



Vaasan yliopisto
UNIVERSITY OF VAASA

OSUVA Open
Science

This is a self-archived – parallel published version of this article in the publication archive of the University of Vaasa. It might differ from the original.

Co-designing User Experience of Moodle Workspaces in Higher Education - Process and Principles

Author(s): Havinen, Laura; Mäkipää, Juho-Pekka; Rousi, Rebekah

Title: Co-designing User Experience of Moodle Workspaces in Higher Education - Process and Principles

Year: 2025

Version: Accepted manuscript

Copyright ©2025 Springer. This is a post-peer-review, pre-copyedit version of an article published in *Learning and Collaboration Technologies: 12th International Conference, LCT 2025, Held as Part of the 27th HCI International Conference, HCII 2025, Gothenburg, Sweden, June 22–27, 2025, Proceedings, Part I*. The final authenticated version is available online at: https://doi.org/10.1007/978-3-031-93564-0_3.

Please cite the original version:

Havinen, L., Mäkipää, J.-P., & Rousi, R. (2025). Co-designing User Experience of Moodle Workspaces in Higher Education - Process and Principles. In B. K. Smith, & M. Borge (Eds.), *Learning and Collaboration Technologies: 12th International Conference, LCT 2025, Held as Part of the 27th HCI International Conference, HCII 2025, Gothenburg, Sweden, June 22–27, 2025, Proceedings, Part I*, 37-56. Lecture notes in computer science, vol. 15806. Springer. https://doi.org/10.1007/978-3-031-93564-0_3

Co-designing User Experience of Moodle Workspaces in Higher Education - Process and Principles

Laura Havinen¹[0009-0000-3364-7407], Juho-Pekka Mäkipää¹[0000-0002-2757-8609] and Rebekah Rousi^{1,2}[0000-0001-5771-3528]

¹ University of Vaasa, Wolffintie 32, 65200 Vaasa, Finland

² University of Jyväskylä, PO Box 35, 40014 University of Jyväskylä, Finland

`laura.havinen@uwasa.fi`

`juho-pekka.makipaa@uwasa.fi`

`rebekah.rousii@uwasa.fi`

Abstract. Studies have shown that user experience (UX) in course learning platforms impacts learning. UX not only stems from user interface design, but the design of instructional information within the workspace. This study examines the teacher-led design elements that students experience to improve the UX of Moodle workspaces. During the study, students were asked to re-design their course workspace for better UX. The study was implemented in two UX courses in 2021 (N=35) and 2024 (N=31). Through co-design workshops, students identified problematic object-level UX issues in the workspaces. We conducted a content analysis on student reports to identify themes describing the issues. From these themes, we derived design principles to improve UX in the Moodle workspace. The results indicate connections between practical improvements and the intended UX in the context of course workspaces. In addition, the study demonstrates how co-design can be used to improve the UX of a course workspace.

Keywords: User Experience, Co-Design, Learning Platforms, Course Workspaces

1 Introduction

As e-learning and blended learning becomes more popular, the value of user experience (UX) within online learning platforms rises to play an important role in the learning experience. Learning platforms in higher education (HE) that feature effective design and interaction promote learning engagement [1, 2]. Poorly designed workspaces that incite negative UX may lead to low rates of use, failures to understand or accept tasks, interrupt learning performance, and may even lead to course dropouts [1, 3]. In contrast, positive UX in workspaces can help students achieve learning goals [4], and lead to significantly improved learning performance [5]. Teachers, however, have limited skills in designing course workspaces in learning platforms. This particularly holds from the perspective of designing for positive UX [6]. Involving students in the workspace design process has proven valuable in the context of instructional design [7]. This

paper explores the results of co-designing with students in improving the UX of a course workspace in Moodle.

Moodle is one of the most popular open-source learning platforms in HE and it has millions of users globally [8]. Like any other product, it should not be seen as simply functional, delivering usability, but should tap into the psychological and social dimensions of users enabling a deeper connection between users, systems, and what the systems represent [9]. In learning platforms other critical factors than simply effectiveness are at play, such as engagement in learning method, selection of appropriate and effective pedagogical methods, and accounting for diverse learning styles (see e.g., [10, 11]). Moodle is a platform that serves as a base for teachers and educational designers to be able to design contents, learning processes and learning progress. This is enabled through careful consideration of information chunking and sequences, hierarchies and order of logic, meaningful tasks and exercises, and effective evaluation methods [12]. Thus, teachers and educational designers enact a level of Moodle UX design that directly impacts the reception, interaction, and learning of required contents.

In the present paper we investigate the teacher and educational designer level of design in Moodle workspaces. The aim of the study was to examine what teacher-led design elements students experience to contribute to better UX in course workspaces. The intention was to give the students the floor as learning and instructional design experts, as well as co-designers of the workspace in question, and for future workspaces on future courses to come. A co-design method was implemented in which students as end-users were asked to re-design the workspace. The re-design task supported mutual learning between students and teachers and empowered them to be involved in influencing students' own learning's future. This was achieved through their participation in designing the pedagogical level of digital learning technology [13].

The current paper outlines a study that engaged students in co-design of the Moodle workspace for their own course. It begins with a brief review of related literature focusing on pedagogical and UX design on e-learning platforms as well as UX attributes. The method section describes the procedure, recruitment, and approach of the study, while the results outline the main findings of the students' object-level design suggestions for the Moodle workspace. In the discussion, we ponder the findings and what they mean in the context of an evolving digital world. For example, in the near future Moodle will most likely have an 'artificial intelligence (AI) design' component that can aid educators and educational designers in effectively designing workspaces. Yet, to arrive at this stage, detailed knowledge of how students perceive, engage with, and re-design the course workspace level of the platform is critical.

2 Learning platforms and related literature

A learning platform is a computer mediated environment that facilitates collaboration via discussions, content sharing, documentation, tracking, evaluation, automation, reporting and these days more [14]. Understandings and applications of learning platforms have fast moved from ideas of virtual traditional classrooms with one standardized format to potentially highly personalized spaces that, with the help of AI and

learning analytics, can tailor content and delivery on an individual level [15]. Since the introduction of learning platforms during the late-1990s, educational professionals and researchers have endeavored to decipher how the domains of education and information technology can effectively be combined to achieve the best possible learning outcomes [16]. Particularly in the fields of educational science and educational technology, frameworks, guidelines, heuristics, and other measures for critical success factors have been developed [10, 16, 17].

From the perspective of the design of e-learning technology, scholars such as Nokelainen [18] and Pham, Singh and Jahnke [19] have developed and built on the concept of pedagogical usability. In his earlier efforts to establish usability criteria that accounted for the learning aspects of educational technology design, Nokelainen outlined that pedagogical usability needs to support: learner control; learner activity; cooperative or collaborative learning; goal orientation; applicability (suitability for support and applied learning); added value; motivation; advancing previous knowledge; flexibility; and feedback. Conversely, the Technology Pedagogical Content Knowledge framework (TPACK) by Koehler and associates [20] focuses on the design of content in e-learning technology. Where Nokelainen's pedagogical usability can be as an extension of traditional technical usability observations, TPACK accounts for the information or content level of the design. It outlines the relationship between the content, the teacher or educational designer, and the students within the context of the technology. Kenttälä, Kankaanranta and Rousi [10] took this further to emphasize the importance of the interplay between UX and learning. Their framework, LETUS – Learning experience technology usability – sought to combine previous usability and technology design insights with an understanding that experience is everything when designing content and technology for learning purposes. LETUS incorporates scholarship in UX to draw the connections between the instrumental, the experiential [21], as well as the hedonic and their role to promote learning with educational technology.

One area of research that requires more attention is the role of students and their expert insight in the design of learning platforms and course workspaces. Regarding Moodle, Moyo [11] studied Moodle from the student perspective in relation to their perceptions of authenticity. Authenticity is a contested concept, as it is value-laden regarding power and authority, hierarchies and rankings, in terms of what is deemed as *authentic* or genuine [22]. This particularly holds in the AI-driven digital era where phenomena such as AI-generated cultural products are becoming commonplace. Yet, Moyo [11] argued that authenticity is a crucial quality in terms of establishing integrity within the learner, technology, and pedagogical delivery relationship. The COVID-19 pandemic also spurred an increase in student-centered studies of learning platforms and other aspects of remote learning UX. Arima and associates [23] studied activities in which students were asked to re-design the face-to-face course workspace in Moodle. Another study by Sheridan and Gigliotti [24] explored re-design of workspaces to optimize learning engagement for all students. They cite that participation in design not only increases the likelihood of improving design for all but instills a sense of ownership that serves to boost motivation to use and to learn. These factors are important to consider when approaching UX in the context of learning technology.

2.1 Previous Studies on UX Attributes

Hassenzahl [9] defined the key elements of design products (c.f. Moodle) as that of content, presentational style, functionality, and interactional style which conveys a product's characteristics. While time and UX research have moved on, we want to reflect on these elements to provide grounding for how the Moodle workspace and its additional educational design layer can and should be understood. Thus, the characteristics of UX design are marked by pragmatic qualities (useful or practical), hedonic qualities (not directly functional, more aesthetic, semantic and motivational), and attractiveness (and the combination of these) [9, 25, 26]. In this study, we approach UX by applying the six UX attributes identified by Schrepp [26]: attractiveness, perspicuity, efficiency, dependability, stimulation, and novelty. Attractiveness is not only contested but complex in aesthetic and psychological scholarship (see [27, 28]). It however can be described as pertaining to appeal, pleasantness, enjoyment, and a psychological 'pull' that incites sentiments and motivation towards innovativeness and creativity [29–32]. Also, back in the 1990s, Tractinsky [33] emphasized that aesthetics and attractiveness have a significant impact on ease-of-use, through influencing choices and encouraging engagement. This has been furthered by numerous studies over the years that show how beautiful things evoke positivity and motivate users [34] while additionally inducing a sense of perceived usability and trust [3, 35, 36]. Studies [e.g., 37, 38] also show, that more visually complex web pages lead to more negative first impressions than medium or low complexity web pages.

Perspicuity has been defined as ease-of-use and comprehensibility. Clear contents can be understood quickly when they are beautiful and rationally organized [39–41], and culturally appropriate for users [42]. Efficiency is often equated with speed, i.e., how quickly a user can perform the desired task [43, 44]. Efficiency also refers to whether the task is possible to perform simply and easily [45]. In evaluating the effectiveness, attention is often paid towards whether the investigated platform offers shortcuts, whether it processes information quickly [46] or whether the most important information is presented first [45]. Dependability refers to the reliability, predictability, logic and correspondence with expectations of the design in question [29]. Functionality is also an important factor in dependability, that connects with user expectations and how the system design supports the user in achieving use goals. Thus, in visual design, it is critical that the function and behavior of the system corresponds with how the user understands the visual information, and thus user interface [47].

Stimulation is one of the hedonistic features of the UX that is highly relevant to learning. The characteristics of stimulation include excitement, curiosity, interest, motivation, creativity, and innovation. Additionally, randomness adds to the factor of surprise for the user, as it creates new starting points and directs the flow state towards further exploration [48, 49]. Furthermore, stimulation affects an individual's personal development, the accumulation of skills and the growth of knowledge [50]. However, stimulation loses its intensity over time [51, 52]. Thus, novelty and the introduction of new elements as time progresses, help sustain the user's (student's) attention. The novelty attribute is converted into whether the product is innovative and creative, and how

it gets the user's attention [53]. In relation to products considered essential, the significance of novelty diminishes due to their mandatory use [54].

2.2 Participatory and Co-Design for the UX of Learning Platforms

In UX scholarship, participatory design and co-design have been discussed as a family of methods that seek to involve stakeholders in the design process, and as co-designers [55]. Considering the e-learning context, these stakeholders include students, administrators, educational designers and teachers [56]. This strain of methodology is particularly valuable from cognitive-affective and social perspectives as it affords designers insight into both the pragmatic attributes of the design spaces, as well as the hedonic, semantic, and experiential dimensions. Designers are thus afforded details concerning the conditions and contexts in which courses are held, and learning occurs. Similarly to ethnography, co-design allows practitioners to more closely align with the multi-dimensional circumstances users (students and learners) face when potentially encountering the design. By encouraging stakeholders to participate in design processes, designers – and in this case, teachers and educational designers who formulate the information content and instructional level of the Moodle workspace – have ample opportunity to design for more effective and enriching user and learning experiences [57].

Through engaging students in the design and re-design of workspaces, students become involved in learning from a different, instructional perspective, in a deeper and more meaningful way. This is not a simple question of improving UX to ease human-learning technology interaction. Rather, the platform contents are embedded with the mental structuration of students, while at the same time, through the design-lead sense-making processes of organizing the contents, students cognitively structure (understand) and process the content for themselves. There is also an instilled ownership, conveyed through identity – as designers – within the course and its goals [11]. In other words, co-design and various forms of participatory design encourage engagement, identification, and learning [55, 58].

3 Methodology

The study involved two groups of university students enrolled in a master's-level stand-alone UX course (5 ECTS) at the University of Vaasa, Finland during the years 2021 and 2024. The course was taught by two teachers (author 1 and 2 of this paper). In these courses students were assigned to evaluate the UX of the course's Moodle workspace. Upon the evaluation results, in small groups, students were instructed to formulate suggestions for improvements. The improvement suggestions collected during both 2021 (Study 1 – January-March 2021) and 2024 (Study 2 – January-March 2024) serve as data for the current paper. We analyzed the project work reports delivered by students via qualitative content analysis. Focus was placed on identifying what students find problematic and how they would improve the Moodle workspace for better UX. In the next sub-sections, we elaborate on how we recruited participants, the procedure, data collection, and steps taken within the qualitative content analysis.

3.1 Participants

For Study 1, we recruited 35 master level university students, of which 29 responded to a questionnaire about their demographics. Out of these participants, 18 (62%) were female and 11 (37%) were male. The age range of respondents was 21 to 42 years, with an average age of 27 years. For Study 2, we recruited 31 master level university students of which 25 responded to a questionnaire about their demographics. Out of these participants, 15 (60%) were female and 10 (40%) were male. The age range of the respondents was 20–53 years, and the average age was 30 years. Participants of both studies contributed to the research voluntarily. From a research ethics perspective, the students were asked individually for permission to use their coursework generated data in this research. The authors stressed that the decision not to participate had no influence on the students' grades. All students enrolled in these courses agreed to participate.

3.2 Procedure

We established groups of three to four students that each were assigned to address one UX attribute as a UX goal (see [46]). For Study 1 there were 11 groups and in Study 2 there were eight groups. The UX attributes were adapted from Schrepp et al. [26] and are listed as: attractiveness, perspicuity, efficiency, dependability, stimulation, and novelty. The application of the study was the Moodle workspace of the course they were enrolled in, excluding the content of the appendices (e.g., PDF files such as lecture slides). The workspace was designed by one of the teachers on the course. As the course in question was the same in both studies, the workspace was mostly similar. The differences were that the workspace was improved for Study 2 based on the suggestions made in Study 1, and the Moodle platform was updated to another version between the studies, which led to changes in some of the features of the workspace and platform overall.

The course workspace during Study 1 had the following structure of six subpages:

- Home page, which included basic information about the course.
- Lectures page, which included lecture slides and recordings.
- Workshops page, which included materials related to information seeking workshop and co-design workshops.
- Seminars page, which included content related to the project work presentations.
- Project work page, which included materials related to the project work.
- Literature and related materials page, that had references to additional reading.

The course workspace in Study 2 had a similar structure, but the contents of the workshops page and seminars page were merged into the project work page. In addition, one page was added to include readings from a mandatory previous course.

During the project work, the groups conducted a literature review to discover existing knowledge of UX principles and attributes in the context of learning platforms. Following this, each group prepared, planned, and facilitated one co-design workshop. The workshop participants were other students participating in the course, instilling

multi-perspective learning experience in terms of co-design UX methods and processes. Lastly, groups presented their findings via a written report. Next, the workshops in both studies are described in more detail.

Study 1. In Study 1, students held 11 workshops in total. In both studies, the students could choose whether to have the workshops onsite or online. In Study 1, all workshops were held online, which was influenced by the outbreak of COVID-19 in 2020. During the co-design workshops, the groups were tasked with finding answers to questions about the users and their aims, as well as to the use context and key functionalities. In addition, they were asked to find out how the participants currently perceived the UX attribute and how perceiving the UX attribute could be improved.

The groups, the UX attributes they addressed, and the techniques they used in the workshops in Study 1 are presented in Table 1.

Table 1. Groups and the techniques used in the co-design workshops in Study 1.

Group ID	Group size	UX attribute	Techniques	Workshop participants
G1	3	Attractiveness	Personas, interview, sketching	2
G2	3	Attractiveness	Interview, task analysis, personas, experience map	2
G3	3	Perspicuity	Semi-structured interview, personas, user story	3
G4	3	Perspicuity	Heuristics [59] used for evaluation	4
G5	4	Efficiency	Personas, journey map, sketching	3
G6	3	Efficiency	Task analysis, interview	3
G7	3	Dependability	Semi-structured interview, experience map, personas	1
G8	3	Dependability	Personas, empathy map	3
G9	3	Stimulation	Personas, interview, empathy map	3
G10	4	Stimulation	Personas, AttrakDiff questionnaire, interview, discussion	4
G11	3	Novelty	Interview, discussion, sketching	3
Total	N=35			N=31

Study 2. In Study 2, students held eight workshops in total. One workshop was held at the campus, while other workshops were held online. The groups conducted co-design sessions aiming to find the answers to the same questions as in Study 1. The groups, the UX attributes they addressed, and the techniques they used in the workshops in Study 2 are presented in Table 2.

Table 2. Groups and the techniques used in the co-design workshops in Study 2.

Group ID	Group size	UX attribute	Techniques	Workshop participants
G12	3	Attractiveness	Word cloud, focus group interview, visual card sorting, survey	4
G13	4	Attractiveness	Sentence completion, self-expression template	4
G14	4	Perspiciuity	Survey, sentence completion, group interview	5
G15	4	Perspiciuity	Focus group interview, sentence completion, self-expression template	4
G16	4	Efficiency	Sentence completion, usability testing with thinking aloud	4
G17	3	Efficiency	Sentence completion, self-expression template	3
G18	5	Dependability	Pre-survey, UEQ, co-creation	3
G19	4	Dependability	Personas, sentence completion, self-expression template	4
Total	N=31			N=31

As a difference from Study 1, no groups in Study 2 focused on stimulation and novelty.

3.3 Data Collection and Data Analysis

The data collected from Studies 1 and 2 consisted of 19 project work reports. The data included on average 22 pages per report, with a total of 435 pages. The documents consisted of theoretical background, description of the methods of the studies, and results section including notes from the workshops and sketches of the workspace illustrating the findings.

After anonymizing the reports, we analyzed them via qualitative content analysis [60]. We coded the reports by asking the following three questions:

1. What is the problem the students have identified in the course workspace?
2. Why is it important to make improvements to solve this problem? What are the negative or positive consequences related to the problem?
3. How do students suggest that the identified problem should be solved?

The content analysis was started by two of the authors individually going through the research data and marking initial findings. Only those problems were included in the analysis that were related to the course workspace and notions related to other parts of the learning platform, e.g., platform home page, were excluded. Also, only those improvement suggestions were included in the analysis which could be implemented with the functionalities that were found in the current installation and did not require altering the design of Moodle learning platform. For example, suggestions such as creating a mobile application to improve efficiency (G6) were excluded. As the focus of the study

was on the design of the workspace, comments that solely focused on altering the documents shared through the workspace were excluded. Then we cross-referenced, discussed, and categorized our findings. After combining and comparing the findings, the content analysis resulted in 12 themes. These themes were then divided into four groups by utilizing Hassenzahl's [9] product features (content, presentational style, functionality, interaction style) to pinpoint which feature they were most related to.

4 Results

The resulting themes, the product features the themes are related to, and the UX attributes the themes were reported to influence are illustrated in Table 3.

Table 3. Themes, their related product features, and the affected UX attributes (abbreviations in the table: attractiveness (A); perspicuity (P); efficiency (E); dependability (D); stimulation (S); and novelty (N)).

Feature	Theme	(A)	(P)	(E)	(D)	(S)	(N)
Content	Information structure	x	x	x	x	x	x
	Content relevancy	x		x	x	x	x
	Text	x	x	x	x	x	x
	Information completeness		x		x	x	x
Presentational style	Visuals	x	x	x	x	x	x
	Fonts	x	x		x		
	Colors	x			x		
	Organizational consistency	x	x	x	x		
Functionality	Course navigation	x	x	x	x	x	
	Study progress		x	x	x	x	x
	Community		x			x	
Interaction style	Internal consistency	x	x	x	x	x	

Next, each theme is described alongside examples from the object-level findings. The sub-sections follow the order of the above-mentioned product features, which emphasize the relevant aspects of the workspace, and the issues connected to these aspects.

4.1 Content

Most of the students' findings were related to the workspace content. The four themes that focus on how the content affects UX are information structure, content relevancy, text, and information completeness, with information structure attracting the highest number of notions. In both Studies 1 and 2 students stressed that the most important information, such as deadlines and instructions for main assignments, should be presented first (G1, G3, G6, G10, G15, G16, G17). Students highlighted that the clarity of the home page caters to both first-time users and returning users. On the first visit, the

home page offers an overall picture of the course (G15) and later supports the effective use of the workspace (G17). Information relevant to all students should be more visible, whereas information relevant to only some should be under subsections (G17). It was also seen as critical that important information was not scattered around the workspace (G4, G14). Rather, this information should be collected and accessible in one place. Additionally, students felt that similar or related content should be placed together in a common section (G17, G19). Students gave suggestions on how to structure the pages to utilize horizontal (G1, G5) and vertical space (G1, G6, G11) more effectively. For example, vertical space could be separated with visual lines (G1) to assist in finding information. Using two column horizontal layouts would minimize unnecessary empty space (G1) and improve novelty through innovation (G11).

Related to content relevancy, the main pain points related to irrelevant information, irrelevant placing of information, and irrelevant ways to express information. Unused modules and unnecessary information should be removed which would add white space that supports attractiveness (G13). Also, students indicated that certain information on the home page should be moved to another place as it was not experienced as important enough to be featured there (G1, G6, G9, G10). Lastly, related to content relevancy, students valued the most effective ways to express information. For example, using PDF files was not seen as necessary if the file content could be expressed directly on the page (G7). As another example, students pointed out that long lists of information (e.g., links) indicate laboriousness and make the user refuse the content (G3, G11). Rather, that kind of content should be compiled and presented on a subpage or in a specific folder (G1, G9, G11).

Related to text, students expressed the consistency and quality of text to affect UX. Titles and materials should be named descriptively, improving dependability (G18) and efficiency (G17). The title of the material should indicate its type (e.g., lecture) (G17). In both Studies 1 and 2 students stressed that to support findability the date that the material was related to should be indicated (G2, G3, G4, G6, G6, G10, G17). Short descriptions should be provided at the beginning of a new page and in relation to materials, such as links (G1, G2, G3, G6, G10, G11). Providing content without description was seen as unattractive and oppressive (G3, G11), whereas descriptions were seen to support efficiency (G1, G3, G6). Using English concepts in a course that did not utilize English as the main language was experienced as disturbing. Central concepts should preferably be provided in the language used on the course (G4, G5) and foreign loan words should be described (G4). Spelling mistakes were felt to indicate the unreliability of the workspace or that it was made in haste (G1) which had a negative effect on attractiveness.

Information completeness referred to instances where the workspace did not feel ready-made. Understandably workspaces have some content that will be updated during the course, but students indicated that when it felt that the teachers just had not had time to update the workspace it had a negative effect on the UX in terms of dependability (G8). Also, un-ready content such as broken links did not support effective use (G14). But on the other hand, students experienced placeholders indicating that updates were coming as stimulating (G10) and supporting the sense of novelty (G11).

4.2 Presentational Style

In relation to the workspace's presentational style, four themes can be depicted as relating to the UX of the course workspace. These are visuals, fonts, colors, and organizational consistency. Regarding visuals, students discussed the use of images from many different viewpoints. Firstly, they reported that the use of videos and images can make the workspace more attractive (G1, G13), as they can awaken interest and increase aesthetic pleasantness (G11), but the images should be of high quality and relevant. For example, in a UX course, an image of two people was felt to indicate interaction (G18) and thus relevant for the course. Students preferred images of people (G18), as images of objects were identified as distant (G12). Using free stock images was experienced as not supporting credibility (G7), and AI generated images were experienced as giving an unauthentic feel (G18). Recommendations supported the use of 'real' or original images – i.e., photographs and drawings. Images of course teachers were positively experienced, as the images supported recognizing who the teacher responsible for the course is (G17). Utilizing images should not be done at the expense of slowing Moodle down, as that would affect efficiency negatively (G17).

Students also experienced fonts as holding significance for the UX. Students pinpointed that the fonts should be legible (G18), and a large font size was mentioned as something that would help to distinguish important information faster (G2, G4, G13). Inconsistent use of fonts was experienced to lead to distrust and unattractiveness, in addition to evoking feelings that the workspace was generated in haste (G1).

Colors were mainly mentioned in Study 2, but in both studies students pinpointed how the colors affect especially the attractiveness (G1, G12). The use of colors was also experienced as supporting the informing of students (G13) and in eliciting trust (G18). Simple and light colors were experienced as boring (G12). The main color of the workspace was yellow in both studies. This was experienced as a preferred choice both in general (G12), and as it was the same as the organizational color. This made the workspace feel familiar and dependable (G18, G12).

The last theme was organizational consistency, which appeared in Study 2 and pertained to the color-related findings mentioned above. Yet, beyond color, students pointed out that there was no uniform layout of workspaces designed by different teachers. This always required learning a new structure and logic when students entered a new workspace. Students wished for a unified structure for each workspace, as familiarity was experienced to support effective use (G14, G16). Also, uniform layout of structure, information and images was experienced to enhance attractiveness (G13).

4.3 Functionality

Three themes are related to the functionality of the workspace. These three themes are course navigation, study progress, and community. The course navigation was experienced as a central functionality. In the workspace of Study 1, the course navigation was statically located in the upper right corner of the workspace, which was reported as difficult to use (G1, G3, G5, G6, G10). Students found it inefficient and frustrating as it forced them to scroll up on the page when wanting to navigate to another page. In the workspace of Study 2, the course navigation was a collapsible menu (i.e., course index)

on the left side of the screen that automatically generated items based on the materials teachers included in their workspace. This led to the course navigation becoming information-dense and unorganized. Students identified that teachers should consider this and aim for a smaller number of items to be included in the course navigation. Teachers should also focus on clearly naming the items they know will be included in the course navigation (G19). This would make it easier to find the information needed (G15).

Within the theme of study progress, students hoped for more possibilities to follow course advancement and returned assignments. As ways to implement this, students mentioned the visual progress bar (G14, G16, G19), course calendar (G9, G11, G16), and checkboxes to mark sections done (G14). Being able to monitor study progress would improve perspicuity (G14) and support effective course completion (G16).

Lastly, in Study 1 students pinpointed that the course workspace had no functionalities that would support communication within the class (G10), or with the teachers (G4). The fact that community was not emphasized in the workspace was felt to be discouraging (G10). A discussion forum was suggested as a solution, which was also later implemented in the workspace. Notions related to the theme of community did not appear in Study 2. This most likely relates to the fact that improvement was made in this respect, so the problem was solved by the time Study 2 was undertaken.

4.4 Interaction Style

The last feature, interaction style, was least represented in the students' findings. The basic interaction style in Moodle's user interface design is a dimension in which teachers have no impact. In relation to interaction style, internal consistency was raised as a key theme. Internal consistency was apparent in both Study 1 and Study 2. In this theme, students reported issues where the workspace functions worked differently than they expected or differently than in other parts of the system. For example, a picture of a video that seemed to be embedded was experienced as misleading (G1). As another example, in both studies, students mentioned that there was inconsistency on how links opened (G4, G6, G10, G15, G19) – whether in the same window, in a new tab, or in a new window. This was experienced as frustrating (G10, G19). In Study 2, the students criticized the unstandardized way that links were indicated within a text (G15, G19). The link text was dark blue in color which did not have enough contrast to be distinguishable from the main black text. Although teachers cannot change the way the platform indicates links, students suggested a workaround where teachers could reference the links in the text (G15).

5 Discussion

As a result of this study, 12 themes depicting the object-level UX issues were created and divided into four groups presenting product features. Next, we will elaborate the findings related to each product feature (content, presentational style, functionality, and interaction style) and illustrate them in the form of 12 design principles to support the practical applicability of the results. These design principles are formed based on the student-reported conclusions from student-led co-design workshops. Features

especially related to the content and presentational style of the workspace were seen as possessing the greatest potential to improve the UX.

Regarding content, the findings can be illustrated with the following four design principles:

1. Organize content based on importance and relevance, and group similar content in one place.
2. Select the most appropriate way to present information and remove unnecessary content.
3. Use descriptive titles and precise language.
4. Avoid providing incomplete information.

The main findings related to content focused on aspects associated with the information structure. The importance of logical order, consistency and grouping of contents were emphasized. Especially the easy findability of the most important issues was seen as crucial, and arising in improvement suggestions related to each of the six UX attributes. This was also well in line with content relevance, which included suggestions aiming to avoid the presentation of irrelevant information or irrelevant ways to distribute the information. Providing clear indicators, such as descriptions and dates, were seen to improve, among other things, findability. Lastly, the feeling of incompleteness of the workspace should be avoided. Instead, the updates should be implemented to stimulate and support a sense of novelty while reinforcing the impression that the course is up-to-date and relevant with continuous developments in the field. From a UX perspective, novelty additionally serves to insight curiosity, motivating engagement and fueling the will to learn more – both about the design, but in this case, about the course and its contents [37, 38]. Thus, the impression of the course and its flow should be communicating a sense that the phenomena presented do not exist in a stationary state, rather, they are dynamic and evolving. This alludes to the idea that through curiosity in the course, students may be a part of the future directions of the taught phenomena. As for product design aesthetics, it is important to emphasize that completeness does not equal novelty, rather, it refers to the impression of a package that has been carefully designed with the user (students) and functional objectives (learning) in mind. This alludes to an understanding that the package as a whole is within grasp in the workspace [61, 62]. So, while the content and progress of the knowledge shared and fostered within the course should maintain a sense of incompleteness, the aesthetics of the workspace should bear an aura of ‘progressive completeness’. That is, the student should feel the safety of being held competently in the teacher’s and Moodle’s hands while preparing for impact after the course is completed.

When it came to presentation style, the power of using the right type of visuals, fonts, colors, as well as following institutional consistency, was depicted to lead to improved UX, as is illustrated with the following design principles:

5. Use relevant visuals.
6. Use legible fonts and maintain font consistency.
7. Acknowledge how colors affect attractiveness.
8. Follow and support organizational consistency.

Although images and videos were seen to improve workspace attractiveness, selecting unsuitable images might lead to depressing UX attributes such as dependability. The selection of font type and size had significance for efficient use, and the consistent use of fonts supported attractiveness and trust. The possibilities of utilizing colors were not merely related to improving attractiveness and efficiency, but color was also seen to communicate dependability when the organizational colors were utilized. Following organizational consistency in the workspace structure, colors, and visuals was seen to improve attractiveness and efficiency. This additionally entails systematic operationalization of the familiar, rendering prototypicality [63, 64] as critical at some level.

The findings related to functionalities and interaction style highlight the importance of the functions and the ways to interact with them for the experienced UX. The findings can be described with the following design principles:

9. Limit the number of items in course navigation.
10. Offer ways to follow course progress.
11. Offer ways to interact.

As central functions in a course workspace, the students identified the tools related to course navigation and monitoring study progress. The course navigation was mentioned in relation to problems and solutions of the information structure, and the expressed notions are intertwined. For example, the course navigation was mentioned when considering information architecture, and in relation to the items aimed at improving efficient use. It was noticed that the course navigation also enhances the clarity of the workspace content. The ability to monitor study progress was linked to efficiency and perspicuity. An interesting finding was the importance of the community for the students. Students felt not being able to interact within the course to suppress stimulation. In other words, students are stimulated via social interaction within learning processes. This finding corresponds with results from other studies that indicate how virtual environments should be designed to enhance social interaction between learners to enable deep and meaningful learning (see e.g., [65]).

Related to the interaction style, the key finding can be illustrated with the following design principle:

12. Follow internal consistency.

Violations to consistency depressed several of the UX attributes, especially perspicuity. This connects with the dimension of pedagogical usability as described by Nokelainen [18], in that the design of the technology and its interaction styles should support seamless engagement with learning materials and processes (see also [10] and [20]). Internal consistency promotes efficient learning of interaction, which enables learners to focus on the learning design itself rather than on how to operate the workspace.

As a research contribution, this study indicates how co-design can be used to improve the UX of a course workspace, while engaging students in deeper and more meaningful learning. The co-design workshops functioned well in extracting improvement ideas for the course workspace, learning about UX design, and instilling greater involvement in the subject matter of the course. Through re-designing the workspace

students actively operationalized theories and principles that were embedded within the course content and learning objectives. Students understood their engagement in the course work by improving their current and future workspaces, rendering it a meaningful task. This strongly resonates with Moyo [11] and others (i.e., [67, 68]).

This study also contributes to research on the UX of course workspaces by indicating possible connections between practical improvements and intended UX. It draws attention to levels of design that are added onto the basic core of interactional products. These are user-designed and implemented levels that also require attention – both at the instructional design level as well as user interface and information architecture levels. The reason being is that, in reality, teachers and educational designers do not have ample amounts of time to invest in careful consideration for the layout and progress of course contents. Studies such as the present one are instrumental in further development of products (learning platforms) from the perspectives of current technological developments, i.e., generative AI. Generative AI, for instance, has the potential to aid teachers and educational designers in producing, arranging, and suggesting effective workspace designs, in which all the teachers would need to do is feed the material required in the course. Prompts may include learning objectives and certain priorities, then the generative AI can produce alternative packages. Thus, this study offers several practical implications for teachers and instructional designers, learning platform designers, and future directions in AI on how to improve the UX of course workspaces.

This study has several limitations. The reported effect of the object-level improvements on UX was done based on the students' reports. The participants represent a homogenous group in terms of nationality and culture. We understand that the findings (e.g., related to colors, images, and information presentation) could and most likely would vary depending on the cultural context. The number of students working with different attributes was not even, as the theme of novelty was only chosen by one group, and stimulation was chosen by two groups, whereas the other attributes were chosen respectively by a total of four groups. Moreover, further analysis from the combined learning experience and UX perspectives, i.e., operationalizing models such as LETUS [10] - to ascertain the balance and presence of essential pedagogical design features and how these influence the learning process and experience in its entirety - would be fruitful. In addition, this study was conducted in a specific context: a HE level UX course that utilized a Moodle workspace. The generalizability of the results regarding courses held in other subjects or utilizing other types of digital learning environments should be further studied. On the other hand, one feature that improves the reliability of the results is the fact that the data was gathered in two timepoints with the years difference and within two different versions of learning platforms.

In this study, we were open to discovering the role of UX attributes overall in the context of learning in a Moodle workspace. The UX attributes are intertwined as can be seen from the results. This corresponds with earlier research results on pedagogical usability and learning experience in digital technology design (see [10, 18]). As highlighted before, the main goal of the course workspace is to support learning, and thus this research could be continued by looking more deeply into the connection between UX and learning. Moreover, future research should emphasize the role of generative AI

in assisting teachers and educational designers in course workspace design. This could also be done by examining the ways in which students could co-design with AI.

6 Conclusion

In this paper, we presented the results of co-designing the UX of a course workspace in Moodle with students. The results are illustrated with 12 design principles describing the possibilities for teacher-led improvements of UX. The findings emphasize the importance of logical order of contents, with a focus on using the most appropriate way to present relevant information. In addition, the workspace should avoid a feeling of incompleteness. Effective use of visuals, fonts, and colors, along with institutional consistency, was found to improve UX. Central functions identified included tools related to course navigation and monitoring study progress. Social interaction within the course was highlighted as crucial for stimulation and meaningful learning. Internal consistency in interaction styles was important for supporting seamless engagement with learning materials. The results of this study offer several practical implications for teachers, instructional designers, and learning platform designers. Also, this study demonstrates how co-design can be effectively used to improve the UX of a course workspace.

Acknowledgments. The authors would like to acknowledge the Research Council of Finland for funding the “Emotional experience of ethics and privacy in everyday pervasive systems (BUGGED)” project (decision number 348391) and the “Multifaceted ripple effects and limitations of human-AI interplay at work, business and society (SYNTHETICA)” project (358714).

Disclosure of Interests. The authors have no competing interests to declare that are relevant to the content of this article.

References

1. Majors, J., Bengs, A., Granlund, S., Ylitalo, A., Byholm, M.: Moodle Moods?: A User Experience Study of a Small Private Online Course for Higher Teacher Education. In: Proceedings of the 22nd International Academic Mindtrek Conference, pp. 228–235. ACM, Tampere Finland (2018). <https://doi.org/10.1145/3275116.3275146>.
2. Maslov, I., Nikou, S., Hansen, P.: Exploring user experience of learning management system. *Int. J. Inf. Learn. Technol.* 38, 344–363 (2021).
3. Norman, D.: Emotion & design: attractive things work better. *Interactions* 9, 36–42 (2002). <https://doi.org/10.1145/543434.543435>.
4. Demir, F., Bruce-Kotey, C., Alenezi, F.: User Experience Matters: Does One Size Fit all? Evaluation of Learning Management Systems. *Technol. Knowl. Learn.* (2021). <https://doi.org/10.1007/s10758-021-09518-1>.
5. de Kock, E., van Biljon, J., Botha, A.: User Experience of Academic Staff in the Use of a Learning Management System Tool. In: Proceedings of the Annual Conference of the South African Institute of Computer Scientists and Information Technologists on - SAICSIT '16,

- pp. 1–10. ACM Press, Johannesburg, South Africa (2016). <https://doi.org/10.1145/2987491.2987514>.
6. Walker, S., Prytherch, D., Turner, J.: The pivotal role of staff user experiences in Moodle and the potential impact on student learning. In: 2013 Second International Conference on E-Learning and E-Technologies in Education (ICEEE), pp. 192–197. IEEE (2013).
 7. Könings, K.D., Seidel, T., van Merriënboer, J.J.: Participatory design of learning environments: integrating perspectives of students, teachers, and designers. *Instr. Sci.* 42, 1–9 (2014). <https://doi.org/10.1007/s11251-013-9305-2>.
 8. Hasan, L.: Usability Problems on Desktop and Mobile Interfaces of the Moodle Learning Management System (LMS). In: Proceedings of the 2018 International Conference on E-Business and Applications, pp. 69–73. ACM, New York, NY, USA (2018). <https://doi.org/10.1145/3194188.3194192>.
 9. Hassenzahl, M.: The Thing and I: Understanding the Relationship Between User and Product. In: Blythe, M.A., Overbeeke, K., Monk, A.F., and Wright, P.C. (eds.) *Funology*, pp. 31–42. Springer Netherlands, Dordrecht (2003). https://doi.org/10.1007/1-4020-2967-5_4.
 10. Kenttälä, V., Rousi, R., Kankaanranta, M.: Towards the learning experience technology usability framework. In: *Handbook of Research on Instructional Systems and Educational Technology*, pp. 128–140. IGI global (2017). <https://doi.org/10.4018/978-1-5225-2399-4.ch012>.
 11. Moyo, N.E.: Students’ perceptions of the authenticity of e-learning design within Moodle at Lupane State University, Matebeleland North, Zimbabwe. PhD Thesis, University of Johannesburg (2023).
 12. Gobet, F., Lane, P.C., Croker, S., Cheng, P.C., Jones, G., Oliver, I., Pine, J.M.: Chunking mechanisms in human learning. *Trends Cogn. Sci.* 5, 236–243 (2001). [https://doi.org/10.1016/S1364-6613\(00\)01662-4](https://doi.org/10.1016/S1364-6613(00)01662-4).
 13. Bødker, S., Dindler, C., Iversen, O.S., Smith, R.C.: *Participatory design*. Springer International Publishing, San Rafael, California (2021).
 14. Ellis, R.K.: *Field Guide to Learning Management*. ASTD Learning Circuits **11**(1), (2009).
 15. Tapalova, O., Zhiyenbayeva, N.: Artificial intelligence in education: AIED for personalised learning pathways. *Electron. J. E-Learn.* 20, 639–653 (2022). <https://doi.org/10.34190/ejel.20.5.2597>
 16. Gunasekaran, A., McNeil, R.D., Shaul, D.: E-learning: research and applications. *Ind. Commer. Train.* 34, 44–53 (2002). <https://doi.org/10.1108/00197850210417528>
 17. Kurhila, J., Miettinen, M., Nokelainen, P., Tirri, H.: The role of the learning platform in student-centred e-learning. In: *IEEE International Conference on Advanced Learning Technologies, 2004. Proceedings*, pp. 540–544. IEEE (2004). <https://doi.org/10.1109/ICALT.2004.1357473>
 18. Nokelainen, P.: An empirical assessment of pedagogical usability criteria for digital learning material with elementary school students. *J. Educ. Technol. Soc.* 9, 178–197 (2006).
 19. Pham, M., Singh, K., Jahnke, I.: Socio-technical-pedagogical usability of online courses for older adult learners. *Interact. Learn. Environ.* 31, 2855–2871 (2023). <https://doi.org/10.1080/10494820.2021.1912784>.
 20. Koehler, M.J., Mishra, P., Kereluik, K., Shin, T.S., Graham, C.R.: The Technological Pedagogical Content Knowledge Framework. In: Spector, J.M., Merrill, M.D., Elen, J., and Bishop, M.J. (eds.) *Handbook of Research on Educational Communications and Technology*, pp. 101–111. Springer New York, New York, NY (2014). https://doi.org/10.1007/978-1-4614-3185-5_9.
 21. Hassenzahl, M., Tractinsky, N.: User experience - a research agenda. *Behav. Inf. Technol.* 25, 91–97 (2006). <https://doi.org/10.1080/01449290500330331>.

22. Handler, R.: Authenticity. *Anthropol. Today*. **2**(1), 2–4 (1986).
23. Arima, S., Yasui, M., Okawa, K.: Re-Design Classroom into MOOC-like Content With Remote Face-to-Face Sessions During the COVID-19 Pandemic: A Case Study in Graduate School. In: *Proceedings of the Eighth ACM Conference on Learning @ Scale*, pp. 299–302. ACM, Virtual Event Germany (2021). <https://doi.org/10.1145/3430895.3460163>.
24. Sheridan, L., Gigliotti, A.: Designing online teaching curriculum to optimise learning for *all* students in higher education. *Curric. J.* **34**, 651–673 (2023). <https://doi.org/10.1002/curj.208>.
25. Hassenzahl, M.: The Effect of Perceived Hedonic Quality on Product Appealingness. *Int. J. Hum.-Comput. Interact.* **13**, 481–499 (2001). https://doi.org/10.1207/S15327590IJHC1304_07.
26. Schrepp, M., Held, T., Laugwitz, B.: The influence of hedonic quality on the attractiveness of user interfaces of business management software. *Interact. Comput.* **18**, 1055–1069 (2006). <https://doi.org/10.1016/j.intcom.2006.01.002>.
27. Rousi, R.: From cute to content: user experience from a cognitive semiotic perspective. PhD Thesis, University of Jyväskylä (2013).
28. Rousi, R., Silvennoinen, J.: Simplicity and the art of something more: A cognitive-semiotic approach to simplicity and complexity in human-technology interaction and design experience. *Hum. Technol.* **14**, (2018). <https://doi.org/10.17011/ht/urn.201805242752>
29. Hinderks, A., Schrepp, M., Domínguez Mayo, F.J., Escalona, M.J., Thomaschewski, J.: Developing a UX KPI based on the user experience questionnaire. *Comput. Stand. Interfaces.* **65**, 38–44 (2019). <https://doi.org/10.1016/j.csi.2019.01.007>.
30. Laugwitz, B., Held, T., Schrepp, M.: Construction and Evaluation of a User Experience Questionnaire. In: Holzinger, A. (ed.) *HCI and Usability for Education and Work*, pp. 63–76. Springer, Berlin, Heidelberg (2008). https://doi.org/10.1007/978-3-540-89350-9_6.
31. Rauschenberger, M., Schrepp, M., Perez-Cota, M., Olschner, S., Thomaschewski, J.: Efficient Measurement of the User Experience of Interactive Products. How to use the User Experience Questionnaire (UEQ). Example: Spanish Language Version. *Int. J. Interact. Multimed. Artif. Intell.* **2**, 39–45 (2013). <https://doi.org/10.9781/ijimai.2013.215>.
32. Schrepp, M.: *User Experience Questionnaire Handbook*. (2015). <https://doi.org/10.13140/RG.2.1.2815.0245>.
33. Tractinsky, N.: Aesthetics and apparent usability: empirically assessing cultural and methodological issues. In: *Proceedings of the ACM SIGCHI Conference on Human factors in computing systems*, pp. 115–122. ACM, New York, NY, USA (1997). <https://doi.org/10.1145/258549.258626>.
34. Jiang, Z. (Jack), Wang, W., Tan, B.C.Y., Yu, J.: The Determinants and Impacts of Aesthetics in Users' First Interaction with Websites. *J. Manag. Inf. Syst.* **33**, 229–259 (2016). <https://doi.org/10.1080/07421222.2016.1172443>.
35. Miniukovich, A., Figl, K.: The effect of prototypicality on webpage aesthetics, usability, and trustworthiness. *Int. J. Hum.-Comput. Stud.* **179**, 103103 (2023).
36. Tractinsky, N., Katz, A.S., Ikar, D.: What is beautiful is usable. *Interact. Comput.* **13**, 127–145 (2000). [https://doi.org/10.1016/S0953-5438\(00\)00031-X](https://doi.org/10.1016/S0953-5438(00)00031-X).
37. Tuch, A.N., Presslauer, E.E., Stöcklin, M., Opwis, K., Bargas-Avila, J.A.: The role of visual complexity and prototypicality regarding first impression of websites: Working towards understanding aesthetic judgments. *Int. J. Hum.-Comput. Stud.* **70**, 794–811 (2012). <https://doi.org/10.1016/j.ijhcs.2012.06.003>.
38. Yablonski, J.: *Laws of UX: Using Psychology to Design Better Products and Services*. O'Reilly Media, Inc. (2024).

39. Al-Hunaiyyan, A., Alhajri, R., Alghannam, B., Al-Shaher, A.: Student Information System: Investigating User Experience (UX). *Int. J. Adv. Comput. Sci. Appl.* 12, (2021). <https://doi.org/10.14569/IJACSA.2021.0120210>.
40. Schrepp, M., Otten, R., Blum, K., Thomaschewski, J.: What Causes the Dependency between Perceived Aesthetics and Perceived Usability? *Int. J. Interact. Multimed. Artif. Intell.* 6, 78 (2021). <https://doi.org/10.9781/ijimai.2020.12.005>.
41. Sterz, S., Baum, K., Lauber-Rönsberg, A., Hermanns, H.: Towards Perspicuity Requirements. In: 2021 IEEE 29th International Requirements Engineering Conference Workshops (REW), pp. 159–163 (2021). <https://doi.org/10.1109/REW53955.2021.00029>.
42. Reinecke, K., Bernstein, A.: Improving performance, perceived usability, and aesthetics with culturally adaptive user interfaces. *ACM Trans. Comput.-Hum. Interact.* 18, 8:1-8:29 (2011). <https://doi.org/10.1145/1970378.1970382>.
43. Fatima, A., Luca, C., Wilson, G.: User experience and efficiency for semantic search engine. In: 2014 International Conference on Optimization of Electrical and Electronic Equipment (OPTIM), pp. 924–929 (2014). <https://doi.org/10.1109/OPTIM.2014.6851023>.
44. Nielsen, J.: Enhancing the explanatory power of usability heuristics. In: Proceedings of the SIGCHI conference on Human factors in computing systems celebrating interdependence - CHI '94, pp. 152–158. ACM Press, Boston, Massachusetts, United States (1994). <https://doi.org/10.1145/191666.191729>.
45. Marques, L., Matsubara, P.G., Nakamura, W.T., Ferreira, B.M., Wiese, I.S., Gadelha, B.F., Zaina, L.M., Redmiles, D., Conte, T.U.: Understanding UX Better: A New Technique to Go beyond Emotion Assessment. *Sensors*. 21, 7183 (2021). <https://doi.org/10.3390/s21217183>.
46. Varsaluoma, J.: Approaches to Improve User Experience in Product Development: UX Goals, Long-Term Evaluations and Usage Data Logging. PhD Thesis, Tampere University of Technology (2018).
47. Ricciardi, S., Nappi, M., Paolino, L., Sebillio, M., Vitiello, G., Gigante, G., Pascarella, D., Travascio, L., Vozella, A.: Dependability issues in visual-haptic interfaces. *J. Vis. Lang. Comput.* 21, 33–40 (2010). <https://doi.org/10.1016/j.jvlc.2009.07.001>
48. Hassenzahl, M.: User experience (UX): towards an experiential perspective on product quality. In: Proceedings of the 20th International Conference of the Association Franco-phone d'Interaction Homme-Machine on - IHM '08. p. 11. ACM Press, Metz, France (2008). <https://doi.org/10.1145/1512714.1512717>.
49. Hassenzahl, M., Platz, A., Burmester, M., Lehner, K.: Hedonic and ergonomic quality aspects determine a software's appeal. In: Proceedings of the SIGCHI conference on Human Factors in Computing Systems, pp. 201–208. ACM, New York, NY, USA (2000). <https://doi.org/10.1145/332040.332432>.
50. Väättäjä, H., Koponen, T., Roto, V.: Developing practical tools for user experience evaluation: a case from mobile news journalism. *VTT symposium*, 258, 240–247 (2009).
51. Kujala, S., Roto, V., Väänänen-Vainio-Mattila, K., Karapanos, E., Sinnelä, A.: UX Curve: A method for evaluating long-term user experience. *Interact. Comput.* 23, 473–483 (2011). <https://doi.org/10.1016/j.intcom.2011.06.005>.
52. von Wilamowitz-Moellendorff, M., Hassenzahl, M., Platz, A.: Dynamics of user experience: How the perceived quality of mobile phones changes over time. In: User experience-towards a unified view, Workshop at the 4th Nordic conference on human-computer interaction, pp. 74–78 (2006).
53. Schrepp, M., Hinderks, A., Thomaschewski, J.: Construction of a Benchmark for the User Experience Questionnaire (UEQ). *Int. J. Interact. Multimed. Artif. Intell.* 4, 40–44 (2017). <https://doi.org/10.9781/ijimai.2017.445>.

54. Prakoso, B.S., Subriadi, A.P.: User Experience on E-Government Online Services: A Case Study on The SIMPATIKA Service Application at The Ministry of Religious Affairs of Indonesia. *J. Inf. Technol. Comput. Sci.* 3, 67–76 (2018). <https://doi.org/10.25126/jitecs.20183152>.
55. Bødker, S., Dindler, C., Iversen, O.S., Smith, R.C.: What Can We Learn from the History of Participatory Design? In: *Participatory Design*, pp. 15–29. Springer International Publishing, Cham (2022). https://doi.org/10.1007/978-3-031-02235-7_3.
56. Tuhkala, A.: A systematic literature review of participatory design studies involving teachers. *Eur. J. Educ.* 56, 641–659 (2021). <https://doi.org/10.1111/ejed.12471>.
57. Rajanen, D., Tornberg, A., Rajanen, M.: Heuristics for Course Workspace Design and Evaluation. In: *34th British HCI Conference*, pp. 60–75 (2021). <https://doi.org/10.14236/ewic/HCI2021.5>.
58. Smith, P.: Engaging online students through peer-comparison progress dashboards. *J. Appl. Res. High. Educ.* 12, 38–56 (2019). <https://doi.org/10.1108/JARHE-11-2018-0249>.
59. Reeves, T.C., Benson, L., Elliott, D., Grant, M., Holschuh, D., Kim, B., Kim, H., Lauber, E., Loh, S.: Usability and Instructional Design Heuristics for E-Learning Evaluation. *Association for the Advancement of Computing in Education (AACE)*, pp. 1615–1621 (2002).
60. Krippendorff, K.: Content analysis. *Int. Encycl. Commun.* 1, 403–407 (1989).
61. Patrick, V.M.: Everyday consumer aesthetics. *Curr. Opin. Psychol.* 10, 60–64 (2016). <https://doi.org/10.1016/j.copsyc.2015.12.007>
62. Sevilla, J., Kahn, B.E.: The Completeness Heuristic: Product Shape Completeness Influences Size Perceptions, Preference, and Consumption. *J. Mark. Res.* 51, 57–68 (2014). <https://doi.org/10.1509/jmr.12.0153>.
63. Coope, M., Huisman, G., Hekkert, P.: Haptic aesthetics in product design: designing headphones that feel beautiful. In: De Sainz Molestina, D., Galluzzo, L., Rizzo, F., and Spallazzo, D. (eds.), *IASDR 2023: Life-Changing Design*, pp. 9–13. Milan, Italy (2023). doi.org/10.21606/iasdr.2023.303
64. Hekkert, P., Thurgood, C., Whitfield, T.A.: The mere exposure effect for consumer products as a consequence of existing familiarity and controlled exposure. *Acta Psychol.* 144, 411–417 (2013). <https://doi.org/10.1016/j.actpsy.2013.07.015>
65. Mystakidis, S., Berki, E., Valtanen, J.-P.: Deep and meaningful e-learning with social virtual reality environments in higher education: A systematic literature review. *Appl. Sci.* 11, 2412 (2021). <https://doi.org/10.3390/app11052412>
66. Demirbas, D., Ogut, S.T.: Re-designing the design brief as a digital learning tool with participatory design approach. *Turk. Online J. Distance Educ.* 21, 83–100 (2020). <https://doi.org/10.17718/tojde.690356>
67. Dindler, C., Smith, R., Iversen, O.S.: Computational empowerment: participatory design in education. *CoDesign.* 16, 66–80 (2020). <https://doi.org/10.1080/15710882.2020.1722173>.