Evaluating the Meeting Solutions Used for Virtual Classes in Higher Education during the COVID-19 Pandemic

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Abstract: When the Ecuadorian government put the country into quarantine as a preventive measure against the Covid-19 pandemic the country's schools and colleges had been working normally up to March 2020. On March 13th, the University of Cuenca decided to suspend face-to-face classes and changed the system to virtual online teaching. Although the teachers and students changed the teaching-learning method from face-to-face to virtual, they were not prepared to continue their education in this new educational system, in which each student's family had different mandatory elements (e.g., an Internet connection, computer, meeting solution). However, they continued the classes through meeting solutions to continue the school year through virtual classes but without any criteria to select the most suitable meeting tool. This paper evaluates two of the most commonly used meeting solutions for virtual university classes: Webex and Zoom. We used User Experience Questionnaire and Microsoft Reaction Cards to evaluate these solutions. The results showed that Zoom was significantly more attractive than Webex, although there was no significant difference between them in the classic aspects of usability or user experience.

1 INTRODUCTION

The coronavirus COVID-19 pandemic has had a very strong influence on the development of many areas of society (UNESCO & IESALC, 2020), including education (at all levels) (Crawford et al., 2020) and business (McKibbin & Roshen, 2020). More than 1.5 billion students and young people all over the world are affected by school and university closures due to the COVID-19 emergency (Universities, 2020). According to UNESCO (UNESCO & IESALC, 2020), Ecuador has 5.131.897 learners affected by COVID-19 (see Figure 1). However, the schools in the Ecuadorian coastal area, Highlands and Amazonia run on different schedules.

Just before this pandemic and from September 2019 to July 2020, educational institutions in the Highlands region had been working in the traditional way, i.e., activities were carried out normally at different levels, students and teachers met in classrooms to learn and teach, respectively. However, in March 2020 when the first COVID-19 cases were detected in the country, the situation at all levels of education in Ecuador changed. The country's educational authorities made the decision to quarantine, which meant, among other things, closing schools, colleges and universities to prevent the virus from spreading further among the student population. This decision changed the working environment for both teachers and students, as they had to stay at home.

This paper focuses on higher education with the traditional method (face-to-face), including the University of Cuenca. In this university, in the Faculty of Engineering, before the quarantine, 52% of the teachers used the institution's Moodle-based virtual platform. This group of teachers had each of their courses and all the material required to teach the classes on the virtual platform, which the students were used to using to participate in forums, chats, quizzes, review class presentations, read book extracts, and receive and deliver assignments, although the classes were given face-to-face. It was not necessary to use any tool to maintain communications between teachers and students, except the traditional tools such as email and messaging systems (for example, WhatsApp).

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In a situation where students are not allowed to go to educational institutions, the alternative is to move from traditional to online education. From a technological point of view, the university authorities had to consider some very important aspects when deciding to change the scheme from face-to-face to virtual: (1) the availability of an internet connection in all the students and teachers' homes, (2) the availability of a computer for education, or (3) a mobile device with an Internet connection.

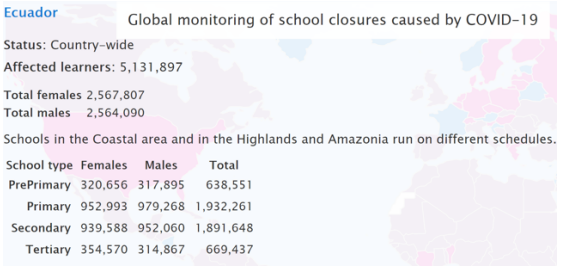

Figure 1: Global monitoring of school closures ((UNESCO & IESALC, 2020)).

In order to teach the students, teachers began to use the meeting solutions (also called collaboration platforms that support live-video communications) available at the University of Cuenca, including Zoom and Webex. Other tools that have also been used are Google Meet, and BigBlueButton by Moodle. Before the pandemic, both teachers and students were unfamiliar with systems such as Zoom and Webex to dictate/attend a class, as Skype, Hangout or WhatsApp were typically used to communicate with others.

In this context, we were interested in analysing how well the meeting solutions supported users in teaching-learning activities. We evaluated usability and user experience (UX) when the students used Zoom and/or Webex for their education. According to ISO 9241-210 (ISO, 2010), UX is defined as "user's perceptions and responses that result from the use and/or anticipated use of a system, product or service". ISO 9241-11 (Bevan & Carter, 2016) defines usability as "the extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use".

The major contribution of this work is as follows: We conducted usability and UX evaluations of two meeting solutions used in some courses in the Engineering Faculty in University of Cuenca (Ecuador) in order to get to know the students' experience when they use them for classes.

[3] https://www.worldbank.org/en/topic/edutech/brief/how-countries-are-using-edtech-to-support-remote-learning-during-the-covid-19-pandemic

2 BACKGROUND

We use Zoom and Webex because these tools are available in University of Cuenca for virtual classes.

Webex facilitates teaching, learning, and collaborative administration anywhere and at any time. Video conferencing is delivered with a software-as-a-service (SaaS) model through the Cisco Webex Cloud. This tool was announced by Cisco as a free access tool for the Covid-19 pandemic, Webex supports up to 100 users and includes a security scheme.

Zoom is a multiplatform meeting solution with a cloud platform for video and audio conferencing, collaboration, chats and webinars and can be used across computers (e.g., desktops, laptops), mobile devices, and telephones. Its features like chatting, screen sharing, annotating, whiteboard, polling, breakout rooms, raising the hand, and managing participants, lend themselves to creating engaging virtual hybrid classrooms and collaborating on projects. Users have the option to record sessions (Reimers et al., 2020). The free edition permits meetings of 40 min of duration. The University of Cuenca has licenses for both Zoom and Webex which made it easier for us to carry out this research work.

3 RELATED WORK

In this section, we review related works about the evaluation of UX and usability of meeting solutions used in the context of virtual education.

In a search of the related literature we found some papers (Basilaia & Kvavadze, 2020), (Reimers et al., 2020) and web sites[3,4] reporting on the situation of the education during to COVID-19 and the need to decide on a meeting solution, although only a few videoconferencing problems were reported (e.g., (Levinsen et al., 2013), (Martin, 2005), (Ørngreen & Mouritzen, 2013) and (Weitze et al., 2013)). (Khalid & Hossan, 2017) described a case of summative and empirical usability evaluation methods of a dedicated Video Conference System in university classrooms. However, this study did not analyze the Zoom and Webex tools and excluded user experience.

(Correia et al., 2020) describe the evaluation of Zoom, Skype, Microsoft Teams and WhatsApp in the context of the COVID-19 pandemic. They conducted an analytic evaluation focused on usability inspection

[4] https://elearningindustry.com/virtual-classrooms-role-during-covid-19-pandemic

using the Quality in Use Integrated Measurement (QUIM) model proposed by (Seffah et al., 2006). These authors do not include Webex in their work. Additionally, (Singh & Soumya, 2020) describe an updated comparison between Zoom, Microsoft Teams, Google Meet, Webex Teams and GoToMeetings, however, this work do not include any evaluation about usability or UX. Finally, (Pal & Vanijja, 2020) describe their work about evaluation of usability of Microsoft Teams by means of TAM (Davis, 1989). They do not include an evaluation of Zoom and Webex.

As the existing literature lacks sufficient methodological guidance for a usability evaluator to conduct a study in the classroom of an educational institution, our objective was to carry out a user-centered exploratory study to evaluate usability and UX. To the authors' best knowledge, no papers have been published on Zoom and Webex usability studies or UX for teaching-learning activities in higher-education.

4 TOOLS TO EVALUATE USER EXPERIENCE

We used Microsoft Reaction Cards (MRC) (Tullis & Stetson, 2004) and UEQ (Hinderks et al., 2020) to evaluate the UX of 79 students of the Faculty of Engineering of the University of Cuenca who used Zoom and Webex for their virtual classes during COVID-19 pandemic.

Product reaction cards were developed by Microsoft as part of a "desirability toolkit" created to understand the illusive, intangible aspect of desirability of UX with a product. 60% of the set of 118 cards contains positive and 40% negative or neutral words. This ratio is based on Microsoft's analysis of higher-than-average positive responses from participants in completing post-test questionnaires. Table 1 shows an extract of the cards.

Table 1: An extract of the MRC card set.

Accessible	Creative	Fast	Meaningful
Advanced	Confusing	Flexible	Motivating
Annoying	Difficult	Fragile	Not Secure
Appealing	Dated	Fresh	Novel
Boring	Desirable	Fun	Stable

UX is seen as a holistic concept that includes all types of emotional, cognitive or physical reactions concerning the concrete or even only the assumed usage of a product (Laugwitz et al., 2008). The UEQ considers aspects of pragmatic and hedonic quality (Schrepp et al., 2017). Perspicuity, Efficiency and Dependability represent ergonomic quality aspects, while Stimulation and Novelty represent hedonic quality (Laugwitz et al., 2008). The scales of the questionnaire cover a comprehensive impression of UX. Both the classical (efficiency, perspicuity, dependability) and UX aspects (originality, stimulation) are measured.

The UEQ consists of 26 items grouped into 6 scales (see Table 2).

Table 2: An extract of UEQ.

	1	2	3	4	5	6	7	
annoying	o	o	o	o	o	o	o	enjoyable
creative	o	o	o	o	o	o	o	dull
valuable	o	o	o	o	o	o	o	inferior
boring	o	o	o	o	o	o	o	exciting
fast	o	o	o	o	o	o	o	slow

Each item consists of a pair of terms with opposite meanings. The items are scaled from -3 to +3, e.g., -3 is the most negative answer, 0 is neutral, and +3 the most positive (Schrepp et al., 2017). The 26 items in the questionnaire are arranged into six scales (Hinderks et al., 2018).

- *Attractiveness*: Overall impression of the product. Do users like or dislike it? Is it attractive, enjoyable or pleasing?
- *Perspicuity*: Is it easy to get familiar with the product? Is it easy to learn? Is the product easy to understand and unambiguous?
- *Efficiency*: Can users solve their tasks without unnecessary effort? Is the interaction efficient and fast? Does the product react to user input quickly?
- *Dependability*: Does the user feel in control of the interaction? Can he or she predict the system's behaviour? Does the user feel confident when working with the product?
- *Stimulation*: Is it exciting and motivating to use the product? Is it enjoyable to use?
- *Novelty*: Is the product innovative and creative? Does it capture the user's attention?

5 EVALUATING USER EXPERIENCE AND USABILITY

5.1 Goal

Analyse the meeting solutions ***for the purpose of*** carrying out a comparative evaluation ***with respect to*** its usability and UX ***from the point view of*** the researchers ***in the context of*** the School of Computer

Science in the Faculty of Engineering of the Universidad of Cuenca (Ecuador).

5.2 Research Questions

In order to study this general goal, we define two research questions:

- RQ1: *When participants have meetings through the selected tools, is their usability perception impacted?*
- RQ2: *Which of the two tools has a higher degree of user experience?*

To answer these research questions, we carried out one user-centred exploratory study to evaluate usability and UX.

5.3 Hypotheses

We defined two hypotheses. The null hypotheses (represented by a 0 in the subscript), which corresponds to the absence of an impact of the independent variables on the dependent variables. The alternative hypotheses involved the existence of such an impact and are the expected result.

- H_{10} Meeting solution does not influence the usability perception (RQ1).
- H_{20} Meeting solution does not influence the UX (RQ2).

5.4 Variables and Metrics

We consider only one independent variable (a.k.a. factor (Juristo & Moreno, 2010)) the meeting solution (Webex and Zoom). As dependent variables (a.k.a. response variables (Juristo & Moreno, 2010)), we considered usability and UX, which were expected to be influenced to some extent by the independent variable.

5.5 Experimental Context

The study was conducted from 20th June to 20th July 2020. The teaching-learning activities of the study programs were given through meeting solutions. The integration, installation, and positioning of various components of the meeting solutions depend significantly on the different factors associated with the students. The main components required in this study included a camera, a monitor, speaker, microphone and Internet connection.

5.5.1 Subjects

The set of experimental subjects was selected by convenience sampling, i.e., the nearest convenient persons were selected as subjects. Seventy-nine Computer Science students (84% males and 16% females) were invited to participate in the experiment. Participations was anonymous (aliases were used instead of names). The subjects did not receive explicit training on the meeting solutions. A demographic questionnaire was applied for the purpose of characterizing subjects according to age, gender, study level, internet connection quality and experience with the different meeting solutions used in the study (see summary in Table 3).

Table 3: Summary of the results of the demographic questionnaire.

Gender	**%**	**Age**	**%**
Male	84%	18-20	31.6%
Female	16%	21-23	57.9%
		>=24	10.5%
Studies Level	**%**	**Quality of Internet Connection**	**%**
1st year	15.8%	Bad	10.5%
2nd year	22.8%	Not good	45.6%
3rd year	52.6%	Good	35.3%
4th year	7.0%	Very good	8.6%

The results of the demographic questionnaire show that the subjects were between 18-20 (31.6%), 21-23 (57.9%) and more than 24 years old (10.5%) comprising 1st year (15.8%), 2nd year (22.8%), 3rd year (52.6%) and 4th year (7%) Computer Science students. Before quarantine, 87% of the students had not used meeting tools such as Zoom or Webex for classes or to participate in a course, while the remaining 13% had some experience in this field. However, after March 13th, all the students began to familiarize themselves with both tools of the Moodle-based virtual platform. Another important detail was related to the quality of the students' home Internet connection. According to the questionnaire, only 8.6% had a very good Internet connection. 35.3% had a good connection, 45.6% had a not good connection and 10.5% a bad. This factor could have had an impact on UX when using Zoom or Webex.

5.5.2 Experimental Design

A within-subject design was selected for the experiment. This design equates the conditions by using the same participants in each condition, which removes individual differences. The order in which the subjects tested the different meeting solutions was randomized. The participants were divided into four groups from the four years of the Computer Science

course and all used Zoom and Webex to perform the tasks specified in the teaching-learning process.

5.5.3 Experimental Procedure

The empirical study began with a short presentation in which general information and instructions were given, after which the demographic questionnaire was applied. The tasks involved in the evaluation were: attending classes, working in groups and sharing screens. The tasks took approximately twenty minutes, using Webex and Zoom on different days. After completing the tasks, they used MRC and UEQ to evaluate UX and usability. In MRC, they selected five positive and five negative adjectives for both meeting solutions and in UEQ they evaluated UX.

6 RESULTS

6.1 UEQ Results

In the next step, we gave to the subjects the UEQ to evaluate their UX of the meeting solutions to stay in class. From the answers of the questionnaire and UEQ tool (available in the UEQ)[5] we obtained the results of classical usability aspects (efficiency, perspicuity, dependability) and UX (originality, stimulation).

The results obtained from the UEQ related with classical usability aspects (perspicuity, efficiency, dependability) are shown in the bar diagram (Figure 2 (a)), where the bars on the left are those of Zoom and those on the right from Webex. Efficiency was given a negative value for both tools (Zoom: -0.32 and Webex: -0.24). We also used a bar diagram to describe the UEQ UX results (stimulation and novelty). (Figure 2 (b)).

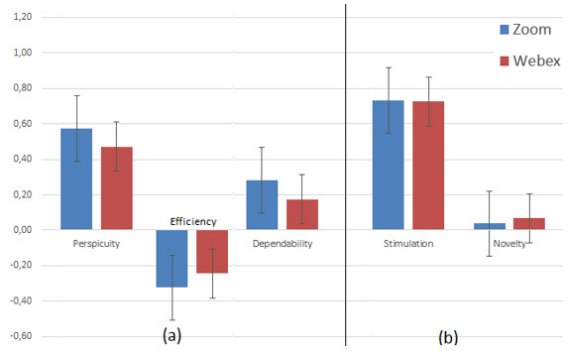

Figure 2: Results of (a) classical usability aspects, (b) user experience.

[5] https://www.ueq-online.org/

Table 4: Comparison of scale means.

Scale	N	Zoom			Webex	
		Mean	Std.		Mean	Std.
Attractiveness	79	0.86	0.59		0.41	0.79
Perspicuity	79	0.57	0.77		0.47	0.70
Efficiency	79	-0.32	0.58		-0.24	0.60
Dependability	79	0.28	0.56		0.17	0.54
Stimulation	79	0.73	1.08		0.72	1.08
Novelty	79	0.04	0.63		0.07	0.66

Table 4 includes the Zoom and Webex results after applying the statistics to the UEQ values. Table 5 shows a simple T-Test to determine whether the scale means of the two meeting solutions differed significantly (alpha level 0.05). It can be seen note that there is not significant difference in the aspects for classical usability or in UX aspects between both meeting solutions. Regarding the attractiveness, it can be seen there is a significant difference between Zoom and Webex.

Table 5: T-test results obtained with UEQ tool.

Alpha level:	0.05	
Attractiveness	0.0001	Significant difference
Perspicuity	0.3900	No significant difference
Efficiency	0.3978	No significant difference
Dependability	0.2190	No significant difference
Stimulation	0.9707	No significant difference
Novelty	0.7821	No significant difference

6.2 MRC Results

Table 6 shows the results obtained from MRC on UX with two groups of values classified as positive and negative adjectives for each meeting solution. The results obtained in the Zoom user experience evaluation by MRC are classified in two groups: (i) the five highest scored positive adjectives (Figure 3**)**: efficient (11.4%), comprehensive (8.1%), fast (6.1%), useful (5.3%) and responsive (4.8%). (ii) The five highest scored negative adjectives (Figure 4): slow (8.6%), not secure (8.4%), boring (7.3%), rigid (4.8%), and stressful (4.3%).

Figure 3 gives the results obtained from the Webex evaluation of UX by means of MRC. The five highest scored positive adjectives are: efficient (7.34%), comprehensive (6.58), useful (6.58), secure (6.08) and responsive (4.81%), while Figure 4 gives the five highest scored negative adjectives: slow (12.2%), boring (10.4%), stressful (5.6%), not secure (4.3%), rigid (4.1%), unattractive (4.1%) and inconsistent (4.1%).

Table 6: The five highest scored positive and negative adjectives for MRC.

The five highest scored positive adjectives		
Adjective	**Zoom (%)**	**Webex (%)**
Efficient	11.4	7.3
Comprehensive	8.1	6.6
Fast	6.1	4.2
Useful	5.3	6.6
Responsive	4.8	4.8
Secure	3.5	6.1
The five highest scored negative adjectives		
Slow	8.6	12.2
Boring	7.3	10.4
Stressful	4.3	5.6
Not secure	8.4	4.3
Rigid	4.8	4.1

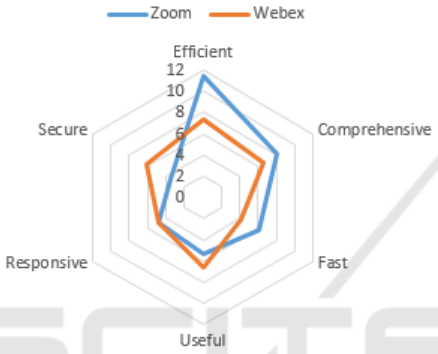

Figure 3: The five highest scored positive adjectives for Zoom and Webex obtained by applying MRC.

Figure 4: The five highest scored negative adjectives for Zoom and Webex obtained by applying MRC.

7 ANALYSIS OF RESULTS

7.1 UEQ

We considered the results obtained with UEQ to answer the research questions:

Usability is related with three factors: efficiency, dependability, and perspicuity. From the results obtained in the evaluation, described in the Table 5 and shown in Figure 2, we can see that there is no significant difference between using Zoom and Webex for classes. However, the efficiency values obtained in the evaluation are negative: -0.24 for Webex and -0.36 for Zoom. This implies that the participants had to make an effort to follow their classes using both meeting solutions, although less effort was required with Webex than Zoom. The other two factors (dependability - Does the user feel confident when working with the product? and perspicuity - Is it easy to get familiar with the product?) obtained very similar mean and SD values, which means that students found it easy to become familiar with both meeting solutions and felt confident in using them.

UX is related with two factors: originality and stimulation. According to the results obtained in the evaluation, there is no significant difference in the UX between Zoom and Webex for classes. The results obtained for the originality (Is it exciting and motivating to use the product?) and stimulation or novelty (Is the product innovative and creative?) have similar values, showing that the students regarded these tools as a novelty. They also saw these solutions as innovative and considered that they help them resolve their current situation of not being able to attend classes. In both cases, the null hypotheses proposed in our work were accepted.

7.2 MRC

From the analysis of MRC results to determine the users' opinion, the following can be said: (i) using positive adjectives to compare both meeting solutions, we can conclude than Zoom is considered more efficient than Webex (Figure 3). The participants considered Zoom more useful, responsive and faster than Webex.

Considering the negative adjectives (Figure 4), we can conclude that the participants considered Zoom to be less secure than Webex, although Zoom was considered less stressful than Webex. Regarding the negative adjective "Slow", Webex was slower than Zoom. This result could have been influenced by the quality of the participants' Internet connection. In the answers to the demographic questionnaire 56.1% said that their Internet connection was "bad" or "not good".

The "attractiveness" factor measures the overall impression of the product and answers the question "Do users like or dislike it?" The participants had a better impression of Zoom that Webex and they like preferred it for virtual classes (Figure 5, blue bar: Zoom, red bar: Webex).

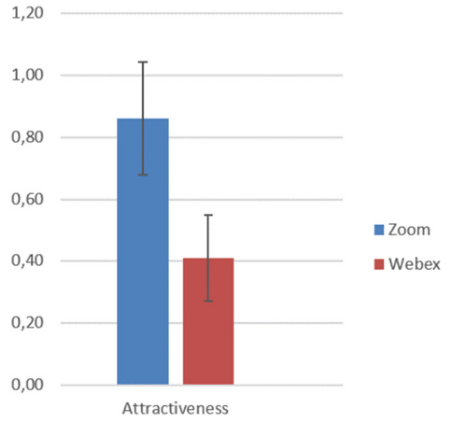

Figure 5: Results of attractiveness obtained from UEQ tool.

8 VALIDITY THREATS

In this work, we considered some validity threats which could have influenced the UX and usability results.

The threats to the validity of the **conclusions** are concerned with issues that affect the ability to draw the correct conclusion about the relations between the treatment and the outcome of an experiment.

a) **Reliability of Measures:** The validity of an experiment is highly dependent on the reliability of the measures. In general, objective measures are more reliable than subjective measures. In order to reduce this threat, we used the tested UEQ and MRC for measuring UX and usability. However, in this experiment, the precision of efficiency may have been affected by the participants' different qualities of their Internet connection and devices.
b) **Reliability of the Application of Treatments to Subjects:** The application of treatments to subjects should be as standard as possible for different subjects and occasions. This factor could have been affected since the evaluations were carried out on different occasions. To ensure maximum similarity, a standard procedure was designed to be similarly applied by the experimenter on each occasion. In addition, as the subjects' perception could have been affected by the order and time of the evaluation, the tasks were assigned randomly with the purpose of diminishing this threat.

Threats to **internal** validity concern issues that may indicate a causal relationship even though there is none.

a) **Instrumentation** refers to the effect caused by the instruments used in the experiment. If these are badly designed, the experiment is affected negatively. To minimize this threat, all the instrumentation and tasks were pre-validated by two persons. Furthermore, UEQ and MRC forms were provided in web form, the data collection and the statistical analysis was double checked. We also used the UEQ tool available on the UEQ website to get the results of the classical aspects of usability and UX.

Threats to **external** validity concern the ability to generalize experiment results outside the experiment setting.

a) **Interaction of Selection and Treatment:** This is the effect of not having a representative population from which to generalize the results of the experiment. This factor could have affected the experiment results since the subjects had similar levels of experience in using the different meeting solutions. Further experiments with a more heterogeneous sample of subjects will be necessary to confirm the results obtained.
b) **Interaction of Setting and Treatment:** This is the effect of not having representative material. In the experiment we carefully selected a representative task. However, more empirical studies with other tasks could also be necessary. Regarding the selection of the meeting solutions, we consider that Zoom and Webex are representative solutions we plan to replicate this experiment with other meeting solutions for teaching-learning activities.

9 CONCLUSIONS AND FUTURE WORK

The aim of our research work was to get an overall picture of the usability and UX of two meeting solutions used in a virtual teaching-learning environment during COVID-19 pandemic.

Applying the UEQ and Microsoft Reaction Cards we obtained results that indicated that Zoom was considered significantly more attractive than Webex. However, there was no significant difference in the classic aspects of usability and UX. As our study only covered the Faculty of Engineering, we will extend our research to all the faculties at the University of Cuenca to measure the impact of COVID-19 on the educational process when the teaching method is changed from face-to-face to virtual. Different stakeholders have different usability goals because they are involved in different activities (teaching sessions, laboratory practices, technical support, interview with students, etc.) and this can affect the evaluation of usability.

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