relate to reduced workload in the ERT period. A strategy adopted by the professor for students to receive the same content as the regular period was less theory and more practical. Thus, the professor sought to make the students active and responsible subjects in constructing their knowledge. Even though some students find this process intense and tiring, due to the variation and sequence of works, they claim that it was possible to learn by doing, and the knowledge may be applied in the future in their graduation, master's and doctoral research.

5.4 Students' Opinion on the Competencies and Skills developed

A student commented that he managed to develop Hard Skills and Soft Skills (see a quotation from P10). Another student believes that he developed a good interpersonal relationship (see a quotation from P26). After, a student shared that he could work as a team and collaborate with his colleagues (see a quotation from P5). Later, another student said that he sought to understand the stages and processes of the work to be used in future activities (see a quotation from P18). Besides, a student said that explaining the work to colleagues helped them understand and learn the contents (see a quotation from P2). Finally, another student shared that the collaborative work developed in an interdisciplinary way allowed for a good experience (see a quotation from P3).

- "*Interestingly, the professor was able to approach the hard skills of research in HCI, but also covered some soft skills such as collaboration and teamwork due to the practical activities carried out in partnership; the flexibility to work in a new format like the remote; and, rigor and organization on how to conduct research activities, highlighted in the examples presented [...]*" (P10).
- "*I am very happy to complete this class. It is one of the first classes that I managed to get involved in well. I got excellent teammates, in which we worked very well together [...]*" (P26).
- "*In the other weeks, when group work was done, it was much better. It was simpler, we managed to divide well. I did the more 'technical' part, another from the team did the more 'grounding' part of writing, and another reviewed everything and made the sentences make sense with each other. Then we can do it in 1 and a half days, and with much less pain*" (P5).
- "*Even though the work was done in trios, I tried to understand all the steps and processes of what each person in my group did so that I can use it as a researcher in the future*" (P18).
- "*I believe that doing a part of the work and having to explain it to the other members of the group helped a lot in the process to understand whether or not we learned the content*" (P2).

- "*The individual activities I did without difficulties. Group activities, mainly because it involves methodologies that are not in my area, required more reading and attention from me. I had a great experience with the colleagues in my group*" (P3).

The students believe that it was possible to develop Hard Skills by practically applying the knowledge of Experimental HCI. In addition, Soft Skills were encouraged through the active learning process defined in the teaching methodology. We also noticed that the students managed to have good interpersonal relationships even remotely. We believe that the students knew each other from other experiences at the university, which may have facilitated socialization among them. Some students recognized the importance of working as a team and sharing tasks to achieve their goals. Moreover, even though it was a collective work, they tried to understand the whole proposal that was being carried out. We identified that this was one of the strategies adopted by students to increase productivity in the delivery of work. One of the skills that stand out is also the ability to learn. Some students could explain parts of the work to colleagues with difficulties, which may have helped better understand the contents. Some students managed to develop the works only with the support materials available in the Moodle, which can demonstrate independence and autonomy in the learning process. Therefore, we observed that the skills allowed the active participation of students and contributed to the implementation of this class remotely.

6 Discussion

We used a virtual Flipped Classroom-based approach, similar to Martinelli and Zaina (2021). Thus, the teacher and her assistants planned and carefully monitored the lessons. One of the challenges of using the Flipped Virtual Classroom approach is related to the problems of low internet connectivity which makes it difficult to participate in synchronous classes. Therefore, it is recommended that teachers check students' internet connections before the course starts (Martinelli & Zaina, 2021). Other works also show that the low quality and reliability of the Internet connection was one of the major obstacles faced by teachers and students in the ERT context (Mohmmed et al., 2020) (El Said, 2021) (Butola, 2021).

In our study, the main problem observed regarding the adoption of the ERT methodology was precisely the connection to the internet, as shared by some students. This problem hampers the collaborative work that requires online meetings to plan and execute activities. For this reason, students were not required to work collaboratively. We observed that the asynchronous approach was helpful for those who did not have a stable internet connection or those who were unable to attend the class day and time for personal reasons. We also observed that the ERT allowed the students to combine the discipline classes with their work, even though they were in a different city from the university, where they are enrolled. We noticed that the students managed to have a good interpersonal relationship within the groups even remotely.

In the literature, we observed that the combination of synchronous and asynchronous activities was well accepted in ERT (Whittle et al., 2020) (Butola, 2021) (El Said, 2021) (Martinelli & Zaina, 2021). Another interesting aspect observed is the contribution of 21st-Century skills to online learning. The authors showed that skills help students deal with their study schedules, develop their continuous learning to solve problems (Martinelli & Zaina, 2021), and choose study content

(Butola, 2021). Furthermore, ERT enabled teachers to also develop their skills through online teaching and learning strategies (Mohmmed et al., 2020). On the other hand, we observed that the poor development of skills, mainly related to the use of digital technologies, hinders learning in the ERT context (Whittle et al., 2020) (El Said, 2021). However, the use of these technologies can improve students' skills, abilities, discipline, and autonomy during ERT (Lima & Isotani, 2022).

In our study, we observed that the lack of autonomy to learn-to-learn impaired the performance of some students. This difficulty occurs especially in the ERT context, where the teacher cannot visualize and follow the activities as she would like and could if it were face-to-face. The asynchronous approach demanded more from students in terms of skills such as autonomy, independence, communication, and the ability to learn. We identified that ERT allowed students to learn at their own pace. Thus, they could revisit the video lessons as many times as necessary to consolidate knowledge or retrieve valuable information for carrying out their activities. In this way, the skills allowed the active participation of students and contributed to the realization of classes remotely.

A problem related to the teaching methodology for ERT was the reduction of the course workload. In this sense, we observed that dividing tasks to achieve the objective was one of the strategies adopted by students to increase productivity and improve their experience in the classes. For the second online class of Experimental HCI, the teacher felt the need to add one more class on SMS to the teaching plan. Among the practical works, the students had more difficulties in the quantitative (fifth week) and qualitative (sixth week) analysis due to the short time to learn the analysis software. However, students believe that they managed to learn by doing, and the knowledge can be applied in the future in their research.

7 Limitations and Threats to Validity

The present study provides evidence of a methodology based on Education 4.0 that can be used in teaching Experimental HCI remotely or in similar disciplines such as Experimental Software Engineering. In this study, we consider the feedback from students. As in all studies, some threats can affect the validity of the results. The threats were categorized according to the approach of (Wohlin et al., 2014). Thus, we identified internal and external, conclusion, and construct threats. Internal and external threats were treated together because there was a remote experience. Furthermore, we tried to mitigate them while conducting the study to reduce possible risks.

- a) Internal and External Validity: The short period of ERT as a response to face-to-face teaching can be considered a threat, as it includes the process of adapting students, assistants, and professors to this type of teaching. In this sense, even if the professor is from the Computing area, adapting to the ERT required experience and effort to prepare support materials, technological test resources, and research ways to personalize the content to engage students in online classes. For the data collection of student feedback, the professor provided a link to the self-assessment questionnaire after the delivery of all works and advised that it would not be worth a grade, reducing the bias of student responses. Moreover, the professor defined five days to answer the questionnaire so that all students could give their feedback, even with unforeseen problems and problems with the internet connection.

- b) Validity Conclusion: The main problem is the sample size, which is not ideal from a statistical perspective. Thus, we recognize the need for more comprehensive research to adapt and suggest a methodology in the context of Education 4.0 that supports professors in remote education. The findings and strategies reported in this study can contribute to future similar situations.
- c) Construct validity: The self-assessment questionnaire for data collection was designed to meet this research. This questionnaire can be considered a threat because a data collection instrument previously validated from the literature was not used. The questionnaire was created by a researcher specialized in Education 4.0 to mitigate the risks of the questionnaire. Moreover, the questionnaire was submitted for two rounds of reviews by two researchers in Experimental HCI with teaching experience. Finally, the three researchers discussed until they reached a consensus on their suitability to be used in the class for data collection.

8 Conclusions and Future Work

This paper presented an experience report on applying the teaching methodology of the Experimental HCI class in the ERT modality. The methodology used Education 4.0 as a parameter. The teaching methodology followed the Flex learning model, which consisted of online classes and offline tasks. In this sense, the role of students was sought through the mediation of the professor. Thus, the professor used the practice of Flipped Classroom in the remote style to encourage self-learning in students. Thus, the students had to prepare for synchronous classes by reading papers and book chapters. The Flipped Classroom Strategy allowed students to receive the same curriculum as in-class teaching, as the subjects of the special ERT period were made more flexible with fewer synchronous classes and more asynchronous activities. In synchronous classes, there were discussions, exposure of the contents, demonstration of the practical application of the theory, and guidelines for weekly activities that consisted of readings and practical work. For the asynchronous approach, students received the recordings of the classes, the specifications of the practical work, papers and book chapters, and suggestions for further reading via Moodle. The classes had a 60-hour workload, with six synchronous meetings of 2 hours each.

No difficulty was reported in using technologies adopted for synchronous and asynchronous classes, such as BBB and Moodle. The problem reported by students was internet access during synchronous classes. However, the availability of video classes and the interaction with the assistants and professor helped mitigate the problem. A guiding question for the construction of the teaching methodology was to prepare students with research skills through the contents of experimental HCI in a practical way, even in the face of the difficulties of the Covid-19 pandemic. A positive factor was that all the participants are from the area of Computing, and somehow have some ease in using the technologies. Therefore, training for the use of these resources was not carried out. Nonetheless, a possible difficulty may be associated with the short time to learn quantitative and qualitative analysis software that is interesting for practical works. For this, the teacher and the subject assistants were available for guidance and to answer questions through communication channels, such as e-mail, chat, and video calls.

Based on the quantitative results, we observed that the students liked to learn the class contents, mainly because it was about subjects related to their academic research regardless of

the area of expertise within Computing. About practical work, we noticed that students had more difficulties performing the quantitative analysis than the qualitative analysis. However, this aspect is understandable, as they had little time to learn how to use the analysis software. Moreover, we found that just reading materials was not enough for some students to understand the content, requiring interaction with the professor. Based on the qualitative results, we identified that some students could learn at their own pace. Therefore, they could revisit the video classes as often as necessary to consolidate their knowledge. Also, we observed that there were students with little autonomy, initiative, and independence in the learning process. We believe that the deficit in these skills hindered the performance of some students in the ERT modality. This reinforces the need to teach students skills and learning to learn to be autonomous and responsible for building their knowledge.

Our methodology can be reused and adapted to other learning contexts, such as face-to-face, hybrid, and e-learning, as it is based on the characteristics of Education 4.0. However, we believe that we would have greater control over the variables in the face-to-face context. The ideal would be to monitor the development of the work more closely to feel the difficulties of the students better, and to help them while they are working. This study represents a first experience of developing 21st-Century skills online in students through practical and collaborative activities, even in the face of the difficulties experienced in the Covid-19 period.

In future work, we intend to include in the course methodology activities that allow students to learn how to prepare their projects for ethical analysis in the Brazilian context, in addition to the preparation of the ICF. We intend to apply this teaching methodology in other classes during the ERT period. Thus, we believe that it will be possible to collect the perception of other students about the adaptation of this methodology, using Education 4.0 as a parameter. Besides, we intend to verify the feasibility of implementing the suggestions for improvements received from students, such as the insertion of exclusive synchronous classes to remove doubts. In extra classes, students could ask questions, produce parts of their work, and receive feedback from the professor. Therefore, even if they did not receive the correction of their assessments immediately, they would support this elaboration of works in the extra classes. This formative assessment given by the accompaniment will allow us to understand and note the real difficulties faced by students in the context of ERT. Furthermore, the formative assessment will contribute to obtain the perception of different students in a complete way, which will strengthen the findings and contribute to a more in-depth discussion about the negative and positive points of this remote teaching methodology. Therefore, we hope that this paper will support professors looking for ways to teach subjects in the ERT modality, allowing for more active learning.

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