





# Understanding the Influence of Collaborative Tasks on User Experience in Moodle

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**Received:** 23 October 2024 • **Accepted:** 28 September 2025 • **Published:** 22 April 2026

**Abstract** Learning Management Systems (LMSs) are widely adopted to support teaching and learning across diverse contexts, including higher education, corporate training, professional certification, and hybrid or fully online courses. These platforms enable flexible access to resources, asynchronous interactions, and integration of individual and collaborative learning activities. While numerous studies have assessed LMS usability and features, the specific influence of collaborative activities on user experience (UX) remains underexplored. This study investigates how collaboration affects UX in Moodle by comparing individual and peer review–based collaborative activities. We conducted a case study with 35 undergraduate Software Engineering students, following Wohlin’s five-step methodology: scope definition, planning, operation, analysis, and presentation. Participants completed an individual task and a collaborative Peer Review activity, after which UX was evaluated through the Attrakdiff questionnaire and Focus Group discussions. Quantitative results indicated notable differences between individual and collaborative contexts, with collaborative activities perceived as more inventive, stimulating, and pleasant, though issues such as lack of interaction, unclear learnability, and system constraints impacted satisfaction. Qualitative analysis revealed that course structure, the configuration of collaborative activities, and specific Moodle features—such as notifications, feedback mechanisms, and progress tracking—strongly shape UX. Contributions include: (i) empirical evidence of how collaboration-related aspects influence LMS UX; (ii) a replicable methodology combining quantitative and qualitative UX evaluations; (iii) actionable recommendations for improving Moodle’s support of collaborative learning, enhancing engagement and learning outcomes; and (iv) we list a set of recommendations for professors to configure Peer Review in Moodle.

**Keywords:** LMSs, UX and Usability Evaluation, Learning

## 1 Introduction

Over the years, discussions about different teaching and learning models have emerged, aiming to improve and energize knowledge construction. Three primary models exist: directive, non-directive, and relational [Becker, 1994]. In the directive model, the teacher is the center of knowledge, transmitting information to passive students. The non-directive model reverses this, with the teacher observing and students learning independently. The relational model emphasizes shared knowledge acquisition, the use of Collaborative Learning creates a new pedagogical environment where teachers and students take on new roles to develop group work skills through activities [Linden *et al.*, 2000; Johnson *et al.*, 1998]. This approach enables Collaborative Learning, fostering a new pedagogical environment where teachers and students work together to develop teamwork skills [Linden *et al.*, 2000].

Traditionally, Collaborative Learning techniques involve face-to-face interactions in the classroom. However, Learning Management Systems (LMSs) have extended Collaborative Learning beyond the classroom, facilitating non-face-to-face and hybrid learning modalities. LMSs are web-based systems that support material sharing, assignment submission

and return, and online communication between teachers and students [Lonn, 2009]. These systems are designed to promote collaboration and shared learning experiences for both teachers and students [Lonn and Teasley, 2009].

Teachers and students must adapt to the course and learning techniques, utilizing LMS platforms. Teachers are responsible for setting deadlines, sharing materials, creating forums, and assigning teams and pairs. Students are expected to access materials, complete activities, send messages, and submit assignments by the deadlines. Activities should adhere to the established schedule. Teachers can guide collaborative activities, while students should remain engaged throughout each stage.

LMSs should provide a positive user experience to enhance engagement and facilitate the production of higher-quality work. Discussions about LMS improvements and user experience evaluations are crucial in this regard. User satisfaction is influenced by factors related to the context and structure of the courses offered. A student’s experience with the LMS directly impacts their task engagement and, consequently, their learning [Psathas *et al.*, 2020; Magyar *et al.*, 2020]. Researchers are exploring how user experience can influence learning during LMS usage. Aspects such as information qual-

ity, interface design, usability, user experience, and system issues have been identified as influential factors in learning [Miya and Govender, 2022].

User Experience (UX) is a person's overall perception of using a product, system, or service. It encompasses not only task completion but also the emotional, meaningful, and valuable aspects of the experience [ISO9241-110, 2010; Hassenzahl et al., 2010]. Many studies evaluate UX in LMSs, but often focus on system features rather than the impact of collaborative activity structure on UX [Gumasing et al., 2022; Magyar and Haley, 2020; Bourgos et al., 2021]. Investigating this is crucial for proposing improvements that enhance UX and maintain engagement.

UX evaluations employ various methods, techniques, and tools to assess whether an application meets UX quality standards [Rivero and Conte, 2017]. Both qualitative and quantitative techniques are used. Quantitative methods, like Attrakdiff, measure hedonic, pragmatic, and attractiveness qualities [Hassenzahl et al., 2010]. Qualitative methods, like Focus Groups, facilitate discussions on specific topics [Tiosso and Bruschi, 2022]. Combined methods, such as Attrakdiff and Focus Groups, can provide a more comprehensive evaluation. In the context of LMSs, some studies have used combined methods to evaluate UX [Ribeiro and Providência, 2020; Cokan and Paz, 2018; Borsci et al., 2015].

UX evaluations for LMSs should consider aspects related to collaborative activities, as they can influence user experience. Studies propose adaptations and combinations of existing UX evaluation methods and suggest new methods for more comprehensive evaluations [Magyar et al., 2020; Krouska et al., 2020].

Moodle, a popular LMS, offers several collaboration features that can impact UX [Ramos et al., 2021; Gamage et al., 2022]. Numerous studies have evaluated Moodle-based systems to identify areas for improvement [Liapis et al., 2022; Hasan, 2021; Saleh et al., 2022]. Some studies analyze both evaluation methods and user perspectives, but they do not explore the effects of collaboration on UX or the differences between individual and group use [Rosetta et al., 2020; Dilan et al., 2022]. This research aims to answer the following question: *How do collaborative activities influence the UX of LMSs?*

This study investigates how collaboration affects Moodle's UX when used for individual and collaborative activities. A case study involving 35 students enrolled in a Software Engineering Fundamentals course utilized tests, quizzes, and the Moodle Evaluation Laboratory to support Peer Review activities [Barkley et al., 2014]. The LMS was evaluated using Attrakdiff and Focus Group techniques.

The Attrakdiff results indicated a difference in student satisfaction between individual and collaborative activities using Moodle. However, the Focus Group discussions revealed that Attrakdiff did not capture all collaboration aspects relevant to UX evaluation. This research explores the difference in UX between individual and collaborative activities supported by Moodle. It discusses collaboration-related factors that influence Moodle's UX and identifies potential areas for improvement in UX evaluation tools like Attrakdiff and Moodle.

This research contributes to advancing the understanding

of how collaboration influences user experience in Learning Management Systems. It delivers: (i) empirical evidence of the differences between individual and collaborative activities in Moodle, highlighting specific factors that shape students' perceptions; (ii) a replicable evaluation methodology that integrates quantitative (Attrakdiff) and qualitative (Focus Group) approaches; (iii) actionable design recommendations to improve Moodle's collaborative features, such as progress tracking, reviewer feedback mechanisms, and notification systems; and (iv) we list a set of 8 recommendations for professors to configure Peer Review in Moodle. These contributions aim to guide both researchers and practitioners in enhancing LMS-mediated collaborative learning experiences.

## 2 Theoretical Background

This section presents concepts related to Collaborative Learning and User Experience Evaluation through the methods of Attrakdiff and Focus Group.

### 2.1 Collaborative Learning (CL)

Collaborative Learning (CL) is an educational approach where students work together to learn and teach each other [Laal and Laal, 2012]. A situation in which two or more people learn or attempt to learn something together [Dillenbourg, 1999]. Collaborative learning is an educational approach involving joint intellectual effort by students, or students and teachers together [Koschmann et al., 2005]. They collaborate on tasks, problems, or projects, actively participating in the learning process [Dillenbourg, 1999; Linden et al., 2000; Laal and Laal, 2012]. Collaborative activities are those in which participants actively build shared meanings around a common task [Roschelle and Teasley, 1995]. A collaborative activity involves two or more individuals who interact in a coordinated way to solve a problem, build knowledge, or carry out a task [Dillenbourg, 1999]. Several techniques, such as Peer Review and Jigsaw, facilitate CL dynamics [Barkley et al., 2014]. These techniques promote teamwork skills [Warsah et al., 2021; Supena et al., 2021; Chorfi et al., 2022], crucial for social and professional success. Other CL techniques include Round Robin, Note-Taking, Learning Cell, and Team Scavenger Hunt. Teachers should select techniques that align with their learning objectives and the educational environment. The concepts and supporting systems for these techniques are discussed:

- Round Robin involves students participating in brainstorming sessions. A key characteristic is ensuring all participants interact, stimulating idea generation that flows uninterrupted from one student to another until everyone has been involved [Sripradith, 2019; Delina and Refelita, 2021; Sahardin et al., 2019].
- Note-Taking helps students acquire information. Participants take individual notes and then correct them based on their partner's notes [Costley et al., 2022; Arlianty et al., 2021; Costley and Fanguy, 2021].
- Learning Cell actively engages students in content thinking. A key characteristic is encouraging students to indi-

vidually develop questions and submit them to discover what other students thought [Castro *et al.*, 2016].

- Team Scavenger Hunt is a collaborative game-based technique for content comprehension. Its main characteristic is introducing artifacts into students' routines [Brown, 2022; Wokocho and Allen, 2021; Delacruz and Maddox, 2022].
- Peer Review helps students develop critical and self-critical skills. It involves three stages: (i) submitting the first draft of an assignment; (ii) reviewing peers' work; and (iii) authors receiving feedback to develop their final version [Herrera-Pavo, 2021; Markowski *et al.*, 2021; Er *et al.*, 2021].

In this context, CL is defined as an activity undertaken by equal partners working together on the same problem, rather than on different parts of it [Brandon and Hollingshead, 1999]. A meta-analysis of the use of collaborative learning in higher education courses showed that it promotes better performance, higher-level reasoning, more frequent idea and solution generation, and greater knowledge transfer compared to individual or competitive learning strategies [Johnson *et al.*, 1991]. Another meta-analysis of 122 studies examining learning in small groups and individuals using technology found that small groups are a more effective learning structure than individual learning [Uribe *et al.*, 2003]. In this sense, the development of social skills enabled by Collaborative Learning techniques becomes essential for learning outcomes.

CL techniques can be effectively implemented in online environments through LMSs, MOOCs and others [Muñoz-Carril *et al.*, 2021; Ludvigsen *et al.*, 2021]. Beyond this, other debates exist about using technology in education. For example, Lavidas *et al.* [2024] investigated factors influencing the intention and actual use of AI technology among higher education students. Specifically, the study examined factors that explain how Greek humanities and social sciences students use AI applications for academic purposes. Multiple studies have focused on improving these systems. Papadakis [2023] conducted a systematic mapping using the PRISMA protocol to understand the development of MOOCs. This work highlights challenges and opportunities, with a focus on user expectations, MOOC typologies, and their pedagogical use. In another approach, Lampropoulos and Papadakis [2025] explore the use of social robots and artificial intelligence in education to identify their educational value and merits. The study's results highlight the robots' role as meaningful and effective educational tools that can be used in diverse formal and informal settings to support both teachers and students. The discussion of intelligent, human-like tutors that offer personalized learning experiences—taking into account students' unique characteristics, needs, knowledge, and preferences—emerged as a key point for improving student learning, engagement, and motivation, enhancing academic performance, and increasing social skills. LMSs facilitate collaboration by assigning new roles to teachers and students, encouraging knowledge sharing and socializing [Schwarz *et al.*, 2021; Lock and Redmond, 2021]. Studies on LMS improvement focus on user experience and learning theories to enhance individual and group learning. LMSs should support effective pedagogical methods in CL, including ad-

ressing challenges faced by introverted students [Stahl and Hakkarainen, 2021; Saidah and Ngazizah, 2022].

## 2.2 Learning Management Systems (LMSs)

LMSs emerge as support tools for educational contexts, enabling everything from course management to collaborative learning techniques. Since Virtual Learning Environments are software artifacts that allow interaction between people [Wouters *et al.*, 2017], they are based on society, where human activity occurs through group work, and rely on four components: material, human, energy, and information [Ivan *et al.*, 2010]. These environments cover educational contexts where students use software artifacts to learn collaboratively [Stahl *et al.*, 2014]. LMS support the spread of knowledge both within specific groups and in large-scale learning courses [Ciurea, 2009]. Therefore, evaluating these environments from a UX perspective is important, as UX is closely linked to teaching and learning. More engaged students in activities may achieve better learning outcomes.

In this context, studies emerge that leverage LMSs to support the use of other technologies during teaching. Examples include: (i) Ramos *et al.* [2021] proposed an approach for collaborative learning group formation with an LMS; (ii) Forman and Miller [2023] examined student perceptions in online courses; and (iii) Yahaya *et al.* [2024] evaluated the acceptance of an AI Chatbot in collaborative learning in Malaysia. This demonstrates the broad range of applications for LMS studies within education and technology.

Within this context, support and guidance systems for learning coaches, teachers, and learners are necessary to promote the educational quality of collaborative activities. As such, quality indicators for these processes should include both verbal and non-verbal measures of student interactions [Buseyne *et al.*, 2024]. Other authors provide recommendations for teachers to incorporate specific educational technologies as a method to enhance particular forms of student engagement. Based on the evidence, the article points out that some educational technologies have a more documented and sometimes broader potential to engage students behaviorally, affectively, and/or cognitively than others [Godsk and Møller, 2025].

Accordingly, a greater understanding of the different ways students use educational technology in their learning benefits teachers' skills in designing Technology Enhanced Learning (TEL). To develop this understanding, the authors [Sweeney, 2024] conducted a qualitative case study with a differentiated interview strategy to explore students' use of educational technology. The research drew on phenomenographic and sociocultural theoretical perspectives and analysis techniques to investigate the educational technology experiences of university students.

Online education systems, often referred to as LMSs, support Collaborative Learning (CL) [Azevedo *et al.*, 2022; Costa *et al.*, 2019; Colombero and Dal Zotto, 2022]. These systems vary from specialized tools for specific CL techniques to comprehensive platforms that enable teacher-student collaboration and interaction [Ito *et al.*, 2021; Srikan *et al.*, 2021; Ahmed and Abdu, 2021; Ayastuy *et al.*, 2021]. Some LMSs offer features like Gamification, Peer Review, and Problem-Based Learning (PBL) activities. Moodle is a popular exam-

ple [Quansah and Essiam, 2021].

Evaluating the UX of LMSs involves assessing factors like system acceptance, satisfaction, usability, and overall user experience [Prati et al., 2021; Mtebe, 2019]. Such evaluations provide valuable insights for understanding user perspectives, suggesting improvements, and identifying appropriate evaluation contexts.

While traditional UX evaluation methods (e.g., SUS, Attrakdiff, UEQ, interviews) are commonly used, they often overlook external factors influencing evaluation results [Girouard and Kang, 2021; Hasan, 2021; Mkpojiogu et al., 2021]. New and adapted methods are being proposed to address these limitations and provide a more comprehensive understanding of LMS UX [Magyar et al., 2020; Jiménez-González et al., 2016; Rosetta et al., 2020].

### 2.3 AttrakDiff

This questionnaire-based UX assessment method allows for evaluating attractiveness through different aspects and comparing user expectations and experiences with the application. The questionnaire consists of 28 pairs of opposite adjectives so potential study participants can report their perceptions of the product. Each pair of adjectives represents an item in the questionnaire that should be answered based on a seven-point Likert scale, ranging from -3 to 3, with 0 being the neutral point [Hassenzahl et al., 2003]. Table 1 presents the complete AttrakDiff questionnaire with its word pairs arranged.

Attrakdiff								
Item	1	2	3	4	5	6	7	Item
Human								Technical
complicated								simple
impractical								practical
cumbersome								straightforward
unrepresentable								presentable
confusing								clearly structured
unruly								manageable
stylish								tacky
predictable								unpredictable
cheap								premium
alienating								integrating
brings me closer to people								separates me from people
isolating								Connective
professional								unprofessional
unimaginative								creative
bold								cautious
innovative								conservative
dull								captivating
undemanding								challenging
novel								ordinary
inventive								conventional
motivating								discouraging
Pleasant								Unpleasant
ugly								attractive
likeable								disagreeable
rejecting								inviting
good								bad
repelling								appealing

Table 1. Attrakdiff Questionnaire

Pragmatic quality focuses on the product, its utility, and usability for a specific task—how one achieves a particular goal. Hedonic quality focuses on the individual based on identity, addressing why someone owns and uses a product, emphasizing communication of identity to relevant others, relationship, and identification with the product. Hedonic quality also focuses on the individual based on stimulation, addressing why someone owns and uses a product, involving novelty, change, personal growth, and inspiring a desire for use. Attractiveness is a dimension encompassing attributes from these three preceding dimensions. The goal is to derive, from Pragmatic and Hedonic Quality, how attractive a product can be considered [Hassenzahl et al., 2008b].

Attractiveness is evaluated by comparing user expectations and experiences with the application. This indicates the overall value of the application based on perceived quality.

Pragmatic Quality describes the quality of an application and indicates the degree to which the user achieves their goals using the application. Hedonic-Stimulus Quality indicates the extent to which the application can support the needs of developing and advancing the application in terms of originality, interest, and stimulation. Hedonic-Identity Quality indicates the extent to which the application allows the user to identify with it [Barbosa et al., 2022].

AttrakDiff has variations like the AttrakDiff Mini, a short questionnaire with only 10 items used to evaluate the perceived pragmatic quality, hedonic quality, and attractiveness of an interactive product. This compact version aims to confirm if the attractiveness hypothesis is positive [Hassenzahl et al., 2008a; Hassenzahl and Monk, 2010]. An example of AttrakDiff Mini’s use is in the evaluation study by Vieira et al. [2023], where the authors presented a new hypothesis for the design of smart fencing apparel, developed through a user-centered design process.

### 2.4 Focus Group

Focus groups are carefully planned discussions designed to elicit group members’ perceptions on a defined area of interest. The discussion is guided and facilitated by a moderator, who follows a predefined structure to keep the discussion focused. The benefits of focus groups include generating candid and sometimes insightful information, and the method is relatively inexpensive and quick to execute. Focus groups involve defining the research problem, planning the event, selecting participants, and conducting the session [Langford, 2002].

The discussion and interaction in a focus group session can take various forms. It can be a structured discussion where the moderator actively engages participants and facilitates the application of brainstorming techniques, such as affinity clustering or team-based methods. The moderator’s role is critical in a focus group session. The moderator should facilitate the discussion but not allow their opinions to influence it [Widdows et al., 1991]. The moderator’s primary task is to listen and probe deeper when necessary, requiring them to grasp the discussion’s content quickly. Quantitative data, if collected, can be analyzed using descriptive statistics and other standard quantitative methods [Kontio et al., 2004].

There are also variations of focus groups. The Traditional Focus Group usually involves 6 to 12 participants in an in-person session lasting between 1 and 2 hours, where the moderator leads the discussion using a semi-structured script. There are also Mini Focus Groups, with 4 to 6 participants, used when the topic is sensitive or when deeper exploration of individual issues is needed, as they allow more speaking time per participant. Another variation is Online Focus Groups, conducted via videoconference or specialized platforms, which can be synchronous or asynchronous. Another type is the Double Moderation Focus Group, with two moderators—one leading the session and the other ensuring that topics are thoroughly explored—helpful for ensuring data quality [Krueger, 2014].

### 3 Related Work

This section presents studies that (i) Evaluate the differences between learning with or without collaboration; and (ii) Evaluate the UX of LMSs.

In this line, researchers such as Martín *et al.* [2020] and Ozkara and Cakir [2020] investigated the use or non-use of collaboration during learning. Although this work does not investigate that, this discussion is necessary to understand the different types of learning systems. Martín *et al.* [2020] investigated the difference between collaborative and individual writing. They reported that feedback, motivation, collaboration, and satisfaction favored the collaborative writing method. They applied a qualitative study through a quasi-experiment with a control group and an experimental group, concluding that collaborative writing was effective compared to individual writing. Ozkara and Cakir [2020] compared groups of graphic animation students who performed tasks individually and collaboratively during online instruction. They compared the control and experimental groups regarding academic success, motivation, and satisfaction. Participants completed tasks online, such as lessons, assignments, and discussions. Thus, the motivation of students who participated in collaborative writing groups was high.

Regarding UX evaluations in LMSs, there are systematic mappings in the literature that identify approaches to evaluate the UX and Usability of LMSs. Júnior *et al.* [2022] present a Systematic Mapping of the literature on the subject, covering approaches used from 2010 to 2020 to evaluate usability and UX in LMSs. They raise the question of whether there are alternative methods, such as those that rely on automation, to ensure that LMSs and other digital products meet usability standards. Nakamura *et al.* [2017], in their article, presented a Systematic Mapping Study (SMS) on UX techniques for evaluating LMSs. In the study, they selected 62 publications related to UX and usability evaluations, gathering techniques and their characteristics in this context, such as originality, type, applied method, learning factors, constraints, and evaluation.

Maslov *et al.* [2021] explored students' perspectives when using LMSs at a university. They used mixed methods, such as semi-structured interviews and surveys. The results showed that students evaluated the use of the Modular Object-Oriented Dynamic Learning Environment (Moodle) as an LMS application positively, and they considered e-learning a sustainable and effective learning solution under current conditions.

Alshira'h *et al.* [2021] present a case study in which they evaluate user experience with LMSs by collecting comments and feedback during use. The authors propose using the User Experience Questionnaire (UEQ) to assess and quantify the user experience with LMSs. The results provide feedback and support for implementing the LMS.

Dilan *et al.* Dilan *et al.* [2022] evaluated the usability of Moodle using open-ended questions. To do this, the authors conducted a case study with computer science students who used a Moodle-based system. The results reported the usability evaluation of a system under development, obtaining data on ease of use, effectiveness, memorability, and satisfaction. The results consider the features necessary for the next

version of this system and show those considered important.

The authors Korableva *et al.* Korableva *et al.* [2019] evaluated and compared satisfaction and UX in the Coursera and Open Education systems. They conducted a case study and evaluated the systems using the Usability Metric for User Experience - Lite (UMUX-Lite) and System Usability Scale (SUS) questionnaires. The study compared the two online teaching platforms, suggesting improvements. In this sense, the Open Education platform is reported as an outdated tool, while the Coursera platform has a modern interface. The authors Rosseta *et al.* Rosetta *et al.* [2020] presented a model for evaluating e-learning systems based on ease of use, usability, and other known aspects. The authors statistically evaluated the model, needs, and evaluation strategies through a case study. These strategies make the user interface attractive and facilitate understanding and student access. Thus, the model provides proposals for tools based on student experience evaluation and creative content according to each student's behavior. The authors considered that interface specialists should make the layouts so that the students feel the platform is more useful when the criteria are met.

This section reviews research related to UX in LMS-mediated collaborative activities. The review considers the following categories: (i) Studies investigating student satisfaction when completing tasks with or without collaboration [Martín *et al.*, 2020; Ozkara and Cakir, 2020]. (ii) Various UX evaluations of collaborative systems that addressed the perspectives of teachers and students during the use of learning environments [Dilan *et al.*, 2022; Korableva *et al.*, 2019; Rosetta *et al.*, 2020]. In line with these investigations, this study addresses how collaboration-related aspects influence the UX of LMSs, what should be considered during evaluations, and proposes improvements for Moodle. To this end, a case study was conducted, presented in the following section.

### 4 Method

This section presents an Case Study based on Wohlin *et al.* [2012] to understand the influence of the need for collaboration on UX during the use of an LMS. According to Wohlin *et al.* [2012], an Case Study comprises five steps: (i) Scope - to ensure that the intention with the experiment is achieved, in this phase the foundation of the experiment is determined; (ii) Planning - where it is prepared how the experiment will be conducted; (iii) Operation - where the treatments are applied to the participants, obeying the planning properties correctly; (iv) Analysis and Interpretation - where conclusions are described about these data through interpretations; and (v) Presentation and Packaging - where the perceptions of the study are presented through different forms, such as articles or packages for replication of experiments or material for education. Figure 1, shows the steps of the study.

In this context, students were invited to participate in individual and collaborative activities mediated by the same LMS. The approved Ethics Committee Project, CAAE number 76918423.0.0000.5020, Opinion number 6.648.023, supports this study. The aim was to investigate the differences in the student experience when using the LMS for individual or group activities. This approach allowed us to describe the

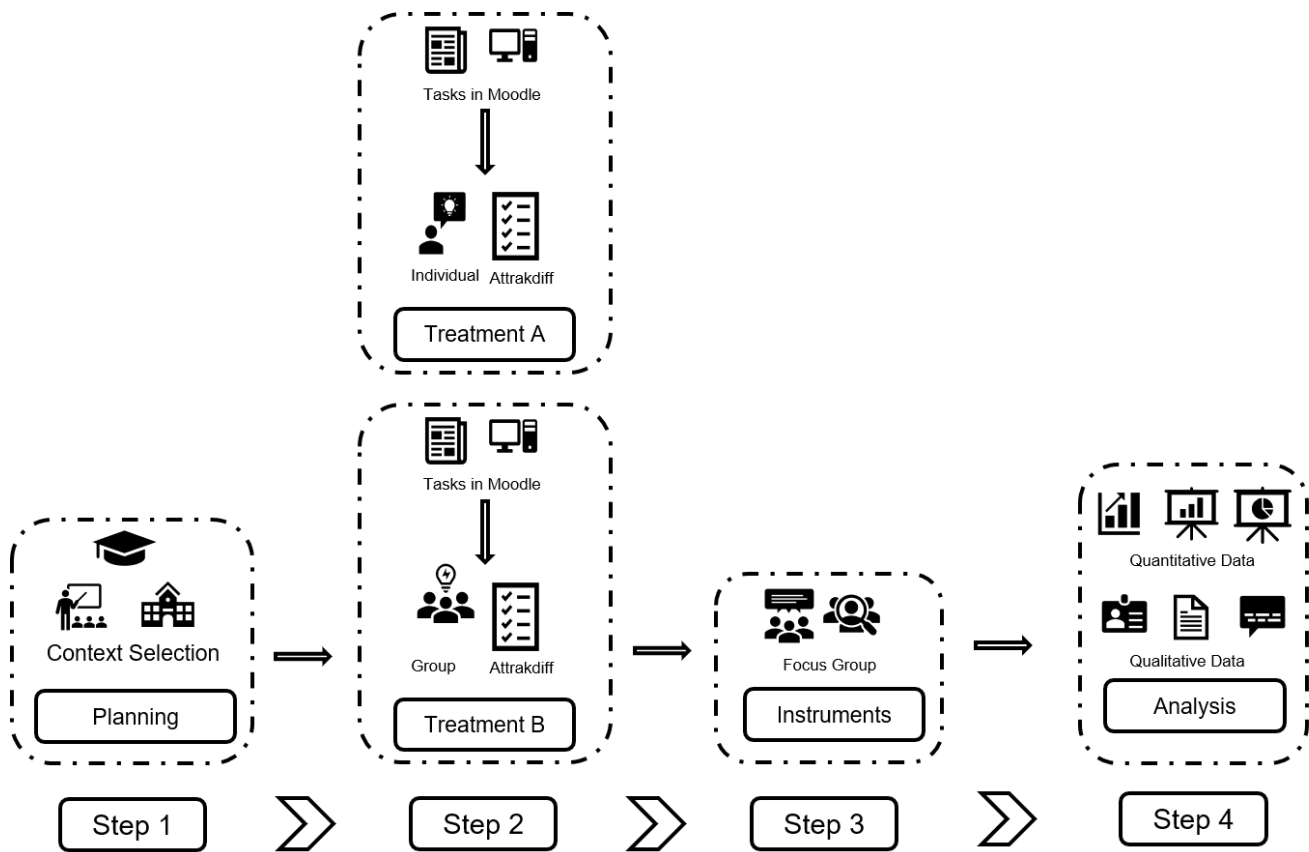


Figure 1. Methodological procedures of the study

aspects related to the need for collaboration that affect UX in LMSs.

The main screen of this system is divided into three sections: Left: The navigation menu, which lists the course’s panels and pages, such as the participant list, topics, and other courses in which the participants are enrolled. Center: The course management area, which includes forums, materials, classes, and dynamics of the course managed by the teacher. Right: The news section, where events are displayed, as well as the search bar for the forums. Figure 4, presented in Portuguese, displays the main screen of a course in Moodle.

### 4.1 Scope

This section describes the work’s scope, which is related to student experiences using LMSs during teaching and learning. To achieve this, we adopt the GQM approach by defining the objective, question, perspective, stakeholders, and context. The UX assessment tools, such as Attrakdiff and Focus Group, are not mentioned in the GQM but we use them to reach our objective.

The study objectives were defined according to the Goal Question Metric (GQM) framework [Wohlin et al., 2012] as follows:

- Goal: Analyze the UX
- Question: Evaluate the UX
- Perspective: Collaboration
- Stakeholder: Researcher
- Context: Academics (undergraduate students in Software Engineering)



Figure 2. System: Moodle Fundamentals of Software Engineering course for desktop access

This section presents the first three phases of this study: (i) Scope: This phase defines the study’s objectives; (ii) Planning: This phase involves selecting the contexts, formulating hypotheses, and developing instruments; (iii) Operation: This phase describes how the study was conducted. The remaining two phases, Analysis and Interpretation, and Presentation and Packaging, are covered in the Results Section.

To analyze UX, the Attrakdiff [Hassenzahl et al., 2003] and Focus Group [Langford, 2002] methods were chosen. These methods were selected because they are widely used and referenced in the Human-Computer Interaction (HCI) community, and they are popular techniques for: Attrakdiff: Visualizing the pragmatic, hedonic, and attractiveness aspects of systems. Focus Group: Understanding the effects beyond UX results.

## 4.2 Planning

During the study planning phase, the objective, object, and techniques to be used were defined. To this end, a literature review was conducted to identify studies on UX evaluation in LMSs. In these studies, researchers used UX evaluations to generate discussions aimed at promoting improvements in the UX of these environments involving collaborative activities. These discussions expand the possibilities for research in this area, allowing for comparisons between systems and aiming to enable teachers and students to choose ideal environments according to their context and environments that promote good UX during learning. These UX improvements can occur in various ways, encompassing aspects of how the course is structured in the environment, how technological resources are made available to users, and how collaborative activity is conducted during the course. For the planning phase, we aimed to answer: "How do collaborative activities influence the UX of LMSs?" To do this, we used both quantitative and qualitative analysis instruments to discuss the influence in the results section. Below, we detail the context selection, study variables, selected participants, and the design and instruments used.

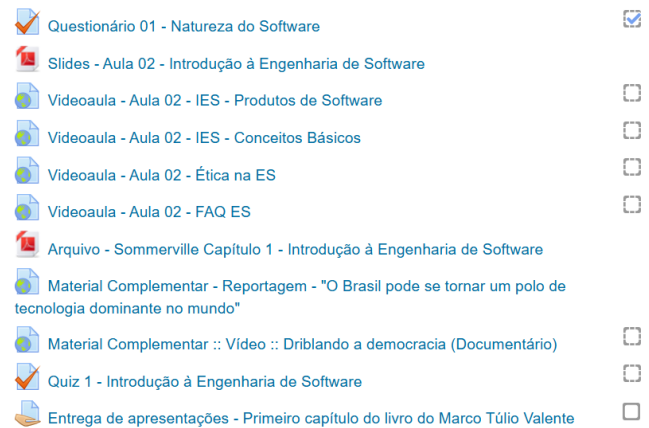
**Context Selection:** The context of this study is an educational setting, specifically 35 undergraduate Software Engineering students at the Federal University of Amazonas (UFAM). The students used Moodle as their course management platform [Ramos et al., 2021; Gamage et al., 2022]. The students conducted two UX evaluations of Moodle: the first after using the system to complete an individual activity and the second after using the system to complete a collaborative activity. These activities were conducted online, with real-world problems and a specific study context.

**Variables:** Independent Variable: Collaboration. Dependent Variables: UX results from Attrakdiff related to pragmatic, hedonic, and attractiveness aspects of system usage.

**Participant Selection:** The sample includes 35 students from the first semester of the Software Engineering course at the Federal University of Amazonas (UFAM). These students had no prior experience with the system and had not taken the Human-Computer Interaction course, which covers user interface evaluations. For this reason, the students were invited to complete a characterization questionnaire, asking for their email address, age, and gender.

**Design:** One factor and two treatments, where the factor is UX, measured by the Attrakdiff technique, and the treatments are the ways in which the activity is structured in the system: (i) using the system without collaboration between students; and (ii) using the system with collaboration between students. The sample was for convenience, considering one experimental unit (UE). The treatments were A and B. Treatment A corresponded to using the system in the class without collaboration. Treatment B corresponded to using the system with collaboration, through the Peer Review technique. Finally, a Focus Group was conducted to capture the students' perceptions of UX during the use of the system. The deadlines and subjects were defined according to the schedule and planning of the discipline, where the students participated in activities mediated by Moodle such as tests, individual questionnaires, group work, and a Peer Review dynamic.

For this study, individual activities were considered to be the tests and quizzes carried out online, with deadlines previously established by the teacher. To answer the quizzes and questionnaires, students accessed support materials available on Moodle, such as slides, video lessons, and book chapters. They also had access to complementary materials like news reports and videos. Figure 3, presented in Portuguese, shows a course topic where students use materials for individual activities.



**Figure 3.** Course topic including: slides, videos, reading materials, and individual activities.

In relation to the collaborative activity, the Peer Review dynamic was considered, where the researchers registered the activities in Moodle, configuring the steps of the technique in the Evaluation Laboratory, including the number of reviewers, the deadlines for the delivery of the activities and a checklist to guide them during the review. Thus, each student had to review the work of a colleague. They would have 4 days to complete the activity submission step, 1 day to review the activities of their colleagues, and 2 days to submit the final version. This preparation involved the three researchers (P1, P2, P3). P1 prepared the study materials, P2 and P3 reviewed the materials and suggested improvements. At the end of the activities, the students answered the Attrakdiff and participated in a Focus Group session.

The Moodle Evaluation Laboratory was defined as the object of this study, as Moodle is widely used, supporting the management of courses and group activities such as the mediation of the Peer Review technique. In this sense, it allows for various research investigations on Moodle UX evaluations. Figure 4, presented in Portuguese, shows the monitoring screen for the Moodle Workshop activity. The study followed the configuration, submission, assessment, and grade calculation phases.

For UX evaluation, the AttrakDiff questionnaire was established to collect quantitative data and a Focus Group session to collect qualitative data. Since together, the techniques can expand the scope of the evaluation. Thus, the Attrakdiff was answered through a Google Forms form. The Focus Group, on the other hand, took place in a face-to-face session with a pre-established and revised script by the researchers.

**Instrumentation:** The instruments developed to conduct the experiment were: (i) Informed Consent Form (ICF), to request permission for the study data and present the terms to the participants; (ii) participant characterization forms, to

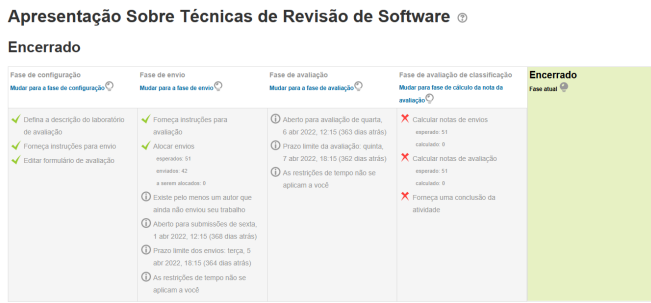


Figure 4. Peer Review

understand the demographic issues of gender and age; (iv) the study scenarios (object of the study); (v) the technique questionnaires; and (vi) post-evaluation questionnaire and Focus Group script.

The Informed Consent Form (IFC) and the participant characterization questionnaire are available at the link: The questionnaire is available at the following link: Click here.

In this stage, the procedures and protocols for data collection using Attrakdiff and Focus Group to evaluate the UX of the Moodle Evaluation Laboratory were developed. For Attrakdiff, a Google form was created that encompassed the questionnaire items. Participants could answer the questionnaire based on the Likert scale. The questionnaire is available at the following link: Click here.

For the Focus Group, a script was defined with the aim of investigating: whether the students enjoyed participating in a Peer Review activity; how the students felt when faced with the need for collaboration when performing the task; the motivation for which the students liked or disliked the activity; the students' experience during the use of the virtual environment; and about the manipulation of the virtual environment of the activity. In this case, the interesting thing was to understand what affected their UX as participants of the individual and collaborative activity mediated by Moodle.

We have prepared the following questions to guide the Focus Group: (a) How was the experience of completing the individual activity mediated by Colabweb? (b) How was the experience of completing the collaborative activity (peer review) mediated by Colabweb? (c) Was there a difference between completing the two activities, despite them being mediated by the same system? (d) What aspects do you think could be addressed to evaluate UX in this context of LMSs? (e) If there was a difference, do you think other aspects of the system, activity planning, or course could be improved? (f) Do you believe that if the experience during use, both individual and collaborative, were better, other outcomes regarding your performance as a participant in teaching and learning could change?

With respect to the Attrakdiff, an attempt was made to verify if there were aspects that the participants would consider important and were not addressed by the standard Attrakdiff form, and it was also verified if there was any pair of words that they would consider adequate or inadequate to evaluate the UX in this environment. This was necessary since the Attrakdiff shows the result of the UX, but does not show what influenced this result.

With the pre-established technique instruments, the Informed Consent Form (ICF), the activity to be developed

by the students during the Peer Review, and the checklist they would use during the activity were developed. The checklist is available at the following link: Click here.

The activity consisted of developing a presentation on software testing, covered during the course. Thus, it was necessary to develop the checklist so that the study participants could be guided during the review stage. The table shows the checklist items for evaluating Software Testing presentations.

### 4.3 Operation

Operation is the stage where treatments are applied as established in the planning [Wohlin et al., 2012]. Figure 1 shows the procedure of the stages of this study. The first stage involves planning, including the selection of the teaching and learning context for undergraduate Software Engineering students at a University. The second stage shows the application of individual and group tasks of the Software Engineering course mediated by Moodle.

The third stage details the application of the instruments, where the students answered the Attrakdiff and participated in a Focus Group on the experiences. The fourth stage shows the data analysis. This stage included the use of Moodle to mediate tests, quizzes, and the Collaborative Peer Review Learning technique during the teaching of Software Engineering. A dynamic that involved the students in the preparation of a presentation on software testing, contained in the syllabus of the discipline. The study was conducted with 35 students of the Fundamentals of Software Engineering course at the Federal University of Amazonas.

### 4.4 Evidence Collection

In the classroom, the researchers presented the purpose of the study and explained that participation was voluntary and that students could withdraw from the study at any time. After the dynamic, the students were invited to sign the Informed Consent Form (ICF) and answer the Attrakdiff questionnaire to express the aspects of their experience during their participation in the activity. Then, they participated in a Focus Group session to report their experiences with the use of Moodle as support for individual and collaborative activities. This session took place during a class time reserved by the teacher for the collection of evidence for this study.

### 4.5 Data Analysis

We quantitatively analyzed the data collected with the Attrakdiff instrument in this stage. We used mid-point plots to group questionnaire items by Pragmatic, Hedonic-Stimulation, Hedonic-Identity, and Attractiveness aspects. We created the plots to understand the results, and the mid-point analysis helped researchers understand the system's UX aspects. The details of the analyses on this graph are presented in the Results section. With respect to the Focus Group, the responses on the use of Moodle during a collaborative activity were analyzed using the following coding procedures from Grounded Theory [Wuetherick, 2010]: open coding and axial coding. In the open coding approach, the aspects that guide the analysis are predefined, based on which the data obtained is labeled

with codes created according to these aspects. In axial coding, the relationship between the codes obtained in open coding was analyzed, resulting in a network of concepts and relationships. The analysis of the collected data is presented in detail in the Results Section.

## 5 Results

The study was conducted with 35 students from the Fundamentals of Software Engineering course at Federal University of Amazonas who used the Moodle environment. Regarding the age of the participants, 73.3% of the students were between 18 and 21 years old, 23.3% were between 22 and 25 years old, and only 3.4% were 30 years old or older. Regarding the gender of the participants, 63.3% identified as male, 33.3% identified as female, and only 3.4% identified as another gender.

### 5.1 Attrakdiff

This subsection presents the Attrakdiff results on the experiences of students individually and in groups in a course mediated by LMS. These results were important to understand how the experience of a given user in the same system changes according to the form of interaction proposed during the activity.

#### 5.1.1 Individual student experience

The data collected with the Attrakdiff questionnaire for individual activities was analyzed, and then the mean point graph presented in Figure 5 was generated, considering the Pragmatic, Hedonic/Identity, Hedonic/Stimulation, and Attractiveness aspects. Each of these aspects is described below:

- Regarding the Pragmatic aspect, Moodle was considered more “practical” than “impractical” and more “clear” than “ambiguous”. However, Moodle was also considered more “complex” than “simple”, more “unpredictable” than “predictable”, and more “well-structured” than “confusing”. One of the factors that may have led users to consider the system as practical and clear in this activity is that it was also considered “conventional”. One of the factors that may have led users to consider the system practical and clear in this activity is that it was also considered “conventional”. On the other hand, being more complex and unpredictable may be related to both the system’s functionality aspects and the proposed activity itself, as these aspects are related to user satisfaction during individual activities.

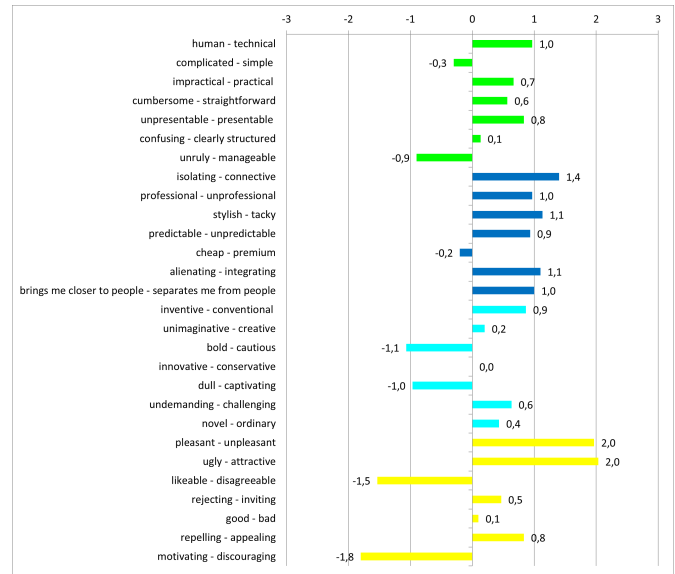


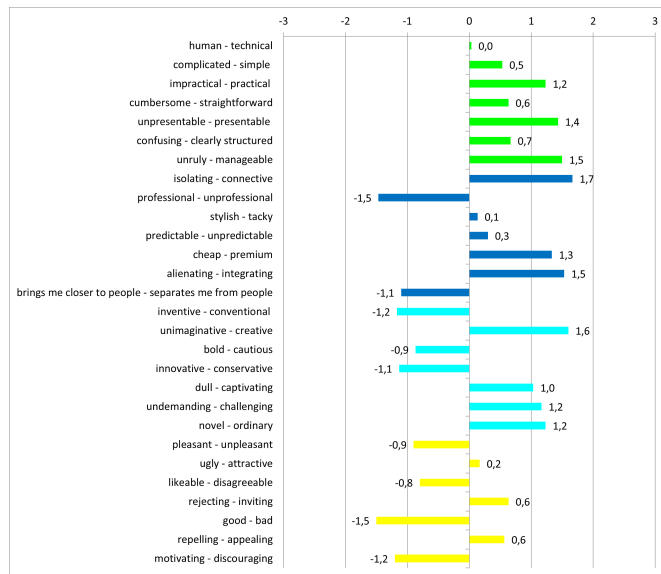
Figure 5. Attrakdiff Individual Activities: Distribution of Results in Mean Points. Green: Pragmatic; Dark blue: Hedonic Identity; Light blue: Hedonic Stimulus; Yellow: Attractiveness.

- Regarding the Hedonic/Identity aspect, Moodle was considered more “connecting” than “isolating”, more “unprofessional” than “professional”, and that the system “distances them from people”. Given that the activity took place asynchronously, participants considered the system as “connecting”, but Moodle, by allowing online activities, distanced them from their colleagues in person. However, the system was considered more “high quality” than “low quality”, more “alienating” than “integrating”, and more “presentable” than “unpresentable”. This was expected, as educational systems tend to be more pragmatic, but less lean and enjoyable during the execution of activities.
- Regarding the Hedonic/Stimulation aspect, Moodle was considered more “conventional” than “inventive”, more “daring” than “cautious”, more “boring” than “eye-catching”, and more “challenging” than “undemanding”. Thus, it was found that the participants felt bored with the use of Moodle during the individual activity.
- Regarding the Attractiveness aspect, Moodle was considered more “unpleasant” than “pleasant”, more “attractive” than “repellent”, more “motivating” than “discouraging”, more “seductive” than “repulsive”, and more “beautiful” than “ugly”. In this context, to use a more attractive system in an activity that helps to develop skills that will be required in the job market, it is necessary that students are connected to each other and to the system.

#### 5.1.2 Collaborative learning experience

The data collected with the Attrakdiff questionnaire for collaborative activities was analyzed, and then the mean point graph presented in Figure 5 was generated, considering the Pragmatic, Hedonic/Identity, Hedonic/Stimulation, and Attractiveness aspects. Each of these aspects is described below:

- Regarding the Pragmatic aspect, Moodle was considered



**Figure 6.** Attrakdiff for group activities: distribution of results in mean points. Green: Pragmatic; Dark blue: Hedonic Identity; Light blue: Hedonic Stimulus; Yellow: Attractiveness.

more “practical” than “impractical” and more “clear” than “ambiguous”. However, Moodle was also considered more “simple” than “complex”, more “unpredictable” than “predictable”, and more “well-structured” than “confusing”. This unpredictability may be associated with the user considering the system more “inventive”. This could be related to both the system’s functionality aspects and the configuration of the Peer Review technique itself. Since these aspects are related to user satisfaction during Moodle-mediated Peer Review.

- Regarding the Hedonic/Identity aspect, Moodle was considered more “connecting” than “isolating”, more “professional” than “unprofessional”, and that the system “distances them from people”. Given that the activity took place asynchronously, participants considered the system as “connecting”, but Moodle, by allowing collaboration through the Peer Review technique, distanced them from their colleagues in person. However, the system was considered more “high quality” than “low quality”, more “integrating” than “alienating”, and more “unrepresentable” than “presentable”. This is a characteristic of educational systems, which tend to be more pragmatic, but less lean and enjoyable during the execution of activities.
- Regarding the Hedonic/Stimulation aspect, Moodle was considered more “inventive” than “conventional”, more “innovative” than “conservative”, more “daring” than “cautious”, more “eye-catching” than “boring”, and more “challenging” than “undemanding”. Thus, it was found that the participants felt stimulated in relation to the use of Moodle during the execution of the Peer Review activity.
- Regarding the Attractiveness aspect, Moodle was considered more “pleasant” than “unpleasant”, more “attractive” than “repellent”, more “motivating” than “discouraging”, more “seductive” than “repulsive”, and more “beautiful” than “ugly”. In this context, using a more attractive system in an activity that helps develop team-

work skills is important, as for collaboration to occur, students need to be connected to each other and to the system.

Using a more connective UX system in an activity that helps develop teamwork skills is important, as in this case collaboration requires connection between both students and their peers and students and the system, and this affects student learning during the activity.

The results presented by the Attrakdiff indicate an overall positive experience for the study participants during the Peer Review activity mediated by Moodle. However, it was also noticed that there was no consensus among the participants about this experience. Thus, to better understand the students’ experience with the activity, a Focus Group was conducted, which is detailed in Subsection 5.2.

## 5.2 Focus Group

During the Focus Group session, students took notes on a whiteboard. The whiteboard was divided into “Lovers”, where students could leave positive comments about the experience, and “Haters”, where students would highlight points for improvement. After the session, the study recording was transcribed with the exact words of the students, teacher, and researcher present at the session. Next, a qualitative analysis of the data contained in the transcript was conducted. The software chosen for the analysis was Atlas.TI because it is widely used for developing codes and networks to map and link concepts [Smit, 2021]. As described in Section 4.5, the Grounded Theory coding procedures were performed [Wuetherick, 2010]: open coding and axial coding. Figures 7 and 8 present the networks resulting from axial coding, covering “Skills and Interaction” and “Learnability and Practice”, respectively. Figure 9 presents the observation networks between “Individual and Group”, and Figure 10 presents the conceptual networks of “Tool and Satisfaction”. To preserve the identity of the participants, in this section they will be represented by P(x) where x is the participant number.

### 5.2.1 Skills and Interaction

Figure 7 illustrates students’ perceptions of the interaction using the system and their participation in the developed activity. Overall, students believe that the dynamic provides group work skills, such as critical thinking and self-criticism. However, the lack of interaction among colleagues causes dissatisfaction with the use.

The red highlights in Figure 7 codes indicate that Moodle does not guarantee interaction, as it fails to notify participants of deadlines and does not facilitate communication between authors and reviewers. This is evident in participant P13’s statement: “I didn’t like that mine wasn’t evaluated”. In other words, the lack of interaction caused by delays and absences of colleagues during the activity stages led to participant P13’s dissatisfaction with Moodle’s use. This is further supported by participant P14’s statement: “I felt terrible because I had a lot of work to check and comment on the many aspects, and when it was time to receive my review, there was none”. This dissatisfaction is also related to the fact that participant P14

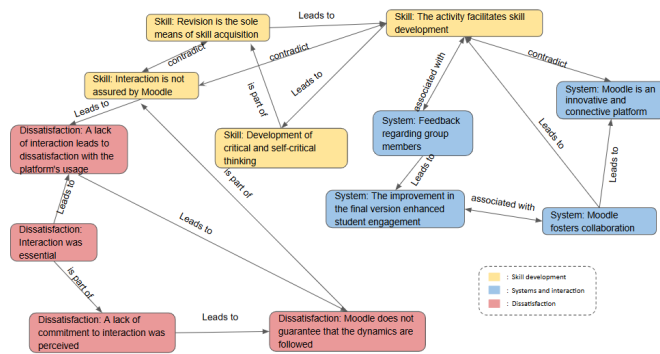


Figure 7. Qualitative Analysis Network Considering Skills and Interaction

had no way to contact the reviewer of their presentation, as the review was conducted blind (*double-blind*), where reviewers and authors did not know each other’s identities. The tool does not allow participants to send reminders or call their reviewer’s attention to review their work.

In this context, a crucial aspect to consider is the need for interaction. Since the activity was conducted in pairs, it was essential for participants to interact with each other. Consequently, the lack of commitment from some students, who did not participate in the peer review, negatively impacted the experience of their peers during the activity. This is evident in participant P13’s statement: *“It did not guarantee satisfactory results for me. Since I was not evaluated. I only had an idea because I evaluated another work, so somehow I found out what should be required in the assignment”*.

In the yellow highlights of Figure 7, it is observed that the task of reviewing another person’s work develops in the reviewer the ability to evaluate their own work in the next stage. This skill is called self-criticism, which is part of a set of skills developed with activities mediated by the Peer Review technique. An example of this is highlighted by participant P13: *“...despite not receiving the review, I was able to improve my final version based on the evaluation I did of my colleague’s work. I learned.”* Regarding not receiving his review, participant P14 reported that contact could have encouraged his reviewer to act: *“...if I knew who it was, I would have said: hey, are you going to do it or not, man?”*

In the blue highlights of Figure 7, it is perceived that Moodle, when supporting the Peer Review activity, was considered an innovative and connective environment. This is evidenced by the statement of participant P01, who declared: *“I found the tool to be innovative in providing the interaction feature. I had never participated in a work like this, evaluating aspects of other colleagues’ work”*. In this sense, it is perceived that the student had not participated in works in this way, so the innovation that the student attributes to the tool is actually related to the dynamics of the activity carried out during the course, which was an innovative dynamic from his point of view. Regarding innovation, the student pointed out that he found it interesting to use the tool, as he had never participated in a work like the one carried out in this study and Moodle could support more dynamic activities.

In this context, the aim was to understand students’ perceptions during the dynamic. For instance, whether accessing other students’ work helped them improve the final versions of their own work. Participant P01 stated: *“Yes, it did, and the tool made it possible. The tool allowed me to see the*

*care that the other person took, through the review”*. This need for interaction among colleagues during the review was seen as positive at this point, as the reviewer visualized the colleague’s work and identified improvements for their own. Therefore, it is perceived that feedback on colleagues’ presentations leads to improvements in the final version of the presentation. In this sense, feedback from group colleagues is associated with skill development, and this is why the student enjoyed the interaction, as they verified that the final version of the activity was better than the initial version.

However, participant P19 questioned: *“But wouldn’t dividing the work with others be important to develop our social skills?”*. In this case, participant P19 understood that this division of labor was good and would help develop the skills proposed in the activity’s objective. Participant P09 said: *“It’s innovative that it provides this support”*. In this case, the UX was influenced by aspects related to the collaborative activity made possible by the system.

### 5.2.2 Learnability and Practice

Figure 8 illustrates students’ perceptions of learnability and practicality during Moodle usage. Upon initial interaction, using the platform was considered challenging. However, once students learned to navigate it, utilizing other Moodle features became easier. This is because they perceived it as a user-friendly system with organized explanatory material.

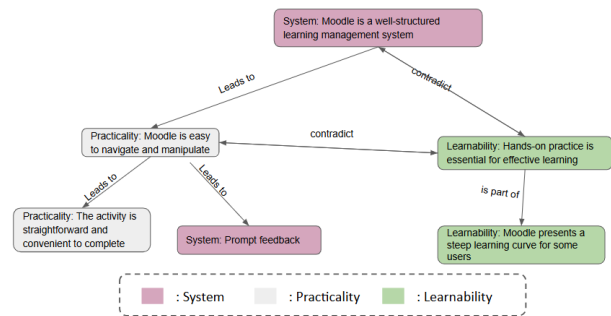


Figure 8. Qualitative Analysis Network Considering Learnability and Practice

In the green highlights of Figure 8, it is evident that the need to practice using Moodle was essential for participants to learn how to utilize it. This highlights Moodle’s steep learning curve. For instance, participant P01 stated that the tool’s learnability was unclear: *“...But I think it doesn’t have clear learnability. Until you practice, you don’t understand very well how to act in the system”*.

In the gray highlights of Figure 8, it is observed that the need for practice to learn contradicts the perceived practicality of manipulating Moodle. Participant P16 stated: *“I’m on the form, but I don’t even know how many aspects are missing.”* In other words, completing the review form while receiving progress feedback is crucial to prevent students from feeling overwhelmed, as this could hinder learning since it’s not a practical activity. Consequently, certain aspects closely related to the technological resources provided by Moodle influenced students’ experiences.

In this context, an opportunity for improvement is evident in the statement of participant P08, who said: *“I also didn’t*

like the fact that I was automatically logged out”. Participant P09 added: “I think this automatic logout function is not suitable for group activities. When I was filling out the evaluation form, I was logged out and lost everything I had filled in”. This indicates that the security measures implemented by the system can cause inconvenience and rework for users, hindering the practicality of their tasks. In this case, the participants had to fill out the entire form again. These aspects, identified since the Attrakdiff survey, influence the UX when using Moodle and can be improved.

In general, several UX issues were identified in the Moodle environment when supporting a collaborative learning technique. Students reported that they needed practice to learn how to use the system. One participant had difficulty finding the reviewer’s feedback and suggested that the environment could be more explanatory. Despite the system allowing the author to review the reviewer’s feedback, the student’s experience during this process was not satisfactory. Another participant stated that they were not familiar with Moodle upon first contact but later felt that the environment was intuitive. They also stated that they did not understand very well how to act in the system until they practiced using it. In this context, several opportunities for improvement arise for Moodle, with the aim of promoting better UX during the mediation of the Collaborative Peer Review Learning technique.

### 5.2.3 Individual and Group

Figure 9 illustrates students’ perceptions of interaction with Moodle in individual and group activities. One of the first insights gained from the analysis of the Individual and Group Network was that the way activities are structured in the course influences UX.

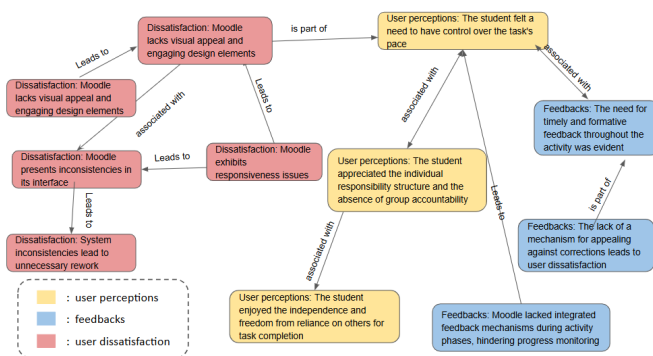


Figure 9. Individual-based qualitative analysis network

In the red highlights of Figure 9, it is evident that users were dissatisfied with using Moodle for both individual and group activities. In this case, it is highlighted that Moodle’s lack of attractiveness is associated with inconsistencies in the tool, which cause rework. This was reported by P08, who stated: “The 8MB file size restriction is a problem. Also, the fact that I get automatically logged out”. These system inconsistencies cause rework and are not bugs, but they hinder the user experience. The logout action is a Colabweb security solution. However, if a student is filling out the review form and the internet is unstable, they may lose their progress.

Thus, Moodle was not considered attractive by the participants. This is associated with the tool having inconsistencies

that cause rework. Since the tool did not allow participants to control the activity and the reviewers’ response time, they found Moodle unattractive. This is associated with the fact that students are not responsible for each other. Additionally, they have a need for feedback during the activity. Since Colabweb did not provide feedback during the stages of the activity and students could not appeal the corrections.

The way the activity is structured in the environment is a reason why Moodle is not considered attractive, and this is a point of dissatisfaction, as reported by P08 when he said: “I made another example, a very good one, and the reviewer gave me zero because it was not the one from the book, as requested in the form. This upset me, I thought it was unfair”. This occurred because the review form used in the Peer Review technique specifically asked for the description of an example contained in the discipline’s textbook. For P08, the form did not seem adequate. For him, the form should allow students to think beyond the example in the book. Thus, P08 felt limited by not being able to use his own example and by the low grade he received unfairly from his reviewer. The form caused this limitation and left the participant dissatisfied during the activity. This reason caused one of the differences in satisfaction during the uses of the system.

In the yellow highlights of Figure 9, it is evident that students enjoyed not being responsible and not depending on others. This is seen in participant P01’s statement: “I liked the individual activity because I only had to rely on myself to do things”. P02 reinforced: “I liked the individual activity too because it’s easier to take responsibility for my mistakes if they happen, but losing points because of someone else’s irresponsibility is something I don’t like”. Thus, it is noticeable that student collaboration influenced the UX evaluation of the system when used to mediate Peer Review. In the individual activity, students did not depend on others. Additionally, during Peer Review, if one student did not complete the review, it caused frustration and fear of losing points for the other student. In this case, the student felt prejudiced in one of the phases due to the lack of commitment of the other, after all, the student submitted their own activity and reviewed a colleague’s. In other words, they expected someone to review theirs. The system could allow a reminder notification so that the reviewer would know that time was running out.

Thus, questions arose during the Focus Group to understand whether the frustration of not having the collaboration of colleagues influenced the UX, as some students did not submit the review of others. P13 responded: “I had no control over others”. and “we depended on others’ reviews, right?” and P16 added: “yes, I think that was fundamental”. The participant felt the need to control the activity and the reaction time of their reviewers. However, in the case of Peer Review, each student depended on the reaction of a colleague to proceed with the activity.

Also regarding dissatisfaction and satisfaction, some participants reported that the tool was intuitive and simple, but archaic. While P06 said: “I found it intuitive. I found it simple too. Individually I found it easy to use and being simple helps in that sense. However, it ends up being ugly, I didn’t see it being very attractive. It’s not seductive.” P10 said: “Regarding the tool, I think it is very archaic”. and P01 said: “I agree that it is archaic. But, I thought the tool



## 6.1 Course Structure

In this study, the Software Engineering Fundamentals course offered to the Software Engineering undergraduate program was organized as a course in Moodle. The course was structured in a topic-based format with the aim of providing support for classroom activities.

This study, which took place in the Software Engineering Fundamentals course offered to the Software Engineering course at Federal University of Amazonas, used the Moodle LMS as support for the face-to-face classes. In this way, a Moodle course was created for the discipline, structured in a topic-based format. For each topic of the discipline, the slides used, the questionnaires on the subjects taught in the classroom to be answered by the students, the links for submitting assignments and taking asynchronous tests, and the forums for discussing content were made available in Moodle.

In this way, Moodle made it possible for the course to go beyond the classroom boundaries, where students were involved in asynchronous collaborative activities. In this sense, the feasibility of adopting the Peer Review technique was verified, aiming at students working together even when they were not in the classroom. With this, it was noticed that higher levels of preparation are required to develop work together. For example, dates must be well established and feedback must be constant, so that students feel engaged during the dynamics, fulfilling all the stages of the proposed activity. Thus, the teacher needs to configure the environment, adjust the preparation of the dynamics to happen using the resources offered by the Evaluation Laboratory, in addition to being attentive to the deadlines of each stage of the activity. Students need to be more engaged and require much more alertness and feedback throughout the execution of the activity.

In this context, research that also evaluated the UX of Moodle considering undergraduate courses, reported that the ease of using the system reflects the engagement of students [Hasan, 2018; Krouska *et al.*, 2020; Dilan *et al.*, 2022]. This ease can be linked to both the functionalities of the system and how the course is organized pedagogically. Since in this work, it was noticed that a course structured in topics, maintaining standardized presentation forms, can make the experience more satisfactory during the execution of the activities. Thus, it was also verified that the ease of using the system reflected the engagement of students during the activities. However, in Moodle, ease depended on learnability, since by practicing and learning the proper use of the system, students found it easier to manipulate it.

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## 6.2 Collaborative Activity

The way the collaborative activity is instantiated and made available to students also influences the UX. However, how the activity is made available depends on the perspective of teachers and students in relation to the course. In this sense, it is important to note that other studies have also evaluated the usability and UX of LMSs [Gumasing *et al.*, 2022; Shekhar and Marsden, 2018; Magyar and Haley, 2020]. In these studies, lessons on educational technology were presented, in addition to UX evaluations, considering the perspective of teachers and students involved in teaching and learning, but they did not investigate how the collaborative activity interfered with the experience. For example, in the Peer Review technique, there are specific aspects that influenced the UX during the use of the environment, such as the number of reviewers, the number of rounds, and the quality of the review checklist.

Since Peer Review takes place in a sequence of steps, where the steps are dependent on each other, students needed to rely on the commitment of their peers to continue the activity. In this sense, it is worth noting that if the dynamic were instantiated with two or more reviewers for each activity, there would be a greater probability of the student receiving at least one review. However, he would have to review the activities of two colleagues. Thus, the presence and absence of peers during the interactions of the dynamic were aspects that influenced the UX according to the students.

In addition to the commitment to deliver or not the review, the quality level of the review delivered during the activity also influences the UX. A student's experience is affected when a reviewer does not evaluate all aspects of the review form or does not assign appropriate grades with the comments he made. For example, during this study, one of the participants said that the reviewer did not remember whether or not he had addressed an item that was contained in the review form. The reviewer assigned a median grade, which is unfair, since he decided not to review the colleague's presentation to evaluate the item correctly. In this case, the reviewer was present, fulfilled his assignment, but the quality level of his review was not adequate to the perspectives established by

teachers and students.

Peer Review assigns students a responsible role in controlling the process where they review each other's work. In this case, while knowledge is shared among students, the teacher only mediates the activity. By controlling the activity, its deadlines, criticisms, and improvements during the versions of the activity, the student ends up participating in a different form of learning. Allowing this control to the student influences the UX. Some students may not feel satisfied, as they end up accumulating functions that are commonly performed by the teacher during the activities. However, other students may feel quite satisfied, as they are exempt from the teacher's demands during the activity.

### 6.3 Technological Resource

In this study, the technological resource used was the Moodle Assessment Lab. The absence of some features such as automatically adjusting the screen formatting, automatically saving the progress of filling in the revision checklist, and the presence of bugs influenced the UX. Students needed to adjust the browser zoom to properly perform tasks such as filling in the checklist, as the fields and texts did not adjust properly according to the devices. The feedback issued by the Assessment Lab during the activities also influences the UX. For example, Moodle sometimes did not issue feedback during the activity, and students missed a message saying that the presentation had been submitted and the review was complete. Thus, it was noticed that the tool should provide more feedback to the participants. For example, they should know when they complete a review, and when the review of their work is also completed.

In this sense, the work of Soares *et al.* [2023] reported aspects that influence the usability of Virtual Learning Environments such as consistency, standard, organization, and minimalist layout design, non-representative buttons and names with the real world, functionalities not explicit to the user, and also, inadequate colors and sizes. However, they did not investigate how the Technological Resource influences the UX of Virtual Learning Environments. That is, they do not investigate the specific functionalities to provide the collaborative activity to students as in this work.

Therefore, feedback should be implemented and provided by the environment during the use of its functionalities and is different from the feedback on the activities, which must be registered by the teacher. In this sense, the progress during the filling out of the revision checklist form is also something important that influences the UX. Since the revision form was extensive, some students reported that they would like to know how many items in the form still needed to be filled out.

Another aspect that influences the UX is the way the student learns to use the environment. In this sense, Al-Omar [2018] noticed that users, when distant, suffer more during the system's learning process, making it more difficult, but noted that the distance was essential during the dynamic and that it was not safe to use only a questionnaire to evaluate the UX. In this study, it was found that although difficult learnability interferes with the UX, practicing it allows students to perform the tasks with more satisfaction.

In this way, learnability is related to the practicality of performing the activity. The student needs to understand well how the Peer Review technique works to use the environment. On the one hand, it is necessary for the teacher to explain how the technique will occur and will be applied during the activity, since sometimes, the students' difficulty may not be in relation to the resource, but in relation to how the technique will be structured in the technological resource. On the other hand, it is necessary that the environment be able to provide resources for which students can participate in the technique more profitably and without the need for interventions and explanations from the teacher. In this sense, the environment could also provide reminders so that teachers would not need to send emails reminding students of the deadlines for the activities. These reminders could also improve the experience of teachers using the environment.

### 6.4 Improvements to Moodle

Analyzing the results of both the *Attrakdiff* and the Focus Group and based on the aspects that influence the UX of LMSs, it was found that there is a need to implement several improvements to the Moodle environment to provide a better experience for students during the support of collaborative Peer Review activities. Table 2 shows the priorities, descriptions, and reasons for recommendations for Moodle, indicating which analyses they came from. These improvements aim to increase engagement, increase the contact of participants with discussions among them, thus increasing collaboration. Thus, 7 improvements are listed based on conclusions from the analyzes, which would help students during the dynamic and include making it possible to:

1. **Improve field formatting during tasks.** During the completion of the revision form, some students complained that the space for commenting on the checklist aspects was not formatted, making the experience unpleasant. This negative experience can influence the quality of the review, as filling in the checklist is a primary task during the dynamic. In this sense, it would be beneficial if Moodle allowed field adjustments according to the screens, providing a better experience for students during the activities, which are fundamental to the Peer Review dynamic.
2. **Corrections and revisions feature.** Some students disagreed with some of their peers' reviews. As a result, they would like to better understand the reviews or challenge some of the reviewers' points. This dialogue would be valuable, as increased interaction can enhance the level of collaboration among participants in the dynamic. It is acknowledged that this deviates from the traditionally established form of Peer Review. However, from an educational standpoint, this exchange of ideas can benefit students through interaction with their peers.
3. **Reviewer feedback evaluation.** It was observed that some reviewers did not submit their reviews with quality or did not demonstrate commitment during the review process. Therefore, the author could provide feedback on what they liked or disliked about the review. This feature would discourage reviewers from acting with-

**Table 2.** Design recommendations for Moodle based on empirical evidence

Recommendation	Priority	Description and Rationale	Supporting Evidence (Participants)
Notifications and deadline reminders	High	Implement automatic notifications (e.g., reminders before deadlines, alerts when feedback is missing) to prevent delays in collaborative tasks.	P13, P14: frustration with missing or late peer feedback.
Clear and accessible feedback	High	Provide a more intuitive interface to locate and interpret peer feedback, ensuring it fulfills its pedagogical role.	P11, P16: difficulty finding and interpreting feedback.
Flexibility in peer review forms	Medium	Allow greater flexibility in evaluation templates to reduce rigidity and perceptions of unfairness.	P08, P17: dissatisfaction with restrictive forms and unfair grading.
Support for learnability and onboarding	Medium	Offer contextual help, tutorials, or onboarding guidance to reduce the steep learning curve and improve usability.	P01, P09: reported unclear learnability, need for repeated practice.
Adjustments to automatic logout	Low	Revise session management for collaborative tasks (e.g., autosave or longer timeout settings) to avoid data loss.	P08, P09: reported losing work due to automatic logout.
Improved aesthetics and motivation	Low	Modernize Moodle’s interface to make it more engaging and visually appealing for students.	P06, P10: described interface as archaic and unattractive.

out commitment, as they would also receive grades for their reviews. Consequently, addressing the lack of commitment of these reviewers can positively impact the learning experience of students using Moodle.

4. **Activity progress tracking.** Study participants expressed a desire to easily monitor their progress during activities. For instance, knowing how many steps of the activity have been completed is crucial for students to feel a sense of control over the activity. This could potentially enhance students’ overall composure during the dynamic. However, it is important to consider that some students might feel pressured by this feature. Therefore, it would be beneficial to provide students with the option to choose whether or not they want to track their progress during activities through Moodle.
5. **Progress tracking during the completion of the revision checklist form.** Similar to the previous point, this feature focuses specifically on the completion of the Peer Review form. By providing students with real-time information on the number of aspects they have already completed and the number remaining, the UX of Moodle can be significantly enhanced.
6. **Peer Review stage notifications.** These notifications aim to enhance activity monitoring and foster peer interaction. It would be beneficial to implement a system that sends students notifications regarding the completion of each activity stage. This feature could address the issue of some students not receiving feedback during Peer Review, potentially stemming from forgotten deadlines for posting activity stages. By enabling Moodle to send email alerts, students would be reminded of ongoing activities and encouraged to maintain active participation.

7. **Enhanced learnability during the teaching and learning process.** Enabling users to grasp the system’s functionality efficiently is paramount. Consistent with student feedback indicating that familiarity with Moodle enhances its ease of use, it is recommended that the platform provide clear and intuitive assistance and resources to minimize the need for extensive practice. This support would also be advantageous from a learning standpoint, as students utilizing Moodle for Peer Review for the first time must balance learning the course content with mastering the platform’s operation.

## 6.5 Recommendations for professors

In this section, we list a set of 8 recommendations for professors to configure Peer Review in Moodle. We derived these recommendations from this study’s qualitative analyses.

1. **Organize Course Material by Dynamic Stages:** Include an explanatory text about the material used in the dynamic or each of its stages. Additionally, set deadlines and the number of reviewers assigned to each round.
2. **Structure the Activity’s Stages Appropriately:** Proper structure is crucial for students to understand their tasks and goals at each stage of the dynamic. This ensures they learn from a previous stage before advancing to the next.
3. **Structure the Course Consistently in the Tool:** The course should be organized consistently, standardizing its information and terms to prevent student confusion during the task.
4. **Encourage Use Beyond Provided Materials:** To stimulate reading and research, students who seek sources

beyond those set by the teacher should receive bonus points.

5. **Allow the use of external elements during evaluation, such as examples beyond the textbook:** This encourages students to think outside the box and not base their evaluations on a specific example, thus developing critical skills.
6. **Send a Reminder to Reviewers About the Deadline:** Remind both reviewers and authors about their current stage and available time to complete their activities, helping them avoid delays.
7. **Determine More Than One Reviewer for Each Task During the Dynamic:** Each reviewer must review the work of at least two other peers, as one might fail.
8. **Enable Students to View Peer Interactions:** Allowing an author to see their revised diagram encourages them to revise their own. Provide authors visibility into one or two completed peer reviews of their diagram without waiting for the next stage of the dynamic. This lets authors expedite changes based on reviewer feedback.

## 6.6 Limitations

This study presents limitations inherent to the adopted method, a case study, in which data collection relied primarily on the perceptions of first-semester Software Engineering students. While this approach is appropriate for exploratory qualitative investigations, it imposes constraints on the generalization of the results.

The small sample size limits the possibility of extrapolating the conclusions to other contexts. However, as qualitative research aims more at generating insights than at achieving statistical generalization, credibility was sought by providing detailed descriptions of the study context, participant profiles, and applied procedures [Ralph *et al.*, 2020]. This information enables both the replication of the study and the assessment of the relevance of the results in other scenarios.

Another aspect to consider is that the collaborative activity was conducted after the individual activities, meaning that participants were already more familiar with the Moodle environment when carrying out the group task, which could have introduced a learning bias regarding the tool. Nevertheless, it is important to note that the collaborative activity adopted, implemented through Moodle's Workshop plugin, had a higher level of complexity and a set of steps that required specific skills (such as conducting and analyzing peer reviews) that had not been addressed in the earlier activities. Thus, while prior familiarity with the system may have facilitated basic navigation, the execution of the collaborative dynamic demanded additional competencies and novel procedures for the participants, which mitigates the potential impact of this bias on the observed results.

Finally, the scope was intentionally restricted to a single institutional context, a specific collaborative activity (Peer Review), and a focused set of evaluation techniques (Attrakdiff and Focus Group) in order to ensure methodological consistency and maintain control over potential confounding variables. These decisions allowed us to obtain clearer insights into the relationship between collaboration and UX in LMSs, avoiding the complexity and heterogeneity that could arise

from multiple contexts, user profiles, or techniques. Thus, the choices adopted were essential to preserve the internal validity of the study and to generate results that could be analyzed with rigor and clarity.

## 7 Conclusion

This paper presents a comprehensive analysis of the UX of the Assessment Laboratory feature within the Moodle system, specifically in the context of supporting both individual and group learning activities, including a Collaborative Peer Review task. To conduct this investigation, an Case Study was carried out involving 35 Software Engineering students enrolled in the Fundamentals of Software Engineering course at the Federal University of Amazonas. The study employed two distinct research techniques: the Attrakdiff methodology and Focus Group discussions. Quantitative data obtained from the Attrakdiff tool were analyzed using corresponding graphical representations. The Focus Group sessions aimed to delve into the qualitative aspects, fostering a deeper understanding of the identified areas for improvement within Moodle, with the ultimate goal of enhancing the UX during Peer Review activities.

The Attrakdiff results revealed that the Moodle system exhibits positive attributes that make it well-suited for the Peer Review task. These attributes include its ability to foster connectivity, innovation, professionalism, and a sense of boldness among users. It is noteworthy that Attrakdiff, a widely recognized tool for UX evaluations, proved instrumental in gaining insights into the Pragmatic, Hedonic/Identity, Hedonic/System, and Attractiveness dimensions of Moodle's UX.

To further explore these findings and gain a richer understanding of the student perspectives, a Focus Group session was conducted. This collaborative discussion enabled participants to delve deeper into the Attrakdiff results and share their experiences regarding how collaboration influences the UX within LMSs. Through this exchange of ideas, valuable suggestions for improvements to Moodle's UX emerged.

The contributions of this study are related to computer-mediated collaborative learning contexts, seeking to understand how collaboration-related aspects can be adjusted to improve UX in Moodle, particularly: (i) the description of an approach that can be replicated to improve UX during the performance of collaborative activities mediated by LMSs in real educational situations; (ii) proposals for improvements for Moodle and similar systems; (iii) discussions about aspects that influence the UX of LMSs, reflecting in improvements for the execution of computer-mediated collaborative activities.

For future work, we suggest: (i) implementing the suggested improvements in Moodle and analyzing the impacts obtained; (ii) replicating this evaluation approach to other collaborative learning methods and/or other LMSs; (iii) investigating the generalization of the proposal for the conception and development of a UX evaluation framework adherent to the peculiarities of collaboration.

## Declarations

### Authors' Contributions

Romualdo Azevedo is the main contributor and writer of this manuscript. Ketlen Lucena, Alberto Nogueira, and Bruno Gadelha contributed to the conception and supervision of this study. All authors read and approved the final manuscript.

### Competing interests

The authors declare that they have no competing interests.

### Acknowledgements

We thank all the participants in the case study and the members of the SPHERE and USES Research Groups for their support.

### Funding

We would like to thank the financial support granted by CNPq 313137/2025-0; CAPES - Financing Code 001; Amazonas State Research Support Foundation - FAPEAM - through POSGRAD 2025-2026.

### Availability of data and materials

The datasets generated and analysed during the current study will be made upon request.

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