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RESEARCH PAPER

Evaluation of the Learner eXperience of HCI course in a Collaborative Context: an Exploratory Study and Lessons Learned

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Abstract. Evaluating Learner eXperience (LX) in collaborative educational settings allows identifying how communication, coordination, and cooperation among peers influence learning, engagement and the construction of knowledge. In the sinse, the aims of this article is to present a study that evaluates LX, as well as to share feedback and insights from the instructor and a learner assistant in a collaborative learning environment supported by interactive systems. This study was conducted the Human-Computer Interaction (HCI) course, involving learners and two practical works: a usability, UX, and accessibility evaluation of a Brazilian Sign Language (Libras) translation app; and the specification, modeling, prototyping, and evaluation of an app for use by visually impaired individuals. Perceptions were collected from learners, the professor, and a assistant learner in the course regarding the observed and lived experiences. Additionally, a questionnaire was applied to the learners for LX evaluation. The data were analyzed quantitatively and qualitatively. The results show that interactive systems positively supported learner interaction by fostering knowledge exchange, creativity, and a more critical perspective. These findings reinforce the importance of evaluating educational systems that promote communication, coordination, and cooperation, contributing to the advancement of LX research within the HCI field.

Keywords: Learner eXperience, HCI, Practical Work, Lessons Learned, Exploratory Study, Collaborative Context

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1 Introduction

The use of interactive systems by users with diverse abilities and for a wide variety of tasks has increased [Coleti and Morandini, 2012]. This growth demands constant preparation by computing professionals for the development of interactive systems and concern for the impact on users' lives [Barbosa *et al.*, 2021].

In this context of growing demand, it is essential to reflect on the training of these learners, especially with regard to the teaching of the course of Human-Computer Interaction (HCI). HCI is defined as a course concerned with the design, implementation, and evaluation of interactive computer systems for human use, as well as investigating the phenomena surrounding the use of these systems [Preece *et al.*, 2015].

When considering the teaching HCI, the importance of peer collaboration in knowledge construction stands out, as it allows learners to share experiences, discuss challenges, and develop joint technological solutions [Kaptelinin and Nardi, 2009]. This exchange between colleagues enriches the learning process by providing multiple perspectives and fostering an active and engaged environment. Such practices are fundamental for training learners capable of facing the dynamic and complex challenges involved in the field of HCI [dos Santos *et al.*, 2025b]. In addition to promoting the development of technical and social skills, the teaching of HCI also provides a opportunity to investigate the Learner eXperience (LX) in collaborative educational contexts supported by interactive systems. LX, a concept derived from User eXperience (UX) [Kawano *et al.*, 2019], focuses on understanding learners' perceptions, emotions, and interactions during their learning processes mediated by technology [Huang *et al.*, 2019]. Evaluating LX in collaborative educational settings allows identifying how communication, coordination, and cooperation among peers influence learning, engagement and the construction of knowledge [dos Santos *et al.*, 2025a]. In this sense, interactive systems used in HCI courses not only mediate tasks and group projects but also shape the individual and collective experiences of learners.

The aims of this article is to present a study that evaluates LX, as well as to share feedback and insights from the instructor and a learner assistant in a collaborative learning environment supported by interactive systems. To achieve this objective, two steps were taken. The first involved sharing feedback and insights from the instructor and a learner assistant. The second step evaluated LX in a collaborative learning context. The study was conducted in the HCI course offered to the Computer Science and Biomedical Informatics program (CS & BI) at the Federal University of Paraná (UFPR) in Brazil. The objective of the course was to enable learners by offering basic notions of HCI from a socially conscious and software project-oriented perspective. The course employed a strategy of expository-dialogued classes, allowing learners to actively participate in discussions on HCI topics. The course was organized through two Practical Works (PWs) carried out in groups. The details of the PWs were presented to allow their replication in other HCI educational contexts, supporting instructors who wish to adopt active and project-oriented approaches in teaching the course. PW1 consisted of evaluating the HandTalk app[1], and consolidating this evaluation in a group. PW2 consisted of the specification, modeling, prototyping, and evaluation of a prototype app to be used by people with visual impairments. Each PW followed a series of steps with specific instructions, using suggested tools, and learners submitted detailed reports at the end of each PW.

In addition, this article present discover new and relevant insights for the assessment of LX when using interactive systems in a collaborative context. The study aimed to answer the research question: "What are the perceptions and experiences of HCI learners regarding communication, coordination, and cooperation when using interactive systems in a collaborative context?". The study consisted of collecting feedback from the learners through a questionnaire, applied after the PWs had been completed and developed based on the 3C model (communication, coordination and cooperation) [Fuks *et al.*, 2008]. The learners' responses were analyzed quantitatively and qualitatively. Based on the results, it stands out that the learners valued the practical work as being collaborative. This context enhanced some experiences when using interactive systems, such as the exchange of knowledge among group members, group bonding, stimulated creativity, and a more critical view of the learners. Furthermore, limitations were identified regarding the interactive systems used, and the strategies used to form the groups, without considering the learners' abilities.

It also presents of the learners, the instructor, and a learner assistant of the HCI course regarding the experiences observed and lived. PWs were analyzed to identify the difficulties faced by learners. Difficulties such as the creation of Personas and hypothetical Scenarios were observed, as well as challenges in collecting real data from users in the assessments. On the other hand, it was found that the combination of different evaluation techniques and methods enriched both the evaluation process and learners' learning. Thus, contribute with by presenting lessons learned and good practices so that other instructors and researchers can make classes more dynamic and promote greater learner engagement, contributing to more meaningful HCI learning.

This article highlighting how the use of interactive systems supports communication, coordination, and cooperation among learners during group work. By integrating the exploratory findings with the course implementation, this article aims to connect practice and analysis, offering a more comprehensive understanding of how LX collaboration and interaction within HCI education. In addition, this work presents didactic-methodological practices that integrate theory, situated practice, and social values, aligning with contemporary discussions on new theoretical and methodological approaches in HCI, according to Grand Challenge Nº.1 [da Silva Junior *et al.*, 2024].

Furthermore, combining feedback and observations from the instructor and a learning assistant, along with LX assessment, provides insights into how learners perceive the quality of interaction through digital tools, their roles within groups, and the emotional and cognitive aspects of teamwork. This approach strengthens the understanding of how collaborative strategies and interactive technologies impact learner engagement and satisfaction, reinforcing the relevance of LX evaluation in HCI education.

This article is an extended and revised version of the paper published at IHC 2025 [dos Santos and Valentim, 2025] is organized into the following sections. Section 2 presents related works. Section 3 presents the background. Section 4 presents teaching methodology of the HCI course. Section 5 presents the exploratory study. Section 6 presents the results with the perceptions of the instructor and the learner listener, and feedback from the learners. Section 7 presents the discussions and lessons learned. Section 8 presents the final considerations and future work.

2 Related Work

This section presents papers that report experiences in the HCI course in different contexts. Oliveira [2020], for example, present an experience report on emergency remote teaching in the HCI course due to COVID-19 pandemic. The course was offered in the first semester of the Information Systems program and enrolled 28 learners. The instructor proposed an activity to the learners through a PW. The PW consisted of developing a technological solution for people aged 60 years or older. This technology should help this audience in times of social isolation. It could be an app, a game, or another type of tool. As a result, it was expected that through this PW, learners would work in a real situation through the interaction design process and develop social-emotional skills, such as teamwork. In general, the final product resulting from the PW sought to promote digital inclusion and accessibility and the social well-being of the elderly, in addition to raising learners' awareness of the importance of offering a social contribution to the surrounding community.

Marques and Melo [2015] present a report on their experience teaching the HCI course offered in the fifth semester of the Computer Science program. This report is based on an interdisciplinary approach involving the courses HCI, Database Modeling and Design, and Systems Design. For the project, the HCI course focuses on user-centered interaction and interface design. The Database Modeling and Design course covers the data to be stored and manipulated by the system. And the Systems Design course focuses on the architecture and functionalities of the developed system. Through this project, learners worked on the three aspects of system development in an integrated manner. In general, by promoting this interdisciplinarity, it was expected that learners would have an experience closer to professional reality.

Miranda *et al.* [2019] present a report on their experience with assessment activities conducted in the HCI course of the Information Systems program. The assessment activity was carried out using gamification strategies. Thus, for the activity, learners were asked to redesign the WhatsApp app interface using HCI practices in order to insert regional and cultural elements from the city of Cametá, in the state of Pará. The strategies used were: phases and challenges, medals, scoring, and ranking. The instructor's perspective is on teaching the gamified HCI course, and the learner's perspective is on learning feedback. In general, competition and medals were differentiators for the course, enriching learners' interest in the area of HCI.

[1] `https://www.handtalk.me/br/`, Accessed: 13 July 2026.

More recently, Zhang *et al.* [2025] investigate the use of LLM (Learning Learning Machine) based AI (Artificial intelligence) in collaborative learning through classroom debates. The study was conducted with 22 learners over four weeks in a Design History course, in which learners participated in structured debates supported by ChatGPT. The results show that AI can enhance collaborative learning by providing scaffolding, supporting argument construction, reducing social anxiety, and facilitating communication among learners. However, the study also highlights challenges such as information overload, cognitive dependency, and reduced learner autonomy. In addition, the authors identify emerging collaboration patterns in human-AI teams, including role distribution (e.g., AI user, information gatherer, evaluator), and different strategies for interacting with AI-generated content. Overall, the findings suggest that while AI can support fast-paced collaborative learning scenarios, its integration requires careful design to balance support and critical engagement.

Like the works of Oliveira [2020] and Marques and Melo [2015], this paper presents a methodology based on experience reports in the HCI course. However, it differs in that it adopts a strategy of expository-dialogued classes and focuses learning on the completion of two PWs. These PWs allowed learners to identify socio-technical factors in the problem domain and propose interactive computational solutions, in addition to fostering a critical and socially responsible attitude towards the technologies developed. In contrast to studies that integrate emerging technologies into collaborative learning contexts, such as the use of LLM-based AI in classroom debates [Zhang *et al.*, 2025], our study does not rely on automated support for idea generation or argument construction. While Zhang *et al.* [2025] emphasize the role of AI in scaffolding learning and mediating collaboration, they also report risks such as cognitive dependency and reduced learner autonomy. Differently, our approach prioritizes situated practice, assessment, and critical enabling grounded in learners' own reflections and interactions. In contrast to the focus on the application of gamification strategies for project development described by Miranda *et al.* [2019], our study prioritized situated practice, assessment, and critical enabling focused on interactive computational solutions. The experience reported here combines collaborative teaching strategies and structured assessment, aiming to strengthen learners' skills and prepare them for the challenges of the HCI field.

3 Background

This section presents the definition of LX, as well as its main characteristics and evaluation elements. It also introduces studies that assess LX in different educational contexts and highlights its application in collaborative contexts. Finally, it presents the collaborative elements considered in this exploratory study, based on the 3C model, which guides the evaluation of LX in group-based interactions through interactive systems. By combining both perspectives, this work contributes to a growing but still limited body of research that integrates LX and collaboration models in the field of HCI.

3.1 Learner eXperience

Learner eXperience (LX) is a concept derived from User eXperience (UX) [Kawano *et al.*, 2019]. The definition of UX, as presented by ISO 9241-210 [2019], is user perceptions and responses that result from the use and/or anticipated use of a system, product, or service. LX focuses on a specific class of user (the learner) engaged in a specific task (related to learning) while using a distinct type of technology (a technological tool designed for learning) [Huang *et al.*, 2019; Schmidt and Huang, 2022; dos Santos *et al.*, 2025a; Silva *et al.*, 2023]. In other words, LX is concerned with the learner's perceptions and responses, involving behavior, attitudes, beliefs, sensations and emotional responses [Shi, 2014]. Thus, LX and UX are interconnected, sharing the goal of improving the quality of interaction, but applying this goal in different domains.

In this sense, the need was identified to create and support learners in LX in activities, seeking protagonism in the learning process [Soloway *et al.*, 1994; Correa *et al.*, 2021]. Thus, the term Learner is used to refer to learners who are constantly learning or professionals who put themselves in a position to learn, submitting themselves to all the challenges faced when using interactive systems [Soloway *et al.*, 1994]. Huang *et al.* [2019] explain that LX with interactive educational systems can be analyzed and evaluated through elements. LX elements guide the evaluation process by enabling the analysis of various characteristics of the learning experience, including emotional and affective aspects [Dos Santos *et al.*, 2024a]. Thus, LX elements can vary according to the objective of the evaluation, the type of artifact chosen and the learning theory adopted [Dos Santos *et al.*, 2024a]. Additionally, the LX evaluation Considers issues of how elements might influence learning effectiveness and how perceptual factors might impact learner performance [Schmidt and Huang, 2022; Hanlon *et al.*, 2021; Law *et al.*, 2008; Marcus, 2002].

For example, Kawano *et al.* [2019] present a training design methodology based on Design Thinking and LX, which allows defining learner-centered problems with empathy through the Learner Journey Map. The authors applied a questionnaire at the end of the training to assess LX through the elements Satisfaction, Understanding and Contribution. Nygren *et al.* [2019] evaluated the affective LX of how the use of the mobile game enhanced the learning of fractions in mathematics. The authors considered the LX elements Value, Receive, Respond, Organize and Internalize. Dos Santos *et al.* [2024b] evaluated LX based on 12 LX elements using an evaluation model (Figure 1). The authors' objective was to evaluate LX longitudinally in a face-to-face HCI course. Unlike these studies, this research is concerned with evaluating LX in a collaborative context.

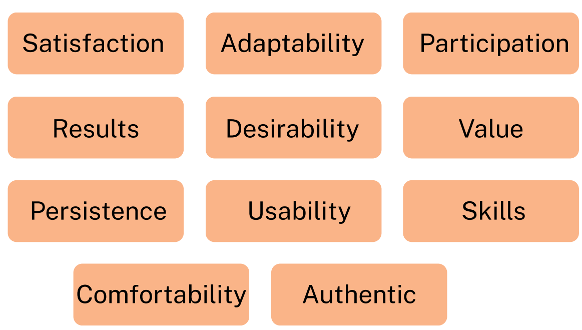


Figure 1. LX elements [Dos Santos *et al.*, 2023, 2024a,b].

LX elements guide the choice of interactive systems based on the objective and scope of the context. In this context, interactive educational systems are one of the factors for improving LX, incorporating elements that promote positive emotions and avoiding unpleasant sensations. This results in more engaging and memorable educational experiences [Huang *et al.*, 2019]. In collaborative learning context, LX becomes relevant as the dynamics of group interaction, mediated by interactive systems, can influence both the quality of engagement and the effectiveness of knowledge exchange among learners. For this research, communication, coordination, and collaboration were considered elements of LX [dos Santos *et al.*, 2025a], which are evaluated in the 3C model [Fuks *et al.*, 2008]. In this sense, the 3C model was not only used as a theoretical reference for collaborative systems, but also adopted as a framework to structure the evaluation of LX in this study, allowing us to analyze the LX through the lens of collaboration.

3.2 3C Model

The 3C model is used for the development of collaborative systems and was initially proposed by Ellis *et al.* [1991]. Ellis *et al.* [1991] show that cooperation is strictly related to operating together. Collaboration involves carrying out all the work, which involves communication, coordination, and cooperation. In contrast, Fuks *et al.* [2008] explain that the three elements should not be addressed in isolation, as they are interdependent. In this sense, the authors defined communication as the exchange of messages; coordination as the management of people, activities, and resources; and cooperation as the execution of tasks in a shared space. We chose to use the version proposed by Fuks *et al.* [2008] because the definitions presented for each element are more aligned with the objective of our research.

According to Figure 2, collaborative systems are positioned in a triangular space, with the vertices representing the elements of collaboration [Fuks *et al.*, 2008]. The space is divided into three elements by the 3Cs. Even though a system's objective may focus on specifically supporting one of the Cs, it will still contemplate aspects of the other Cs.

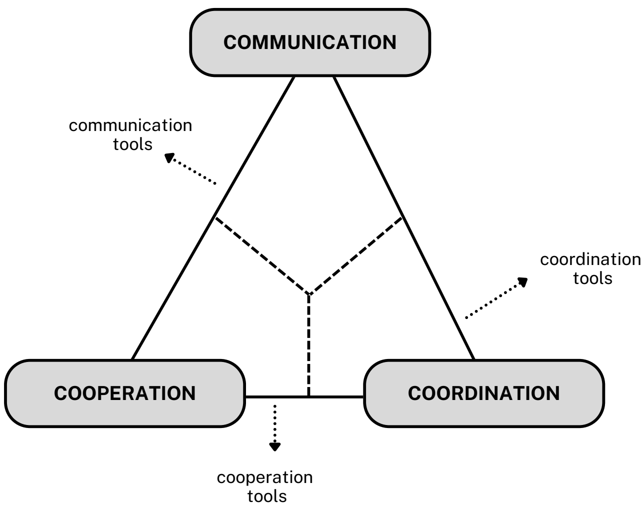


Figure 2. 3C model [Pimentel *et al.*, 2006; Fuks *et al.*, 2008].

Pimentel *et al.* [2006]; Fuks *et al.* [2008] show that, based on the 3C model, it is possible to identify the constituent items of a synchronous communication tool and classify them according to the three elements. The communication includes the following aspects: language (written, spoken, pictorial, or gestural), transmission (one-off or continuous), and categorization (type of speech, discourse, or emotion). The coordination element includes the following aspects: topic (course to be discussed), access (who or how many can take part in the conversation), availability (status of the participant), roles (assignment of roles), frequency, addressing (indication of the recipient) and evaluation (qualification of the messages, participants or discussions). For the cooperation element, there are the aspects: recording (storing messages and discussions) and space configuration (viewing and retrieving messages).

The 3C model has been applied to different interactive systems. For example, Melo *et al.* [2017] presented a collaborative repository aimed at autistic users. They performed an analysis to verify adequate support for collaboration, based on the 3C model. Neto and da Silva [2018] presented a tool to create and provide instructors with an interactive timeline with information about learner interactions in the message and discussion forum tools of Virtual Learning Environments. The authors correlated the results obtained from the tool with the 3C Model. These studies demonstrate the applicability of the 3C model in the context of interactive educational systems, particularly for evaluating collaborative aspects mediated by interactive systems.

For the exploratory study, the 3C model was adopted as a theoretical and methodological foundation for assessing the LX, as it enables the structured identification of how learners interact, organize their work, and perform tasks in a collaborative setting. We chose not to use the 12-element LX model [Dos Santos *et al.*, 2023, 2024a,b] cited in the Subsection 3.1, as they do not focus solely on the collaborative context. Thus the motivation for using the 3C model lies in its ability to capture not only the functional dimensions of group interaction, but also the social dynamics that emerge when learners engage with each other through interactive systems. By aligning the questionnaire with the elements of communication, coordination, and cooperation, it was possible to investigate the learners' perceptions in a comprehensive and consistent manner, thus reinforcing the innovation and relevance of this model for evaluating LX in collaborative educational contexts.

4 Teaching methodology for the HCI course

The HCI course has a workload of 60 hours distributed weekly in four-hour sessions, totaling 30 meetings. To take this course, learners must be in their fourth semester. It is offered to undergraduate learners in the CS & BI programs at UFPR.

The general objective of the course is to provide basic notions of HCI from a socially conscious perspective oriented toward software projects. To assist in achieving the general objective, four specific objectives were presented, namely: (1) learners must be able to identify existing socio-technical factors in the domain of the problem addressed and propose interactive computational solutions that demonstrate an understanding of the identified factors; (2) learners should present a critical and socially responsible view of the proposed solutions and be able to specify it succinctly, developing and evaluating interactive prototypes; (3) learners must demonstrate the ability to work in teams and make decisions informed by theoretical or empirical knowledge; (4) learners must be able to analyze non-functional requirements (usability, accessibility, UX) from an HCI perspective.

Within the scope of the HCI course, the main topics covered are: Introduction to HCI; Basic concepts in HCI; Quality in HCI; HCI theories; Ethics in HCI design; Socially Conscious Design; Participatory Design and Universal Design; Specification, Modeling, and Prototyping in HCI; Prototyping Techniques and Tools; Evaluation in HCI. By attending this course, learners will be able to analyze and consider socio-technical issues in the interface and interaction design of interactive computer solutions.

4.1 Readings and Bibliographies

For this course, the instructor organized some readings for each HCI topic and suggested additional materials from websites, booklets, and articles, some of which were: Web Content Accessibility Guidelines 2.1[2], W3C Brazil Web Accessibility Primer[3], Guidelines for Accessibility, Usability, and User Experience Design in Mobile Applications for People with Visual Impairments [Rosa and Valentim, 2022], The Laws of Simplicity[4], Accessibility Model in Electronic Government [Oliveira and Eler, 2015], Almeida and Baranauskas [2010], Ergonomic Criteria for the Evaluation of User Interfaces by Bastien and Scapin[5], Inostroza *et al.* [2013], Universal Design applied to the web with a focus on accessibility[6], Universal Design applied to the web with a focus on accessibility[7].

The basic bibliographies were: Vieira and Baranauskas [2003], Soegaard and Dam [2012][8], Horizontes Magazine[9] and articles from the Digital Library of the Brazilian Computer Society (SOL)[10]. The supplementary bibliographies for learners interested in furthering their knowledge of the topics presented in the course were: Barbosa *et al.* [2021], Benyon and de Souza [2011], De Souza [2005], and Rebelo [2016].

4.2 Teaching procedures

The classes used a lecture-dialogue strategy. This strategy is characterized by the presentation of content with the active participation of learners, taking into account their prior knowledge, with the instructor acting as a mediator so that learners could question, interpret, and discuss the topic being studied [Hartmann *et al.*, 2019]. Furthermore, the course had two group assignments on the topics covered in class. The course was organized with group assignments so that the problems identified could be discussed and solutions practiced in groups.

Classes were held in person in classrooms and computer labs at UFPR. In this sense, the instructor used a whiteboard/chalkboard, notebook, and multimedia projector as support materials for the course. Furthermore, attendance was monitored based on learner attendance in face-to-face classes and the submission of exercises.

Finally, learners earners were required to register for and attend the course through Moodle C3CL[11], which was used as a virtual classroom where the instructor made materials and readings available. Furthermore, learners could interact, share PWs, and hold discussions through forums.

4.3 Pratical Works

The course was designed around two PWs. For each PW carried out, the groups were required to submit a report and deliver a presentation. The report detailed all the documentation of the PWs' development. The PWs' presentation consisted of a detailed explanation of all the documentation used for the PWs' development to the other learners in the course. Learners were free to form groups with guidance to have four to six members per group. The instructor also instructed learners to remain in the same group to complete both PWs.

4.3.1 *First Practical Work (PW1)*

PW1 consisted of evaluating an application and consolidating the results withing the group, organized into two stages. The first stage was completed individually, while the second second was carried out collaboratively. The first stage consisted of evaluating the HandTalk app[12] available for Android[13] and iOS[14]. The evaluation was performed using the checklist entitled Usability, User eXperience, and Accessibility Checklist for Deaf Assistive Technology (UUXAC-DAT) [Godoi *et al.*, 2020]. Part of the checklist is shown in Figure 3.

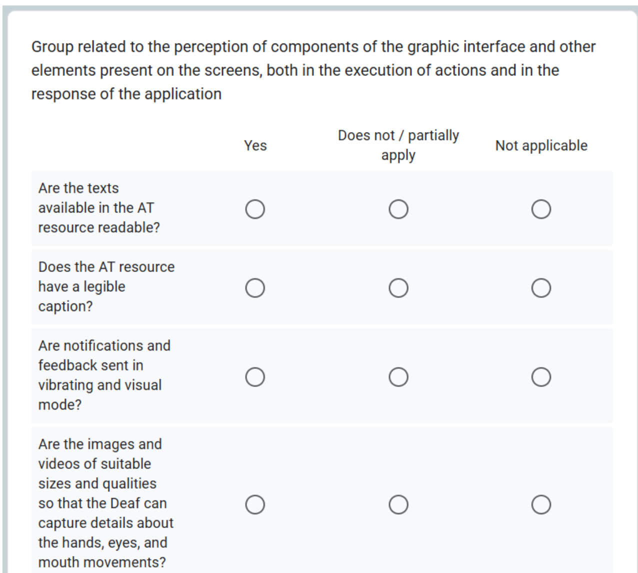


Figure 3. Part of the UUXAC-DAT evaluation checklist.

[2] `https://www.w3c.br/traducoes/wcag/wcag21-pt-BR/`, Accessed: 13 July 2026.
[3] `https://abrir.link/zDsHz`, Accessed: 13 July 2026.
[4] `http://lawsofsimplicity.com/`, Accessed: 13 July 2026.
[5] `https://capian.co/ergonomic-criteria-bastien-scapin`, Accessed: 13 July 2026.
[6] `https://abrir.link/xVVan`, Accessed: 13 July 2026.
[7] `https://abrir.link/kqRHk`, Accessed: 13 July 2026.
[8] `https://www.interaction-design.org`, Accessed: 13 July 2026.
[9] `http://horizontes.sbc.org.br/`, Accessed: 13 July 2026.
[10] `https://sol.sbc.org.br/`, Accessed: 13 July 2026.
[11] `https://moodle.c3sl.ufpr.br/`, Accessed: 13 July 2026.
[12] `https://www.handtalk.me/br/`, Accessed: 13 July 2026.
[13] `https://play.google.com/store/apps/details?id=br.com.handtalk`, Accessed: 13 July 2026.
[14] `https://apps.apple.com/br/app/hand-talk/id659816995`, Accessed: 13 July 2026.

Following the presentation of the application and the evaluation checklist, learners were instructed to perform four tasks within the app and rate them according to their perception and experience. The tasks were: type the phrase (1) "I am evaluating the app" in the text field and ask the app to perform the translation; (2) move the avatar to the right side and repeat the translation; (3) repeating the translation procedure, alternating between the speeds "slow", "normal", and "maximum" (if using Android) or "slow", "normal", and "fast" (if using iOS); (4) and changing the avatar's gender in the app. Figure 4 shows an example of the final task performed by the learners. After completing the tasks, learners were instructed to answer the UUXAC-DAT evaluation checklist based on their interactions on HandTalk.

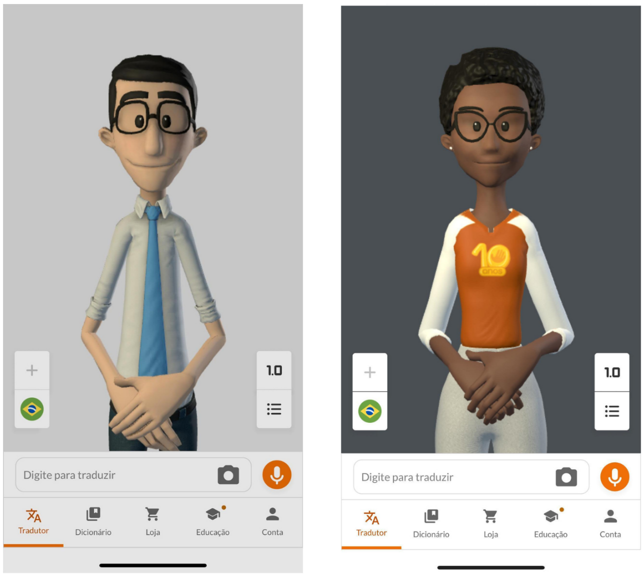


Figure 4. Example of the avatar gender change task in HandTalk (in Portuguese).

To respond to the UUXAC-DAT, instructor guided the learners to select option whenever a checklist item did not apply to the assistive technology under evaluated (HandTalk). Then, justify in the "Comments" field why the item does not apply to HandTalk; if the assistive technology (HandTalk) meets the checklist item, select the "Yes" option; and if the assistive technology (HandTalk) does not meet the checklist item, select the option "Does not / partially apply" and justify the problem identified in HandTalk. After completing the evaluation of HandTalk and filling out the UUXAC-DAT checklist, checklist, the instructor asked the learners to generate a PDF of their evaluation to attach to the report.

For the second stage of PW1, the instructor asked the learners to form groups and manage the schedule and deadlines for the consolidation team. Initially, learners consolidated the results of the HandTalk assessment. The instructor provided learners with a spreadsheet template for consolidation[15] (Figure 5). This spreadsheet should contain the ID of the identified problems, a description of the problem, who identified each problem, the type of defect, as well as suggestions for improvements and/or corrections. Another guideline was for the group to discuss all identified problems together, consolidate similar problems (duplicates) by selecting one as the main issue, and also identify unique problems, i.e., those reported by only one member. For this consolidation, the instructor emphasized that the consolidated assessment is not the sum or combination of individual assessments, but rather the result of discussion and collaborative work, generating better descriptions of the identified problems and recommendations for their solution.

Defect ID	Evaluator	Problem Description	Defect Type	Improvement/Solution
3001	Evaluator 1	The message returned after translation is only in sign language and text (no vibration feedback).	Main	Add vibration features
5001	Evaluator 2	There is no vibration feedback in the app.	Duplicate	
2003	Evaluator 4	The button to close the ad is too small.	Unique	Increase button size
3003	Evaluator 1	The captions for the translation of a sentence are displayed at the top of the	Main	Standardize legend
4004	Evaluator 3	The captions are shown at the top of the screen.	Duplicate	
5004	Evaluator 2	The captions are at the top of the screen, not at the bottom.	Duplicate	

Figure 5. Example of the consolidation spreadsheet.

Also for PW1, learners developed a consolidated report on the evaluation of HandTalk. The report was designed to identify problems and provide recomendations for improving the evaluated application. The group's consolidation report covered five points: (1) Identification form; (2) Evaluation matrix; (3) Description of the main problems and recomendations for improvement; (4) Overall assessment of the app's quality based on the evaluation results; and (5) Evaluation of the team responsible for the assessment. For the Identification Form (1), the following information was requested; the full name of each group member, the name of the evaluation checklist used in the first part of PW1; the time spent on consolidation of the evaluation; the total number of problems found by the group; and also the total number of problems identified by each learner.

For the Evaluation Matrix (2), the instructor provided a spreadsheet template[16] (Figure 6). The purpose of the evaluation matrix was to provide an overview (problems identified and by which learners), as well as to allow a practical visualization of: the learner who identified the most problems; the problems identified by two or more learners; and the problems identified by only one learner. The instructor emphasized the difference between the evaluation matrix and the consolidated evaluation spreadsheet.

For the Description of main problems and recommendations for improvement (3), the instructor asked for a list of each problem (without repetition) with its ID; a direct and objective explanation of the problem and why the group considers it to be a problem; information necessary to understand the problem with illustrations and/or explanations; and an objective description of the correction/improvement proposal developed by the group during consolidation.

For the General assessment of the app's quality based on the evaluation results (4), the question asked was "How

[15] `https://figshare.com/s/a5b7a7ab573a944cd453?file=55938683`, Accessed: 13 July 2026.

[16] `https://figshare.com/s/a5b7a7ab573a944cd453?file=55938674`, Accessed: 13 July 2026.

ID	Problem description	Evaluator 1	Evaluator 2	Evaluator 3	Evaluator 4	Evaluator 5
4007	Subtitles located at the top of			x		
4009	Without an internet connection, the app only			x		
4008	I couldn't find any contact			x		
3002	It doesn't provide any feedback if the typed word is		x		x	
2001	If the application is translating and any tab in the "tab menu" is pressed, the	x				x
1006	The program does not handle homonyms well	x		x		x
3007	Ads prevent the user from having a fluid experience		x		x	x
1021	Some features are only available for the pro version	x				x
5002	The app's battery consumption is not				x	x

Figure 6. Example of the evaluation matrix.

does the group assess the overall quality of interaction with the app in relation to the evaluation objectives?" For the assessment of the evaluation team (5), the question asked was: "Did anyone have greater 'success' in the evaluation? Why?" and also, "Were the costs of effort versus the problems encountered adequate?".

4.3.2 *Second Practical Works (PW2)*

PW2 consisted of specification (I), modeling (II), prototyping (III), and prototype evaluation (IV) of an app for use by people with visual impairments. For the specification (I), learners had to: create Personas to represent the hypothetical users (visually impaired people) of the app, with each group member having to create at least one Persona; create Problem Scenarios to represent problematic situations that hypothetical users might encounter when using the app, in which each group member had to create at least one Problem Scenario; and hold a Brainstorming meeting for the group to discuss the Personas and Problem Scenarios and identify the app's features. learners were asked to generate a list of the identified features. In addition, new application features could emerge at this stage.

For modeling (II), learners had to use the Hierarchical Task Analysis technique (HTA) [Stanton, 2006] or the Goals, Operators, Methods and Selection rules (GOMS) [John, 1995] method to represent the decomposition of one of the main tasks that could be performed in the app. To prototype the app (III), each group had to: use the Usability, Accessibility, and User Experience Design Guidelines for Visual Impairment (UAUDG-VI) [Rosa and Valentim, 2022] technique to support the construction of low-fidelity prototypes of the app. Figure 7 shows an excerpt from this technique. One recommendation from the instructor was to represent the system messages and navigability between screens in the prototypes. Regarding prototyping software, the instructor advised learners to use software according to their preference, but recommended free collaborative tools such as Marvel[17] and Figma[18]. The instructor also suggested including screenshots and/or photos of the screens in their reports, or providing links to the prototyped screens.

For the prototype evaluation (IV), each group member had to choose a technique or method for evaluating usability and/or UX and/or accessibility of their choice, whether learned in the HCI course or identified in the literature, evaluate all prototypes created by their group using the chosen

Categoria Letras, fonte e textos

3. **Evitar entrada de texto**: Uma boa opção é oferecer listas com opções ou fornecer uma função de preenchimento automático em vez de exigir a entrada de texto. Ou seja, a interface sugere frases ou palavras quando o usuário começa a inserir texto, dando a opção para selecionar a palavra/texto mais adequada(o). Neste caso, a aplicação deve fornecer frases ou palavras com conteúdo útil para proporcionar uma melhor experiência ao PDV.

Exemplo: No protótipo abaixo (item 3) é apresentado um campo que evita entrada de texto. Esta funcionalidade possibilita aos PDVs que conforme os mesmos vão inserindo texto na aplicação, opções correspondentes ao texto digitado vão surgindo na tela.

Figure 7. Excerpt from the UAUDG-VI technique (in Portuguese).

technique or method, record their impressions, and make suggestions for solving the problems encountered. This evaluation was done individually by each group member. The instructor reminded learners that, while the evaluation may be exploratory in nature and offer suggestions and notes, it is also critical for anticipating problems that impact the overall quality of the solution, and even its viability.

Finally, the learners prepared a report containing a list and explanation of the problems encountered, suggestions for solving each problem or how to deal with each problem, an explanation of which technique or method they used and why it was appropriate, and additional comments they deemed relevant.

The HCI course and its PWs constituted the authentic educational context in which learners interacted collaboratively through interactive systems. The PWs involved activities such as requirements specification, modeling, prototyping, and evaluation, which required learners to communicate, coordinate tasks, and cooperate in shared workspaces. These collaborative dynamics provided the basis for investigating the LX in a real educational setting. Thus, the exploratory study presented in the next section represents a continuation of the same course context, conducted in the same semester and with the same instructor, aiming to evaluation LX regarding communication, coordination, and cooperation after the finalization of the PWs. The following section describes the study design, participants, instruments, and procedures used to evaluate LX in this collaborative context.

[17] https://marvelapp.com/, Accessed: 13 July 2026.
[18] https://www.figma.com/, Accessed: 13 July 2026.

5 Exploratory study in the course of HCI

An exploratory study was conducted to discover new and relevant insights [Swedberg, 2020] for the evaluation of LX when using interactive systems in a collaborative context. Exploratory studies are essential in HCI to identify emerging patterns, generate hypotheses, and deepen the understanding of complex sociotechnical interactions, especially when investigating subjective experiences in real-world settings [Corbin and Strauss, 2014; Lazar *et al.*, 2017].

5.1 Ethical Care

This work was approved by the Research Ethics (REC) Committee under CAAE: 84496124.0.0000.0102. The activities involved learners regularly enrolled in an undergraduate course, carried out in the context of regular pedagogical practices. There was no collection of sensitive data or images of the participants, nor was any form of remuneration offered for participation. The study was conducted following the principles of the Guidelines and Regulatory Standards for Research Involving Human courses – CNS Resolution No. 466/2012, Operational Standard No. 001/2013, CNS Resolution No. 510/2016 and CNS Resolution No. 674/2022. All information collected was anonymized to guarantee the confidentiality and privacy of the participants. Participation was voluntary and mediated by the signing of the Informed Consent Form (ICF), made available prior to data collection.

The possible risks to learners are related to discomfort, such as tiredness and boredom, when answering the questions in the questionnaire, which is the data collection instrument used. Another possible risk is related to the time taken to answer the questionnaire. The occurrence of these risks can be considered low, especially in relation to discomfort when reading and answering the questionnaire, since most of the questions are optional. In addition, the possibility of discomfort due to the time required to complete the questionnaire can also be considered low. One way to minimize these risks was to give a deadline of seven days to read and return the completed questionnaire.

In addition, to minimize the possible risks related to the methods adopted to obtain the participants' perceptions, the researchers were available to clarify any doubts that arose during the study. The instructor and the learners could contact the researchers via email and/or social media, or consult them at the time of the study. In this way, it was possible to provide individualized support and allow greater interaction between researchers and participants. Participants were guaranteed confidentiality regarding their responses to the questionnaire, which will subsequently be stored for five years in a database that only researchers will have access to. The data was stored and encrypted. In this way, we attempt to minimize risks to the participants involved in this research.

The benefits to the participants of this study are associated with the learners and the instructor. In this sense, learners will be able to have their LX improved in the collaborative context, since it will be possible to investigate what the challenges, facilities and also suggestions for improvements are for the scenario of this study; and they will be able to improve their LX using interactive systems, since this study also evaluates the interaction of learners with interactive systems in an educational activity. Another benefit may occur through the analysis of collaboration, cooperation and communication. In this scenario, learners will be able to have their collaboration experiences evaluated and improved in the future. instructors have the benefits associated with analyzing and evaluating the experiences and 3Cs of learners' collaboration when using interactive systems, which will allow an analysis of the current scenario, reflecting on possible improvements in their classes.

5.2 Participants

The participants in this study were the learners who were taking the HCI course in the program in CS & BI at the UFPR in Brazil, and their respective instructor. First, the instructor was invited to participate in the study through an invitation letter; she was selected to participate in the study based on convenience. In addition, there were prerequisites for this selection, such as being the instructor of the HCI course; having planned the PWs and instructed the learners to use interactive systems; and having planned the PWs and instructed the learners to carry them out collaboratively. After the instructor voluntarily accepted, she received the study guidelines presented in the Subsection 5.4.

The instructor, together with the main primary researcher of this paper, invited verbally the learners to participate in the study in one of the face-to-face classes of the HCI course. In addition to the invitation, the objective of the study and the task that they would perform were explained. Some prerequisites were also listed for the selection of learners, such as being enrolled in the HCI course, performing the PWs using interactive systems, and performing the PWs collaboratively. Thus, the 16 learners who agreed to voluntarily participate in the study received the data collection instruments, including the ICF.

5.3 Context

The exploratory study was conducted in the same HCI course described in Section 4, during the same academic semester and with the same instructor responsible for planning and teaching the course. The HCI course was planned and organized independently by the instructor, without interference from the researchers. The instructor had previously defined that the PWs would be carried out collaboratively and supported by interactive systems as part of the strategy of the course.

The study context was a real educational scenario. The learners first carried out the PWs as regular course activities, following the methodological structure defined by the instructor. After completing these PWs, the learners were invited to voluntarily participate in the exploratory study aimed at evaluating the LX in the collaborative context supported by interactive systems. Therefore, the concept of LX was not introduced to the learners prior to the study.

The same instructor responsible for designing the course and the PWs also inviting the learners to participate in the study and clarifying possible doubts regarding the PWs. For this reason, the instructor signed the ICF, as she was directly involved in the educational context in which the study took place and contributed to facilitating communication with the learners. However, it is important to emphasize that the instructor's experience was not collected or analyzed as part of the study data in the evaluation of LX.

In the context, the exploratory study represents a continuation of the educational activities carried out in the HCI course, maintaining coherence between the design of the PWs and the evaluation of LX. In this sense, the exploratory study does not constitute a separate research setting, but rather an extension of the same course experience, allowing the integration of the lessons learned and LX assessed.

The requirements specification and prototyping stages, presented in the PWs, made it possible to have a collaborative context in which the LX was evaluated. During these stages, learners worked in groups to define system requirements and develop prototypes, which required continuous communication, coordination of tasks, and cooperation in shared digital environments. The requirements stage involved negotiation of ideas, alignment of interpretations, and organization of information, evidencing communication and coordination processes. The prototyping stage required collective decision-making and joint construction of artifacts, evidencing cooperation practices. Therefore, the stages at PWs derived from authentic collaborative situations experienced by learners during the development of the PWs, ensuring coherence between the course and the evaluation of LX.

5.4 Data Collection Instruments

The data collection instruments used in this study were the ICF and the exploratory study questionnaire. Two ICFs were administered, one for the learner and one for the instructor. It was considered necessary to develop an ICF for the instructor, although her active participation consisted of inviting the learners and answering any questions they might have.

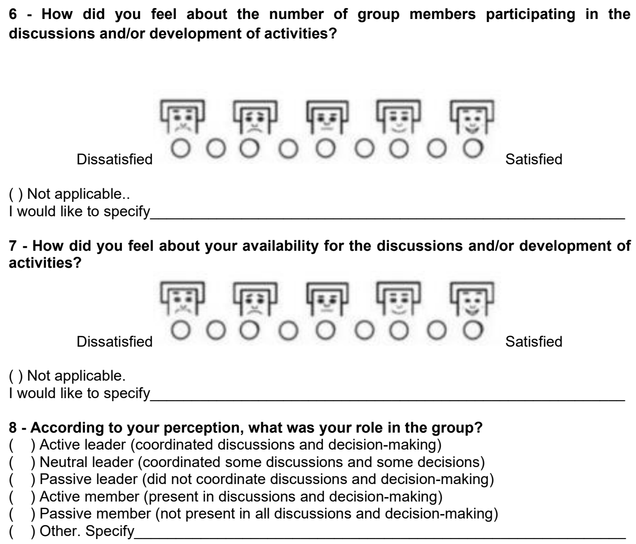
We decided to use the questionnaire from dos Santos *et al.* [2025a] because based on the elements of the 3C model. In addition, it underwent a careful peer review to refine the questions and thus strengthen the learners' responses to the study's research question. Another distinguishing feature of this questionnaire is the use of different scales for different objectives. The Self-Assessment Manikin (SAM) scale [Lang, 1980] was used to assess the learners' feelings, and the Likert scale was used to quantitatively measure the learners' perception of their experience in the collaborative context using interactive systems. Further details of the process of its construction are available at dos Santos *et al.* [2025a].

The questionnaire had 21 questions (Figure 8), four for characterizing the learners and 17 questions based on the elements of the 3C model. In addition, there were open and closed questions and the use of different scales to collect feedback from the learners. For characterization, we collected information such as the course in which the learners were enrolled, gender, age and number of learners present in the group for the development of the PWs. The instruments used in this study are available at Figshare[19].

5.5 Preparation and execution

Before carrying out the study, the learners were invited to take part in the study and were also given a presentation on what

[19] https://figshare.com/s/ee0d8ab582971e7d8d5d, Accessed: 13 July 2026.


6 - How did you feel about the number of group members participating in the discussions and/or development of activities?

Dissatisfied ○ ○ ○ ○ ○ ○ ○ ○ ○ Satisfied

( ) Not applicable..
I would like to specify____________________

7 - How did you feel about your availability for the discussions and/or development of activities?

Dissatisfied ○ ○ ○ ○ ○ ○ ○ ○ ○ Satisfied

( ) Not applicable.
I would like to specify____________________

8 - According to your perception, what was your role in the group?
( ) Active leader (coordinated discussions and decision-making)
( ) Neutral leader (coordinated some discussions and some decisions)
( ) Passive leader (did not coordinate discussions and decision-making)
( ) Active member (present in discussions and decision-making)
( ) Passive member (not present in all discussions and decision-making)
( ) Other. Specify____________________

Figure 8. Part of the exploratory study questionnaire [dos Santos *et al.*, 2025a].

their participation would consist of and the instruments used in the exploratory study. The invitation and presentation lasted approximately 15 minutes. Afterward, the 16 learners who voluntarily agreed to take part in the study received a printed ICF. The instructor also received the ICF in printed form and signed it. She was responsible for guiding, monitoring, and carrying out the execution of the PWs in a collaborative context using interactive systems.

To carry out the exploratory study, the learners signed the ICF and received the questionnaire. The learners had the duration of the lesson to complete the questionnaire (Figure 9). The primary researcher of this paper was available in the classroom to answer any questions the learners might have about the study and the instruments used.

Figure 9. Photo of learners answering the exploratory study questionnaire.

5.6 Data Analysis

The data obtained through the questionnaire was analyzed quantitatively and qualitatively. The data was cleaned, coded, and then organized. The quantitative data was analyzed using descriptive statistics [Lazar *et al.*, 2017]. The qualitative data were analyzed using the thematic analysis method [Braun and Clarke, 2006]. First, the data were read in their entirety, and then codes were generated; the analysis of these codes was reviewed by all the authors of this article. Finally, the codes were grouped into broader themes, and a thematic map was developed, as presented in Section 6.2.1. The data collected in the study are available on Figshare[20].

6 Results: Perceptions and feedback

This section presents the results of the experiences observed and lived. It presents too the results of the evaluation of LX through the exploratory study. To provide a comprehensive understanding, the data were analyzed both quantitatively and qualitatively. Initially, we detail the perceptions of the instructor, the learners, and a learner observer regarding the PWs conducted during the course. Subsequently, we present the findings from a questionnaire based on the 3C model (communication, coordination, and cooperation) to evaluate the LX in this collaborative context. These results highlight how interactive systems supported knowledge exchange, creativity, and the development of a critical perspective among learners.

6.1 Results of Observations and Experiences

The course had 55 regularly enrolled learners, one guest learner, and one instructor. Fifty-one learners completed PW1, divided into 11 groups. The number of members per group ranged from two learners (G8) to six learners (G3, G6, G9), as shown in Table 1. The total number of problems identified per group ranged from 24 (G2) to 105 (G9) problems. The perception was that the number of members did not influence the number of problems identified per group. This is because there are groups with a small number of members, such as G8 with two learners, which identified 31 problems. On the other hand, there are groups with a significant number of members, such as G10 with five members, which identified 42 problems.

Regarding the number of unique, duplicate, and main problems identified per group, G10 identified eight unique problems, whereas G8, which had fewer members, identified five. This shows a similar number of unique problems despite the difference in group size. G11 was the only group that did not identify any unique problems. In terms of duplicate problems, G9 identified 77, exceeding the average of the other groups, showing strong convergence among the evaluators. In contrast, G2 had the fewest duplicate problems, with only nine. With respect to the main problems, G9 also stood out, consolidating 22 main problems, in contrast to G2, which reported only three. In this context, we believe that the learners' preference, interests, and individual needs may have influenced the evaluation of the app.

[20] `https://figshare.com/articles/dataset/Study_questionnaire_HCI/28399739?file=63793542`, Accessed: 13 July 2026.

Another relevant insight for PW1 was the time spent consolidating the problems identified in the evaluation of the HandTalk app, as shown in Table 1. It should be noted that to perform this evaluation, there was a significant variation in the time dedicated by each group. G9, for instance, spent approximately 1h30min, while G6, G7, and G11 each dedicated about 5 hours. It is believed that the learners' knowledge and experience, the time available for this evaluation, and the quantity and quality of the available data may have influenced the results.

Still for PW1, learners were required to answer the following questions: "How does the group rate the overall quality of interaction with the app in relation to the assessment objectives?", "Did any learner have greater 'success' in the assessment? Why?", and also, "Were the costs of effort versus the problems encountered adequate?". The responses these questions were analyzed qualitatively. The data were first cleaned and organized, and then examined using the thematic analysis [Braun and Clarke, 2006]. In this sense, the data were read in full, codes were generated, and the code analysis was peer-reviewed. Next, the codes were grouped into broader themes, and a thematic map was developed, as shown in Figure 10.

Five themes were created: Experiences, Differences in experiences, Efficiency, Other highlights, and About HandTalk. Four sub-themes were created under the theme About HandTalk: General perception, Suggestions for improvement, Positive points, and Negative points.

For the theme **experiences**, there is the code "different experience with avatar", in which G2 reported that a member of their group *"had difficulty [interacting] with the avatar, as they had not noticed the zoom gesture available"*. For the code "similar experience among members" G1 reported that their group *"worked uniformly, with each member performing their role and task competently, so that no member [was] overloaded"* and G2 reported that the members of their group had *"a similar experience during the evaluation, with the effort dedicated being adequate in relation to the problems identified. Each member used the app for around 30 minutes, reported the problems encountered and organizing them in a spreadsheet"*.

Regarding the code "different experience with ads", G2 reported that *"one of the members [of their group] did not encounter problems with ads because they used an ad blocker on their cell phone"*. For the code "positive experience with group work" most groups reported that it was positive, except for G1 and G2, which did not address this topic in their statements. G3 reported that *"the evaluation group did a good job both in analyzing the individual app and in the group discussion regarding the consolidation of problems and ways to improve/solve them"*, and G10 said that their *"group was well aligned, in the way that similar and analogous errors were recognized by several different members, who generally agree on the level of severity of these errors, especially the main ones"*.

For the theme **differences in experience**, there is the code "member with experience with spreadsheets", in which G6 reported that a member of their group *"had more advanced knowledge of Excel, which greatly facilitated the process of transforming the evaluations into a table"*. For the theme

Table 1. Main results PW1.

Groups (G)	Members	Problems				Consolidation time
		Duplicates	Uniques	Main	Total	
G1	4	17	12	11	40	3h
G2	4	9	12	3	24	4h
G3	6	42	22	18	82	-
G4	4	31	6	13	50	2h30min
G5	5	30	33	17	80	-
G6	6	31	7	13	51	5h
G7	5	21	36	16	73	5h
G8	2	19	5	7	31	4h
G9	6	77	6	22	105	1h30min
G10	5	26	8	8	42	-
G11	4	50	0	17	67	5h

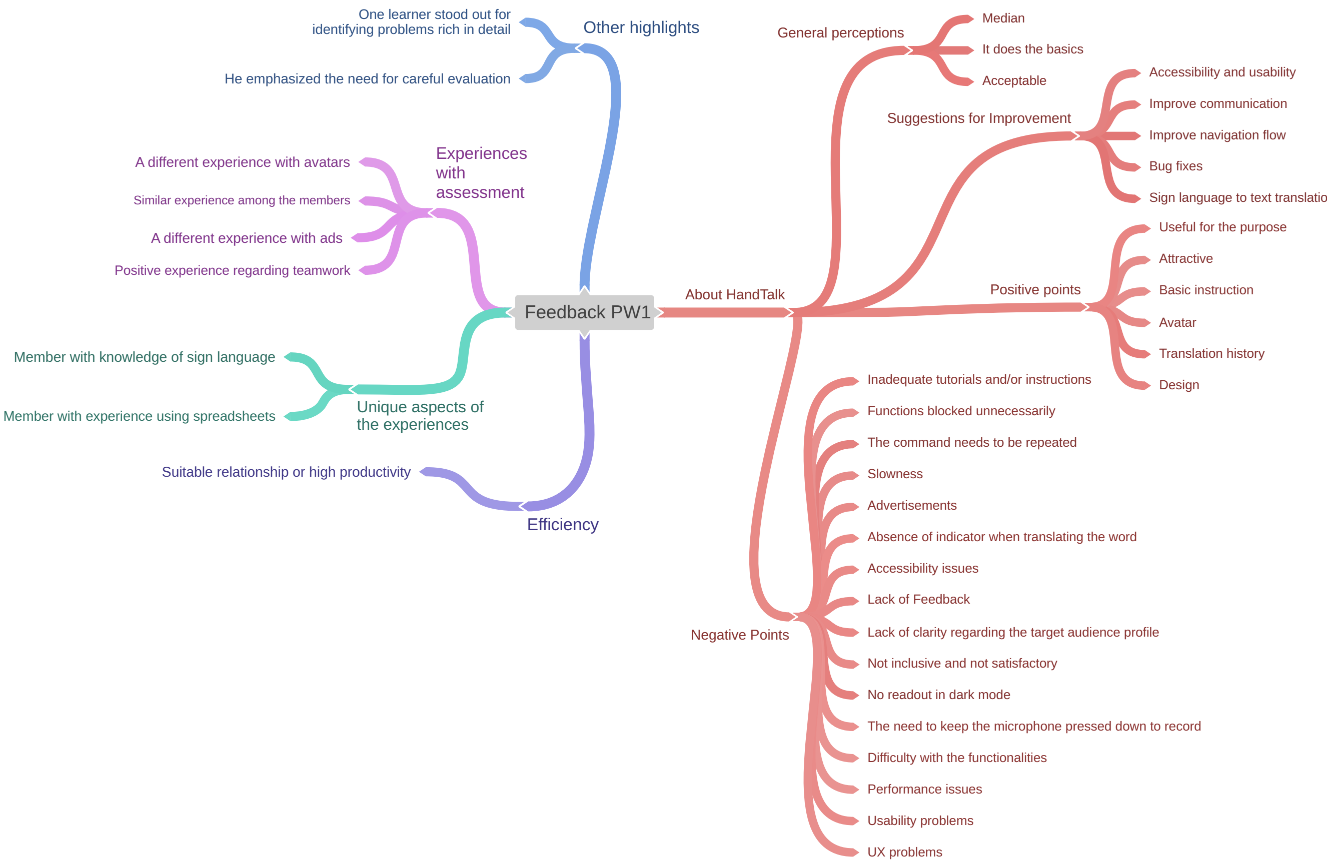


Figure 10. Thematic analysis of PW1.

efficiency, we have the code "adequate relationship or high productivity" in which G6 stated that *"despite the few hours available for the consolidation evaluation, several problems were found in the app. However, we know that if the testing period had been longer, we would have had time to test more features and different input options in the app, which would certainly have increased the number of problems found"*. In contrast, G11 reported that they spent *"more time than expected analyzing the problems due to their inexperience in the course. However, we feel more prepared to perform a similar analysis in other applications in the future"*.

For the topic **other highlights**, there is a code stating that "one learner stood out for identifying problems rich in detail" in G3, in which they reported that *"the problems identified by the evaluator were observed more carefully, in greater detail, so they are not explicit and are more difficult to notice"*. In this sense, the group "emphasized the need for careful evaluation", stating that *"many of the results obtained are difficult to find without careful review from the user's point of view and difficult to consolidate without group discussion"*.

For the theme **about HandTalk**, there is the subtheme *"general perception"*, with the code "does the basics", in which G1 reported that *"the app fulfills the proposed basics, but is not fully satisfactory"*. For the subtopic "suggestions for improvement" there is the code "bug fixes" in which G4 pointed out that *"to be a truly inclusive tool, improvements must be* *made"*. For the sub-theme "positive points" there is the code "avatar" in which G4 reported *"the possibility of customizing the avatar"*. And for the sub-theme "negative points" there is the code "ads" where G1 reported that *"the app has many ads, making it visually cluttered for usability"*. The complete thematic analysis is available in a technical report[21].

With respect to the first stage of PW2, the specification is related to the creation of personas and scenarios. Table 2 shows the number of personas and scenarios created in each group. We can observe that most groups created at least one persona and one scenario per member, except for G10. In addition, some groups created more than one *persona* and one scenario when compared to the number of members, such as G2, G4, and G8. These finding suggest that learners primarily focused on meeting the minimum requirements to complete the task.

Regarding the second stage of PW2, modeling, learners could choose either the HTA technique or the GOMS method to represent the decomposition of one of the main tasks that in the app. Table 2 shows that most groups chose to use the HTA technique (6 groups), but the GOMS method was also widely used (5 groups). In the third stage of PW2, prototyping, all groups created screens using the Marvel or Figma tools. The prototypes were medium fidelity, i.e., they presented the hierarchy of information on the screens and the flow of interactions, allowing for simple usage simulations, such as interactions with buttons. In addition, they represented messages that the app should present to the user, such as confirmation and error messages.

The last stage of PW2 involved choosing a usability, accessibility, and/or UX technique or method to evaluate the prototypes developed by the group. Table 3 presents the various evaluation techniques or methods selected by the learners. The number of "x"s in the table represents the number of learners who selected the respective technique or method. The two evaluation methods most used by learners are Nielsen's Heuristics and Cognitive Walkthrough, which are evaluation methods by inspection. We believe that learners selected these methods because they can be applied more quickly than methods involving users.

Nielsen's Heuristics is an evaluation method that guides evaluators to systematically inspect the interface for problems that impair usability [Nielsen, 1995]. In accordance with the scope of the course, during the HCI Evaluation theme, the instructor presented this method and cited examples of evaluations that had been carried out. We believe that this factor contributed to learners' choice of this method. In addition, it is an inspection method for performing a quick evaluation and has a low cost when compared to methods involving users [Barbosa *et al*., 2021]. Another method chosen by learners is the Cognitive Walkthrough. This method aims to evaluate the ease of learning an interactive system through interface exploration [Wharton *et al*., 1994]. We believe that learners chose this method because they are motivated to "learn by doing" rather than through training, reading manuals, among others [Barbosa *et al*., 2021]. On the other hand, there are evaluation methods and techniques used only by one learner, such as the SUS questionnaire [Brooke *et al*., 1996] and the usability test [Ferreira *et al*., 2002].

In addition, perceptions and feedback from learners were collected for PW2. For this qualitative data, thematic analysis was performed [Braun and Clarke, 2006]. The data was read in its entirety, codes were generated, and the analysis was peer-reviewed. The codes were then grouped into broader themes, and a thematic map was developed, as shown in Figure 11. Two themes were created: Prototype Evaluation and Comments on PW2. In the latter theme, two sub-themes were created: positive comments and comments on difficulties.

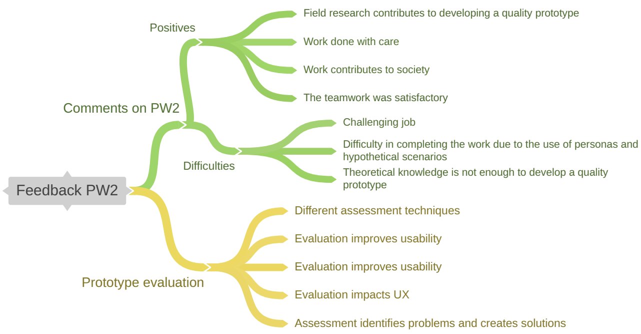


Figure 11. Thematic analysis of PW2.

For the topic **prototype evaluation**, the code is "evaluation identifies viable, low-cost solutions", in which G2 reported that *"the evaluation shows that the problems identified have viable, low-cost solutions for prototypes"*. For the code "evaluation impacts UX", G2 commented that *"the problems identified have a direct impact on the UX, particularly on navigation and system efficiency"*. For the code "evaluation identifies problems and creates solutions", G2 reported that *"the defects found were analyzed, and the above solutions were developed for them. It is worth noting that the general nature of the problems was minor and that, despite their existence, the prototype represents an app with the potential to be extremely accessible and powerful in satisfying its users' varied demands"*. For the code "evaluation improves usability", G2 reported that *"the suggested solutions are relatively simple to implement and can significantly improve the usability of the prototype, making it more intuitive and efficient for users"*. And for the code "different evaluation techniques", G5 reported that *"the report shows that the use of advanced methodologies, such as HTA and iterative evaluation, is not only applicable but essential for the development of accessible interfaces"*.

For the topic **comments on PW2** there is a subtopic called "Positive comments on PW2" with the code "field research contributes to developing a quality prototype", in which G8 reported that *"field research, non-hypothetical personal accounts, conducted anonymously and securely, would make the development of the prototype much simpler and more accurate"*. For the code "work done with care", G3 mentioned that *"the work was done with great care from the beginning of the prototype planning, in addition to the creation of personas along with a scenario for each of them to analyze the application created"*. For the code "work contributes to society", in which G5 reported that *"the practical application of HCI concepts reinforces the relevance of this*

[21] https://figshare.com/s/a5b7a7ab573a944cd453, Accessed: 13 July 2026.

Table 2. Quantitative analysis of specifications and modeling in PW2.

G	Team Members	Number of Specifications		Technique or Method for Modeling	
		Personas	Scenario	HTA	GOMS
G1	4	4	4	-	x
G2	4	5	5	-	x
G3	6	6	6	x	-
G4	4	5	5	x	-
G5	5	5	5	x	-
G6	6	6	6	-	x
G7	5	5	5	x	-
G8	2	4	4	-	x
G9	6	6	6	x	-
G10	5	2	2	-	x
G11	4	4	4	x	-

Table 3. List of techniques and models used for evaluating the prototype.

Techniques or Methods	**G1**	**G2**	**G3**	**G4**	**G5**	**G6**	**G7**	**G8**	**G9**	**G10**	**G11**
Nielsen's Heuristics [Nielsen, 1995]		xxxx			x	x	x		x	x	
Cognitive Pathway [Wharton *et al.*, 1994]	x		x		x		x		x	x	
User Experience Questionnaire (UEQ) [Laugwitz *et al.*, 2008]			x	x	x	xx					x
Maeda's Laws of Simplicity [Maeda, 2006]				x			x		xxxx		
AttrakDiff [Hassenzahl *et al.*, 2003]			x	x	x	x	x				
Usability Heuristics for Touch-Enabled Mobile Devices [Inostroza *et al.*, 2013]	x		x						x	x	x
8 golden rules of Shneiderman [Shneiderman and Plaisant, 2010]	x		x						x		x
Thinking Aloud [Nielsen, 1995]									x	x	x
7 Principles of Universal Design	x				x						
Ergonomic criteria of Bastien and Scapin [Bastien and Scapin, 1993]		x					x				
Universal Design applied to the web with accessibility guidelines [Almeida and Baranauskas, 2010]								xx			
Web Content Accessibility Guidelines (WCAG) [Caldwell *et al.*, 2008]			x			x					
e-MAG [MPO *et al.*, 2014]				x							
System Usability Scale (SUS) [Brooke *et al.*, 1996]						x					
Usability Testing [Ferreira *et al.*, 2002]										x	

field of study and demonstrates its potential to positively impact society. This work is not only an academic example of excellence, but also a model of how technological projects can intrinsically integrate accessibility, meeting the demands of an often neglected audience and paving the way for a more inclusive and just society". For the code, "teamwork was satisfactory", in which G8 reported that *"the group found the experience of producing this PW to be satisfactory and educational".*

There is a sub-theme on the "difficulties" in relation to PW2, with the code "challenging work," in which G8 commented that *"the experience of developing, even in the form of a low-fidelity prototype, an app with so many visual accessibility features proved to be quite challenging for the team".* For the code "difficulty in performing the work because they are hypothetical personas and scenarios", G8 reported that *"the group relied purely on the knowledge provided in the classroom during the HCI course to develop the prototype. The difficulty is mainly due to the fact that all personas and scenarios are hypothetical, that is, there was no direct interaction with a person who actually needs accessibility options".* And for the code "theoretical knowledge is not enough to develop a quality prototype", in which G8 reported that *"even though flaws and imperfections are clear in the prototype, it is understood that it is a good starting point and has the potential to serve as a basis for a more mature project in the future. An important point to note: simply using guidelines and theoretical knowledge is not enough to achieve significant quality in terms of accessibility".* The thematic analysis is available in a technical report[22].

In addition, the instructor's perception regarding the impact of PWs on teaching and learning is reported. She highlighted that PW1 contributed significantly to the development of learners' critical view of the evaluated applications, emphasizing that *"it was very clear to see how their critical view of the applications, whether web or mobile, improved considerably".* This statement shows that the practice of collaborative evaluation allowed learners to go beyond the perspective of experienced technology users, broadening their understanding of the difficulties faced by different user profiles. As the instructor adds, *"the perspective I tried to bring to them is*

[22] `https://figshare.com/s/a5b7a7ab573a944cd453`, Accessed: 13 July 2026.

that not everyone has the same ease with technology that we do, because we are computer scientists", reinforcing the alignment of the practice with the principles of inclusive and socially conscious design.

With respect to PW2, the instructor observed an even stronger impact on learner engagement and motivation, as PW involved "a large part of the development process or development cycle of an app". She pointed out that experiencing activities from specification to prototype evaluation provided learners with *"a somewhat disruptive view of what they had learned so far in the course"*, allowing them to understand the importance of considering users from the earliest stages of design. This perception is in line with the approaches recommended by Preece *et al.* [2015], emphasizing the need to involve users and their real needs throughout the interaction design lifecycle.

Among the challenges faced, the instructor reported difficulties in ensuring similar engagement among learners to carry out group PWs, indicating that *"some learners take the lead [...] and others do not want to contribute as much"*. To mitigate this situation, she implemented strategies to monitor individual participation, such as requiring reports to indicate who performed and who reviewed each part of the work. This practice reflects a concern for promoting effective collaboration and shared responsibility, which are fundamental aspects of project-oriented HCI teaching. The instructor also noticed a difference in engagement between PW1 and PW2, observing that *"for PW2 they really felt more motivated [...] because it was more practical and visual"*. This extra motivation is related to the possibility of "getting hands-on experience", favoring more active and meaningful learning, as expected in project-based approaches.

Finally, the instructor reflected on future adjustments to the course, suggesting the inclusion of methods that allow learners direct contact with real users, such as interviews or questionnaires, believing that "this would certainly bring a wealth of detail to the work". This reflects a move toward participatory and contextualized practices, underscoring the relevance of integrating methodologies in HCI teaching to enhance empathy and understanding of user needs. Overall, the instructor's perception reinforces the effectiveness of the expository-dialogical and project-oriented approach adopted in the course, highlighting the importance of balancing theory and practice to promote more engaged, critical, and socially conscious learning in HCI teaching. The instructor's feedback is available in a technical report[23].

6.2 Results LX Evaluation

This section presents the results of the LX evaluation based on the questionnaire structured according to the 3C model: communication, coordination, and cooperation. The analysis goes beyond descriptive results by interpreting each question in relation to the concept of LX, which considers the learner, the learning task, and the use of interactive systems. In addition, each result is analyzed according to the specific collaborative element assessed in the question. The course HCI offered had 55 learners regularly enrolled, 16 of whom voluntarily participated in the LX evaluation. To characterize the profile of these learners, data on program, gender, age, and the number of learners per group were collected, as shown in Table 4.

It was observed that the majority of learners were enrolled in the CS program (69% | N = 11) rather than in the BI program (31% | N = 5). In addition, it was observed that a minority identified as female (25% | N = 4) and the majority identified as male (75% | N = 12). Furthermore, the majority of learners were 21 years old (38% | N = 6), followed by those aged 19, 20, 22, and 26 (each 13% | N = 2), and a smaller proportion aged 23 and 25 (each 6% | N = 1). Concerning group composition, half of the learners (50% | N = 8) worked in groups of four members, while the remainder were equally divided between groups of five (25% | N = 4) and six members (25% | N = 4).

Table 4. Characterization of learners' profiles.

Category	Description	Results	
		%	Number (N)
Programs	CS	69	11
	BI	31	5
Gender	Male	75	12
	Female	25	4
Age	21 years old	38	6
	19 years old	13	2
	20 years old	13	2
	22 years old	13	2
	26 years old	13	2
	23 years old	6	1
	25 years old	6	1
Group size	4 members	50	8
	5 members	25	4
	6 members	25	4

From the learners' descriptions, it was possible to identify the seven groups formed to carry out the PWs. Figure 12 shows the groups and their composition. The learners who took part in the study were coded from P1 to P16. Participants not taking part in the study were coded from NP1 to NP19.

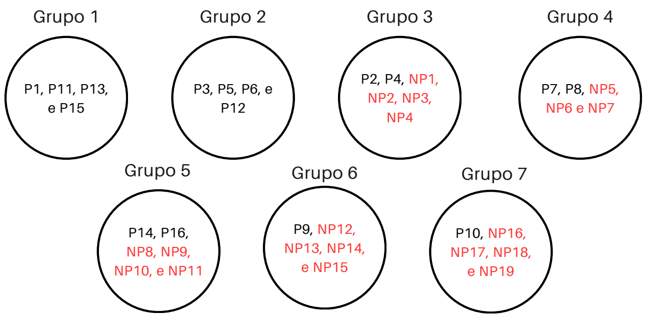


Figure 12. Grouping of learners for the completion of the PWs.

The exploratory study questionnaire had 17 questions to assess the three elements of the 3C model and LX. Thus, three questions were about the Communication element (Q2 to Q4), eight questions about the Coordination element (Q5 to Q12) and six questions are about the Cooperation element (Q1, Q13 to Q11). For this questionnaire, learners answered according to their perception and experience of developing PWs in groups, and each learner could select more than one

[23]`https://figshare.com/s/a5b7a7ab573a944cd453`, Accessed: 13 July 2026.

answer option for each question. The results are presented in these Section.

Regarding the interactive systems used by learners to communicate with their peers (Q1 | Table 5), the most frequently reported platforms were WhatsApp[24] (38% | N = 16) and Discord[25] (31% | N = 13), followed by email and BBB C3SL (each 2% | N = 1). WhatsApp and Discord emerged as the preferred channels for interaction, largely due to learners' familiarity with these tools. However, one group reported instances of ineffective communication among its members. To address such challenges, promoting alignment strategies and offering guidance on the effective use of communication tools could enhance participation and collaboration. These findings highlight the importance of providing diverse technology-mediated communication options that support effective group interactions. The selection of communication technologies should consider the nature of the tasks, group composition, and coordination needs to foster engagement and efficiency in collaborative work. From an LX perspective, this result indicates that the LX is shaped by the technological ecosystem used to support collaboration. The choice of tools reflects how learners interact with the task, influencing immediacy of communication, and engagement.

Table 5. Results of the Q1.

Question	Possible Answer	Results	
		%	N
Q1. What computing resources did you use to communicate with group members to carry out the PWs?	WhatsApp	38	16
	Discord	31	13
	E-mail	2	1
	BBB C3SL	2	1
	There was no communication	2	1

Regarding the communication languages used through interactive systems to engage with group members (Q2 | Table 6), learners predominantly preferred written (text-based) communication (44% | N = 16), followed by spoken (audio) communication (33% | N = 12), pictorial forms (images and/or animations) (17% | N = 6), and signature (video and/or animation) (6% | N = 2). It is believed that there is a preference for more practical and accessible forms of communication when interacting with interactive systems, such as text and audio. This reinforces that persistent communication records increase situational awareness and facilitate the coordination of activities, especially in distributed contexts. However, the diversity of communication languages reflects the flexibility of interactive systems, although not all of them are adopted by all learners. This diversity highlights that LX is influenced by multimodal interaction, allowing learners to adapt communication according to their preferences and task demands. Thus, the use of multiple communication formats contributes to a more flexible and inclusive LX.

With respect to the type of communication within the groups (Q3 | Table 7), most learners reported engaging in continuous communication (63% | N = 12), while a smaller proportion communicated punctually (37% | N = 7). Regarding how learners categorized their communication (Q4), responses included inquiries (questions, doubts, assumptions)

[24]`https://www.whatsapp.com`, Accessed: 13 July 2026.
[25]`https://discord.com`, Accessed: 13 July 2026.

Table 6. Results of the Q2.

Question	Possible Answer	Results	
		%	N
Q2. What communication languages were used to communicate with the other members of the group?	Written (text)	44	16
	Spoken (audio)	33	12
	Pictorial (image)	17	6
	Signature (video)	6	2

(48% | N = 14), speech types (affirmative or negative) (21% | N = 6), discourse style (direct or indirect) (17% | N = 5), and emotional expression (happy, angry, sad) (14% | N = 4). It can be seen that the majority of learners preferred to communicate continuously, indicating a more constant interaction between learners in the development of PWs. For example, in one of the topics of PW1, the learners consolidated the problems about the Hand Talk app, in which they had to discuss, debate, and establish a consensus. In this sense, it is possible to perceive a positive interaction with interactive systems focused on collaboration and fulfilling the topics of the PWs, as the learners were able to carry out this topic of PW1 successfully. This result reinforces that LX includes not only functional aspects but also emotional and social dimensions, showing how learners interpret and express their experiences during interaction with peers and systems.

Table 7. Results of the Q3 and Q4.

Question	Possible Answer	Results	
		%	N
Q3. How was your communication with the other members of the group?	Continuous	63	12
	Punctual	37	7
Q4. How do you categorize your communication with group members?	Type of questions	48	14
	Type of speech	21	6
	Type of discourse	17	5
	Type of emotions	14	4

The emoticons from the SAM scale were used for Q5 to Q7, Q9 to Q12, and Q17 [dos Santos *et al.*, 2025a]. For better visualization of the results, the SAM scale was organized into three points, where dissatisfied responses are those marked to the left of the central column (1 to 3); neither dissatisfied nor satisfied responses are those marked in the central column (4 to 6); and satisfied responses are those marked to the right of the central column (7 to 9) [Dos Santos *et al.*, 2024b]. Figure 13 presents the learners' responses according to the SAM scale.

According to Figure 13, in relation to the topics discussed within the groups during use of the interactive systems (Q5), most learners reported being satisfied (88% | N = 14), while a minority expressed dissatisfaction (12% | N = 2). It can be seen that the majority of learners were satisfied, showing their potential in terms of engagement and active participation in group discussions when interacting with interactive systems. However, it is essential to consider the not-so-positive feedback to make possible improvements, such as scheduling prior alignment meetings with a detailed agenda of topics to be discussed. From an LX perspective, satisfaction with topics indicates alignment between the learning task and learner expectations, directly influencing engagement and perceived value of the activity.

To the number of members present in the discussions and development of the PWs when interacting with the interactive

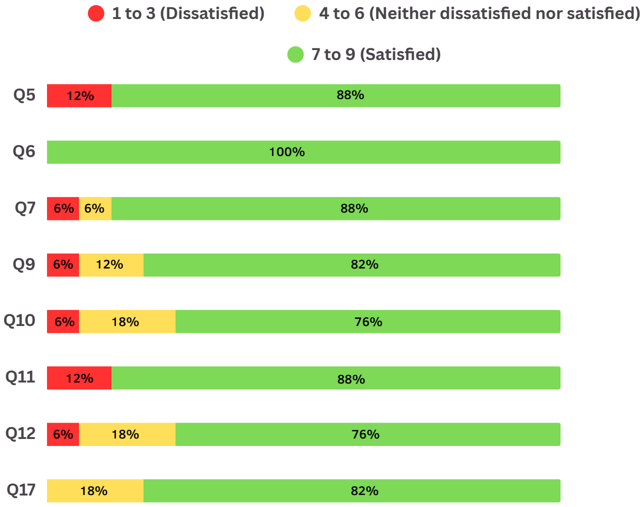


Figure 13. Results of scale SAM.

systems (Q6), all the learners felt satisfied (100% | N = 16). It is believed that the number of members per group made the learners feel like they were in a comfortable, participative, and productive environment, which allowed collaboration and positive interaction between them. This result highlights that LX is influenced by how collaboration is structured, as balanced participation can enhance interaction quality, while unbalanced participation may negatively affect the experience.

Regarding the availability of learners for discussions and the development of PWs when interacting with interactive systems (Q7 | Figure 13), the majority of learners were satisfied (88% | N = 14), one learner was neither dissatisfied nor satisfied (6% | N = 1), and one learner was dissatisfied (6% | N = 1). It can be seen that most of the learners were satisfied with the availability of the other members of their group for the discussions and development of the PWs when interacting with the interactive systems. This highlights the commitment of the majority of learners. For example, for PW2, the learners had to get together to discuss and define which technique the group would use for modeling. However, some learners were not as satisfied. In this sense, it is believed that some factors influenced this non-positive satisfaction, such as the lack of modeling and prototyping practice for PW2. This results reflects how external factors and time management impact LX, demonstrating that the experience is not only shaped by the system but also by the learner's context and constraints.

Concerning the learner's perception of their role in the group (Q8 | Table 8), it appears that the learners called themselves active members (50% | N = 9), i.e. they were present in the group's discussions and decision-making (Figure 14). On the other hand, some learners called themselves passive members (17% | N = 3), i.e. they were not always present in the group's discussions and decision-making. About leadership, some learners called themselves neutral leaders (28% | N = 5), while others called themselves active leaders (6% | N = 1). There was a balance between active participation and leadership among the learners. It is, therefore, conjectured that most of the learners were involved in the group's discussions and decision-making for the development of the PWs. However, in some groups, such as G1 and G4, there was more than one leader per group. On the other hand, some groups had no leader, such as G5. In this sense, it is suggested that the instructor characterize the learners to identify each one's abilities. This characterization is intended to leave the groups with more balanced profiles. And thus provide a more positive engagement for all learners. In addition, this result indicates that LX varies according to the learner's level of involvement, as active participation tends to promote deeper engagement and learning.

Table 8. Results of the Q8.

Question	Possible Answer	Results	
		%	N
Q8. According to your perception, what was your role in the group?	Active member	50	9
	Passive member	17	3
	Neutral leader	28	5
	Active leader	6	1

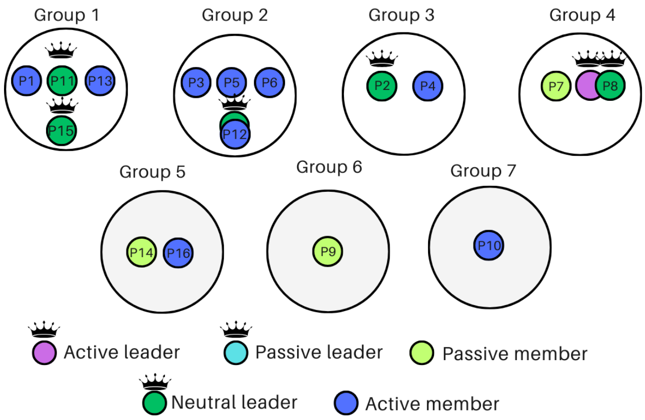


Figure 14. Results of Q8.

About how the learners felt about their role in the group (Q9 | Figure 13), the majority of learners were satisfied (82% | N = 13). Regarding their frequency of interaction with interactive systems to communicate with the group for discussions and development of PWs (Q10), the majority of learners were satisfied (76% | N = 12). It can be seen that the majority of learners were satisfied with their role in the group, as well as with the frequency of use of interactive systems for communication with the group for discussions and development of PWs. In this sense, the members of the group contributed actively, allowing the learners to develop and improve skills such as engagement, participation, and communication. This reinforces that LX is influenced by role alignment and group dynamics, affecting motivation and participation.

Regarding learners' feelings about some topics in the PWs, and discussions being directed at the learner (Q11 | Figure 13), two learners are dissatisfied (12% | N = 2). Regarding the learners' feelings about their communication, discussions, and decisions made when developing the PWs (Q12), one learner was dissatisfied (6% | N = 1). It can be seen that the majority of learners felt satisfied, as the groups worked cohesively. As for PW1, the groups sought to deliver a quality assessment of the accessibility, usability, and UX problems identified in the Hand Talk. In this sense, each member played an essential role in constructing the final PW1. A minority of learners were dissatisfied. It is believed that this dissatisfaction may have been because the learner had a more shy profile and did not like explaining his perceptions to the other members of the group. Showing that the environment was not so well structured for collaborative work from the point of view of this type of learner. This result shows that LX is influenced by how responsibilities are distributed, impacting the sense of inclusion and accountability within the group.

About how the learners organized the execution of the PWs (Q13 | Table 9), the majority of learners divided the PW topics among the group members (59% | N = 10), and some learners worked simultaneously on all the PW topics (41% | N = 7). It is believed that the majority of learners answered that they divided the PW topics between the group members, as both PW1 and PW2 required that some PW topics should be carried out individually and others collaboratively. As in PW2, which was carried out individually and collaboratively. Initially, the learners had to create Personas and Problem Scenarios individually. Then, they held a brainstorming meeting to discuss the personas, problem scenarios, and functionalities of the app, and this meeting was collaborative. From an LX perspective, this reflects how the organization of collaborative space influences interaction patterns and the construction of knowledge.

Table 9. Results of the Q13.

Question	Possible Answer	Results	
		%	N
Q13. In your opinion, how was the activity organized for its execution?	They divided the PW topics They worked simultaneously on all the PWs topics	59 41	10 7

For Q14, a five-point Likert scale was used, ranging from totally disagree (1) to totally agree (5) (Table 10). About the learner's perception that the exchange of knowledge between the members helped in their knowledge acquisition (Q14), some learners totally agreed (50% | N = 8), partially agreed (44% | N = 7), and one learner totally disagreed (6% | N = 1). It is believed that the majority of learners were optimistic about the exchange of knowledge between group members, as this type of scenario provides a richer and more dynamic experience and exchange of knowledge between learners and promotes and aids a greater understanding of the content of the PWs. This is a central aspect of LX, as it directly relates to the learning outcome, showing that interaction with peers and systems can enhance knowledge acquisition.

Table 10. Results of the Q14.

Question	Possible Answer	Results	
		%	N
Q14. How do you rate how much the exchange of knowledge among the members of your group helped you acquire knowledge?	Totally agree Partially agree Totally disagree	50 44 6	8 4 1

Concerning the learner's self-perception of their profile about their group (Q15 | Table 11), three learners considered themselves to be more knowledgeable than the rest of the group (19% | N = 3), two learners considered themselves to be more skilled than the rest of the group (13% | N = 2), one learner considered that all the members of the group had equivalent knowledge (6% | N = 1), and the rest of the learners said that this did not apply (63% | N = 10). It is believed that the majority of learners said that they do not consider themselves to have more advanced skills or knowledge than the other members of the group, as they are at the same level of education and have the same access to information. This result indicates that LX is also shaped by self-perception and social comparison, which can influence confidence, participation, and engagement.

Table 11. Results of the Q15.

Question	Possible Answer	Results	
		%	N
Q15. Do you consider yourself a member of the group with:	Not applicable Greater knowledge Greater skill Equal knowledge	63 19 13 6	10 3 2 1

Four collaborative techniques were used for the PWs in the perception of the learners (Q16 | Table 12), and they are shown in Figure 15. Highlights include consolidation of usability, UX, and accessibility problems (48% | N = 15), and prototyping using collaborative tools (45% | N = 14). In addition, collaboration in Word documents (3% | N = 1) and putting together presentations in Canva were used (3% | N = 1). It can be seen that for PW1, the learners consolidated the usability, UX, and accessibility problems. For PW2, learners prototyped using collaborative tools. For both PW1 and PW2, the learners collaborated on text editing tools to write the final report and prepare presentations. This demonstrates that LX is strongly connected to the nature of the task, as different techniques require different forms of interaction with both peers and technological tools.

Table 12. Results of the Q16.

Question	Possible Answer	Results	
		%	N
Q16. Depending on the course and your perception, what collaborative techniques did your group use?	Problem consolidation Prototyping Collaboration on Word documents Creating presentations on Canva	48 45 3 3	15 14 1 1

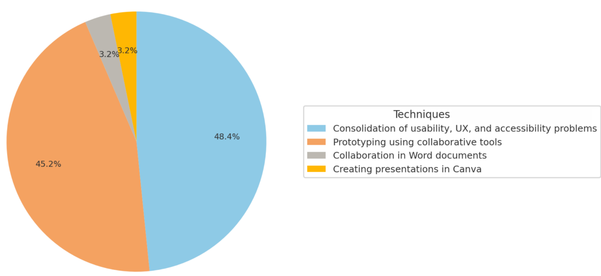


Figure 15. Results of Q16.

The last question in the exploratory study questionnaire was to identify how learners felt about the fact that PWs were not sequences, but somewhat different (Q17). Figure 13 shows that the majority of learners were satisfied (82% | N = 13), and a few learners declared themselves neither dissatisfied nor satisfied (18% | N = 3). This results showed that most learners felt satisfied with the fact that the PWs were different. Next, the comments made by the learners in the open fields of the questionnaire will be presented. This result highlights that LX is influenced by the design of the course, as the organization of tasks affects continuity, learning progression, and overall LX.

6.2.1 Qualitative Analysis

Figure 16 presents the thematic analysis derived from the open-fields responses of the study questionnaire. Four themes were identified: **Feelings about the role played in the group (1)**; **Feelings about the frequency of communication with the group (2)**; **Perceptions regarding knowledge acquisition (3)**; and **Feelings about the PWs being different (4)**. These themes complement the quantitative results by revealing how learners interpreted their participation, interaction dynamics, knowledge exchange, and perceptions of the PWs' design. From an LX perspective, these findings are especially relevant because they make explicit the learner's responses while performing learning tasks mediated by interactive systems.

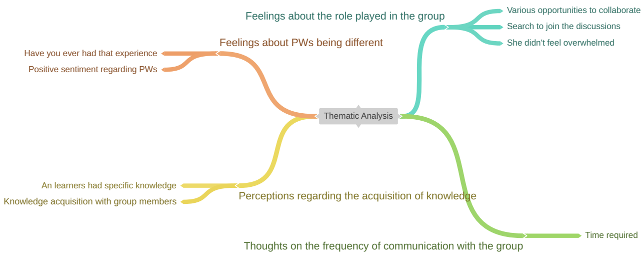


Figure 16. Results of qualitative analysis.

For the theme **Feelings about the role played in the group (1)**, there is the code "researching to join the discussions", in which P10 reported that she had to *"do a lot of research on the subject to be able to join the discussions"*. For the code "did not feel overwhelmed", P12 notes that through the role she played in the group, *"at no point did I feel overwhelmed"*. And for the code "several opportunities to collaborate", P14 commented that throughout the PWs she had *"several opportunities to collaborate but did not take advantage of all of them"*. Altogether, this result show that LX, in relation to roles, was shaped by the balance between opportunity, readiness, and personal involvement in the collaborative task.

For the theme **Feelings about the frequency of communication with the group (2)** there is the code "necessary time", in which P12 stated that the frequency of communication with the other members of her group *"was great. It took only the necessary time and they were very understanding. [Furthermore], no one disregarded the others' opinions"*. This result suggests that, from the learner's perspective, a positive LX does not necessarily depend on intense or constant communication, but rather on communication perceived as sufficient, respectful, and well-adjusted to the task. In this sense, the qualitative result refines the quantitative finding by showing that satisfaction with communication frequency emerged not only from how often learners interacted, but from the quality and adequacy of these interactions within the collaborative process.

For the theme **Perceptions of knowledge acquisition (3)**, there is the code "one learner had specific knowledge", in which P10 comments that *"one of the [group] members had a lot of knowledge about health insurance plans, [and I was able to] learn a great deal"*. For the code "knowledge acquisition with group members", P12 commented that they learned *"various topics on the subject, regarding points I hadn't understood, but some of the other group members had"*. It is observed that the learners sought out other group members to exchange knowledge and discuss the topics of the PWs. These statements reinforce that LX in collaborative contexts is strongly influenced by how learners benefit from peer interaction during the execution of learning tasks. More specifically, the results indicate that interactive systems and group work did not merely support task completion, but also created conditions for distributed expertise to circulate within the group. Thus, the cooperative dimension of LX was manifested through knowledge sharing, clarification of doubts, and access to perspectives that individual work alone might not provide.

For the theme **Feelings about the PWs being different (4)**, there is the code "already had this experience", in which P15 reported having *"the experience of a similar course where the assignments were ongoing"*. Finally, there is the code "positive feeling about the PWs", in which P12 expressed that *"liked that [the PWs] addressed different practices (evaluation and prototyping)"*. From an LX perspective, this theme highlights that the design of the learning tasks themselves influenced the LX. The fact that the PWs were different seems to have been perceived as positive because it exposed learners to distinct HCI practices, expanding the scope of learning and preventing the activity from being reduced to repetition. Therefore, LX here was shaped not only by the technologies used, but also by how the PWs sequence was designed to diversify participation and practice.

Overall, the qualitative analysis deepens the understanding of LX by showing that LX were influenced by how they perceived their place in the group, the adequacy of communication rhythms, the value of knowledge exchange, and the design of the practical works. These findings reinforce that LX in collaborative contexts supported by interactive systems is not limited to task performance, but includes how learners interpret their participation, learning opportunities, and the pedagogical structure in which interaction occurs.

7 Discussions

This session presents the discussion, linking them to the literature and the objectives proposed for the HCI course. Based on the perceptions of the learners, the instructor, and the analysis of the PWs, it seeks to understand how the expository-dialogical approach, combined with collaborative activities mediated by interactive systems, influenced the development of the competencies foreseen in the HCI enabling. This discussion also highlights the challenges faced throughout the process, the observed potential, and the lessons learned, allowing for critical reflection on pedagogical practices, collaboration strategies, and ways to improve teaching and the LX in similar contexts.

7.1 Discussion of Observations and Experiences

A comparison of Miranda *et al*. [2019], Oliveira [2020], Marques and Melo [2015] and the present article reveals that all share the goal of promoting active and meaningful learning in the HCI course, while encouraging the development of technical and social skills through PWs. As in Oliveira [2020] and Marques and Melo [2015], this work emphasizes the importance of situated practice to strengthen learning, evidenced by the completion of two PWs. These PWs encouraged critical analysis of socio-technical factors and the development of interactive solutions. However, there are significant courses with the approach of Marques and Melo [2015], as they integrated different disciplines into the same project. In contrast, this article presents the experience specifically with the HCI course.

Based on the results presented in Section 6, seven lessons learned were identified. The first lesson learned is the importance of individual motivation, as the number of problems identified did not correlate with the number of group members (G8 and G6). As an implication, in practice, there was a need to encourage individual engagement and motivation among learners. O'Brien and Toms [2008] comment that individual motivation influences persistence in performing tasks, affecting the depth of evaluation.

The second lesson learned is that theoretical knowledge is not sufficient and requires practical application of certain topics in HCI, as reported by G8. In this sense, the practical implication is to promote PWs and contact with real users or the use of field data to strengthen learning. The third lesson learned is the use of different techniques or methods to enrich the evaluation, as reported by G3 and G5, who noted benefits in applying multiple approaches. Thus, the practical implication is to encourage the use of multiple evaluation techniques or methods, since the combined use of methods enables the identification of a broader set of problems, with each approach offering complementary strengths and contributions.

The fourth lesson learned is the efficiency of inspection methods, such as Nielsen's Heuristics and the Cognitive Walkthrough, for PW2, which helped identify problems. The practical application is to continue teaching inspection methods for quick evaluations, but to complement them with empirical methods. Barbosa and Silva [2010] cite that inspection-based evaluations are more economical and agile, but should be complemented by empirical evaluations with users to obtain a more realistic view of the interaction. The fifth lesson learned is the importance of collaborative work, according to the positive experiences reported by G3 and G10. We believe that the practical application lies in guiding collaborative work from the beginning of the PWs. In HCI teaching, this practice is fundamental to encourage the equitable division of tasks, the exchange of knowledge, and the construction of richer and more effective solutions.

The sixth lesson learned concerns the challenges of creating personas and hypothetical scenarios, a difficulty reported by G8. Therefore, when considering practical application, it is suggested that, whenever possible, real data collection methods be used, even on a small scale. This practice provides valuable insights and develops learners' critical thinking skills to design solutions that are more aligned with users' needs. The seventh lesson learned is the social value of inclusive design, reported by G5. In this sense, it is suggested to always strengthen the socially conscious design approach for the realization of PWs. Strengthening this approach contributes to training professionals capable of creating more inclusive, ethical technologies that are aligned with social well-being.

Based on the results and lessons learned highlighted, there is a new space for experimentation and development of teaching materials and practices adapted to the Brazilian context. This article is in dialogue with Grand Challenge Nº. 1 [da Silva Junior *et al*., 2024], as it contributes to discussions on new methodological approaches in HCI by proposing teaching that transcends the application of techniques, incorporating ethical and social values, and encouraging learners to critically question traditional user-centered design practices. Continuing this research, LX was evaluated in this context of collaborative learning, as presented below.

7.2 Discussions LX Evaluation

We would also like to emphasize some of the results obtained in this evalutation LX. The majority of learners were optimistic about the questions asked in the study. It is believed that it was possible to enhance the development of new skills and also the appreciation of the learners' existential skills, through the evaluation of LX elements, such as communication, coordination and cooperation.

Regarding the LX element of Cooperation, for example, one learner reported that carrying out the PWs when using interactive systems in a collaborative context was essential for understanding some topics in the HCI course content. The quantitative findings show positive perceptions of collaboration, while the qualitative data highlight that interaction with peers enabled clarification of doubts and access to different perspectives. This suggests that cooperation played a fundamental role in promoting meaningful learning, as learners did not rely solely on individual interaction with the task, but benefited from the collective construction of knowledge. In addition, the use of collaborative techniques, such as the consolidation of usability, UX, and accessibility problems, reinforced this dynamic by requiring negotiation, discussion, and joint decision-making. From an LX perspective, this indicates that cooperation is strongly linked to the depth of the learning experience, as it enables learners to engage more critically with the task and with each other.

Regarding the LX element of Communication, both quantitative and qualitative results indicate that learners perceived communication sufficient to support the development of the PWs. While the quantitative data suggest high levels of satisfaction, the qualitative findings reveal that communication was described as occurring "when necessary and effectively", indicating that learners valued adequacy rather than frequency. This result suggests that LX, in this context, was shaped not by the intensity of communication, but by how well it supported the collaborative task. In addition, the use of multiple communication modalities (e.g., text, audio, images, and video) contributed to a richer interaction, enabling learners to adapt communication strategies according to their needs and preferences. Thus, communication, as an LX element, extended beyond information exchange, supporting meaning-making and collaborative understanding.

As for the LX element of Coordination, there was total agreement among the learners regarding the number of members per group for the development of the PWs. The results highlight generally positive perceptions regarding group organization, participation, and role distribution. The quantitative data indicate agreement among learners about the adequacy of group size and participation, while the qualitative results reveal different levels of engagement, with some learners actively participating and others reporting missed opportunities for contribution. This suggests that, although coordination was perceived as effective at a group level, LX was not uniformly experienced among all learners. From this perspective, coordination influenced LX by structuring the collaborative process, but individual engagement depended on how learners perceived and enacted their roles within the group. These findings reinforce that coordination is not only a structural element, but also a social and experiential one, directly impacting learners' involvement in the task.

Another strong point was the interactive systems used by the learners to communicate with the other members of the group. This is believed to be a positive point, as all the learners used WhatsApp, and most of the learners used Discord. This selection of interactive systems helped the learners get on well with each other and set up meetings to make group decisions. These interactive systems support different types of languages, such as text, audio, images, and video. This support allows learners to share different types of data/information. It also allows for more transparent language for the other members of the group by exemplifying the text message in an image and/or audio. Beyond their functional role, these systems influenced how learners interacted, shared information, and organized their work. The support for multimodal communication allowed learners to express ideas in different formats, contributing to a more inclusive and flexible interaction. From an LX perspective, this highlights that the technology dimension is not neutral, but actively shapes the quality and nature of the LX.

Another highlight is the collaborative techniques used to develop the PWs in the learners' perception. One positive point was the use of the technique of consolidating usability, UX, and accessibility problems for the development of PW1 when interacting with interactive systems in a collaborative context. By using this technique and following the instructor's guidance for the execution of PW1, the learners reported that the result of this PW reflects a collaborative effort, with discussions and notes made together. This collective approach explains the absence of an individual highlight, as the success of the assessment is not based solely on isolated efforts, but on the sum of each member's contributions to identifying and solving problems, reported by group G2. The use of this technique in a collaborative context helps groups prioritize solutions to the most critical problems, maximizing positive impact and providing a more effective and inclusive interactive systems.

Furthermore, it is worth noting that the choice of interactive systems influenced not only the execution of the PWs, but also the perception of belonging and engagement of the learners when working collaboratively. This highlights the need to evaluate these experiences in order to subsequently design systems that allow for personalized interactions, respecting the differences in communication and participation styles among learners. Furthermore, the data suggest that the balance between individual autonomy and collective collaboration should be further explored in the design of educational environments. When users (in this case, the learners) have the freedom to define interaction strategies, there is an increase in satisfaction and engagement, even in contexts mediated by technology. It was also considered that this study revisits practical issues for teaching HCI, such as the role of PWs in stimulating cooperation skills and empathy.

The results reinforce that LX emerges from the interplay among three main dimensions: the learner, the learning task, and the interactive systems used. The learner dimension is reflected in individual perceptions, participation, and prior knowledge; the task dimension is represented by the structure and requirements of the PWs; and the technology dimension is embodied in the systems that mediate collaboration. The integration of these dimensions demonstrates that LX is not determined by isolated factors, but by how these elements interact in a collaborative learning context.

These findings highlight the importance of considering LX in the design and evaluation of collaborative educational practices. While the results indicate positive experiences, they also reveal opportunities for improvement, particularly in promoting more balanced participation and ensuring that all learners can effectively engage in the collaborative process. This reinforces the need for further investigations aimed at developing guidelines and strategies to support instructors in evaluating and enhancing LX in contexts mediated by interactive systems.

This study contributes to the advancement of LX research in collaborative educational contexts by moving beyond descriptive accounts of collaboration and providing an perspective grounded in the 3C model. Unlike previous LX studies focused on individual educational experiences, this study evaluates LX through collaborative dimensions grounded in the 3C model. First, it operationalizes communication, coordination, and cooperation as elements of LX, offering a structured lens to interpret how collaborative dynamics emerge in authentic HCI learning scenarios. Second, the results reveal that collaborative LX is not homogeneous, but shaped by factors such as prior experience, group organization, and the mediation of interactive systems, exposing tensions such as variability in engagement, asymmetries in participation, and inconsistencies between effort and outcomes. These findings challenge the assumption that collaboration inherently leads to positive learning experiences. Third, by linking LX manifestations to specific stages of HCI practice (e.g., requirements specification and prototyping), this study provides empirical evidence that different collaborative activities activate distinct LX dimensions. Together, these contributions extend existing literature by highlighting not only the benefits, but also the complexities and limitations of collaborative learning supported by interactive systems.

Answering the research question of this study, it can be said that the proposed objective was achieved. Through an environment rich in technology in a collaborative context, it was possible to evaluate learner interactions and experiences. In this sense, there was a need to continue investigating these topics, as there is a lack of guidelines and instructions to help and enable instructors to evaluate LX when used with interactive systems in a collaborative context. These future investigations intend to explore in depth how the use of feedback, visual representations such as collective progress and individual recognition and reward mechanisms can contribute to increasing learners' engagement and motivation, favoring more meaningful interactions, and consequently a more engaged LX [Huang *et al.*, 2019]. Ultimately, the results can influence the evaluation and design of interactive educational systems, reinforcing the importance of expanding paradigms in HCI and considering embodied and sociocultural dimensions, as proposed by the First Grand Challenge [Pereira *et al.*, 2024].

8 Final Considerations and Future Work

This article presented a study that evaluates LX, as well as to share feedback and insights from the instructor and a learner assistant in a collaborative learning environment supported by interactive systems. To achieve this objective, two steps were taken. The first involved sharing feedback and insights from the instructor and a learner assistant. The second step evaluated LX in a collaborative learning context.

This study presents an experience obtained in an HCI course at UFPR. The course aimed to enable learners by offering basic notions of HCI from a socially conscious perspective, oriented toward software project work. To achieve this objective, learners carried out two project works (PWs): PW1 consisted of individual app evaluation followed by group consolidation of the evaluation, while PW2 consisted of specification, modeling, prototyping, and evaluation of a prototype app designed for people with visual impairments. Learners', instructor's, and an observer-learner's perceptions were captured through lessons learned in the course. Independent of the modality adopted, the promotion of PWs, encouragement of collaborative work, and contact with real or simulated social contexts proved to be essential strategies to strengthen learners' engagement and develop skills relevant to academic and professional performance in HCI. The planning and detailed execution of PWs were designed to allow replication in other educational contexts, supporting instructors and researchers who wish to adopt active and project-based approaches in HCI teaching.

In addition, this study discovered new and relevant insights into the evaluation of LX when using interactive systems in a collaborative context. The study was conducted with 16 learners and the instructor of the HCI course. The study aimed to answer the research question: "What are the perceptions and experiences of HCI learners regarding communication, coordination, and cooperation when using interactive systems in a collaborative context?". By choosing to use a questionnaire based on the 3C model, it was possible to evaluate the communication, cooperation, and coordination of the learners, enhancing the identification of results according to the objective of this study.

Based on the data collected (Section 6), it can be stated that the study's objective was achieved. The analysis confirmed the importance of continuing investigations in LX, as there were insights into learners' not-so-positive experiences, such as difficulties in scheduling meetings to align PW topics effectively. The study also identified a limitation in the difficulty some learners had in creating personas and scenarios for hypothetical contexts. Future recommendations include using real data and real application contexts to analyze LX, conducting case studies with usability tests or feedback from end users of the PWs' produced personas, and improving PW specifications and guidelines to encourage future learners to interact with potential users.

Another limitation of this exploratory study concerns the participation rate in the exploratory study. Out of the 55 learners enrolled in the course, 16 voluntarily agreed to participate, while 39 did not take part in the data collection. This participation was entirely voluntary and conducted in accordance with ethical procedures approved by the REC. Consequently, no detailed information was collected about the non-participants, which limits our ability to assess whether they differ systematically from those who participated. This introduces the possibility of self-selection bias, as participants may represent learners who were more engaged, available, or interested in reflecting on their experiences. However, it is important to note that, in qualitative and exploratory research, smaller and voluntary samples are considered appropriate for capturing in-depth perceptions and experiences in context. Therefore, while the findings cannot be generalized, they provide relevant and meaningful insights into the LX in collaborative settings supported by interactive systems.

The results suggest that the selection of interactive systems helped create a positive rapport between learners within the same group, supporting different communication modalities such as audio, text, and images. This led to more transparent communication and more positive interaction. The findings also suggest that technology-mediated collaborative work can foster learner autonomy and confidence, contributing to a stronger sense of ownership in the learning process. Overall, by evaluating the three elements of LX (coordination, communication, and cooperation), the study obtained differentiated reports of experiences when using interactive systems in a collaborative context.

Finally, this research advances the state of the art in LX in collaborative contexts and aligns with the HCI Grand Challenge by suggesting pathways towards more inclusive evaluation and design, with social impact and integration between theory and practice. Unlike previous LX studies focused primarily on individual LX, this study evaluates LX through collaborative dimensions grounded in the 3C model. By investigating LX in a real collaborative learning context, this study addresses an underexplored area in HCI research and contributes to expanding empirical knowledge on learner-centered evaluation models. In future work, we intend to conduct a literature search to verify and characterize technologies that evaluate LX when using interactive systems in a collaborative context, conduct studies with a more varied sample of learners and instructors, and perform longitudinal studies to evaluate LX and the impact of interactions on engagement and learning over time. Furthermore, the intention is to expand the availability and organization of the data produced in the study, aiming to strengthen the transparency, reproducibility, and depth of analysis of LX by each group.

Declarations

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Authors' Contributions

GC, DE, RC and NM contributed to the conception of this exploratory study. GC performed the questionnaire development, conducted the investigation and data collection, curated and analyzed the data, and wrote the original draft of the manuscript. DE, RC and NM supported and supervised the methodological design and data analysis, and substantially revised the manuscript. All authors read and approved the final version of the manuscript.

Competing interests

The authors declare that they have the following competing interests.

Availability of data and materials

The datasets generated and analysed during the current study are available at: `https://figshare.com/s/ee0d8ab582971e7d8d5d` and `https://figshare.com/s/a5b7a7ab573a944cd453?file=55938683`, accessed: 13 July 2026.

Further relevant information

This research adheres to the ethical guidelines established by the SBC and our institution with approval from the Research Ethical Committee of the university, under protocol CAAE: 84496124.0.0000.0102. The authors acknowledge that, during the editing process of this article, AI (OpenAI's GPT-4o model and Gemini 3 Pro) was used as an auxiliary tool for translation, grammar revisions and occasional textual restructuring. In all such cases, the content was reviewed and rewritten by the authors as appropriate. All content in this article is original and authored by the researchers.

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