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A Study of Learnability in Software as Perceived by Practitioners in User Experience and Learning Design Professions

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A STUDY OF LEARNABILITY IN SOFTWARE AS PERCEIVED BY PRACTITIONERS IN USER EXPERIENCE AND LEARNING DESIGN PROFESSIONS

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ABSTRACT

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In the technology space, there are many factors that contribute to the marketability of software, including pricing and overall usefulness of the product (Jayathilaka, 2021). Many factors contribute to how usable a software is, including satisfaction, error prevention, memorability, efficiency, and learnability (Nielsen, 1994b). Learnability is one factor that may be affected or addressed by both user experience (UX) and learning design (LD) professional groups. While both fields address learnability, very few studies have been conducted to look at the UX interpretation of learnability as it relates to the LD interpretation (Elliott et al., 2002; Li et al., 2023). This study addressed the gap in understanding between UX and LD professionals regarding learnability in software by exploring the degree of consensus on the importance of various learnability factors.

A survey was distributed to UX and LD professionals, comprising open-ended, multiple-choice, categorical, and Likert-type questions about demographics, perceptions of usability and learnability, and the importance of specific learnability attributes. Data were analyzed using descriptive statistics, Kaiser-Meyer-Olkin (KMO) and exploratory factor analysis, Krippendorff's Alpha, independent samples *t*-tests, and chi-square analyses. The analysis showed significant differences in how UX and LD professionals prioritize learnability factors, suggesting potential for collaborative improvement. These findings highlight the need for a unified framework to define and assess learnability in software and lays the groundwork for

developing integrated assessment tools and methodologies applicable across both fields to support more effective software design and training.

This dissertation is dedicated to my husband, Jacob, who inspires me daily, supports me tirelessly, and lifts me high enough to touch the stars. To my family, Gina, Tim, and Alex, who raised me to exist loudly, to care about people, and to always ask “where’s the pony?” This is also dedicated to my friends and chosen family who have taken this roller coaster with me: Janine, Ashley, Jeremy, Suzanne, Maria, and Anna. And, finally, to Lucia, my stalwart study buddy from Lean Six Sigma and beyond.

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CHAPTER 1

INTRODUCTION

Do user experience and learning design professionals have a common understanding of the term *learnability* in the software context? Traditionally, learnability in user experience is interpreted as a part of usability testing (Nielsen, 1994b), whereas learning in the education space is substantially more multi-dimensional (NASEM; National Academies of Sciences, Engineering, and Medicine, 2018). Though the lenses may be different, it is important to investigate the similarity between these two fields because of the overlap in audience and both profession's mutual interest in that audience's overall success in meeting learning/use objectives (Soloway et al., 1994). One such area where this question may be explored is through an intersecting topic: software development and the way in which that software may be taught to a user. In the technology space, there are many factors that contribute to the marketability of software, including pricing and overall usefulness of the product (Jayathilaka, 2021). An application, even if it serves a meaningful purpose, may still fail in the market if it is too difficult to use by the end-user (Feng & Wei, 2019). Ease of use of a product intended to support effective completion of a task, i.e., the *usability* of the software, is a large factor in the success of software applications (Feng & Wei, 2019; Fernández et al., 2013b; Paz & Pow-Sang, 2016). There are many identified factors that contribute to how usable a software is, including satisfaction, error prevention, memorability, efficiency, and learnability (Nielsen, 1994b, Quiñones et al., 2018).

Learnability is an interesting factor of usability because it can be argued that learnability can be affected, or potentially overcome, by interventions outside of the development of the software itself. Sousa and Martins (2021) stated, "learning is a complex activity which involves different stages, each with multiple tasks and emotions. Hence, understanding how humans learn is a key component for creating more meaningful products and experiences for users" (p. 46). Soloway et al. (1994) made the argument that the role of user, a term often favored in the user experience professions, and the role of learner, a term used by those in learning design professions, are quite parallel, especially in the context of software. The user and the learner are arguably the same person viewed through two different lenses. Their needs should be at the center of design, whether for the product itself or the training interventions chosen to teach the learner (Soloway et al., 1994).

Because learnability may be affected in both the product's design as well as the training support that is provided, there may be two professional groups that could affect learnability. On the product development side, the usability and learnability of a product is often evaluated by user experience design (UX) professionals: individuals who work or conduct research in UX roles, e.g., User Experience Designer, Interaction Designer, Experience Strategist, etc. On the education and enablement side of an organization, the assessment of training needs is conducted by learning design (LD) professionals: individuals who work or conduct research in education roles, e.g., Instructional Designer, Learning Experience Designer, Technical Trainer, etc. While LD methodologies, such as human performance technology (HPT), human-centered design, and needs assessment take contextual learner factors into consideration, can the same be said about the user UX profession's understanding of learnability?

Both LD and UX practitioners use assessment techniques to determine need; however, the goals of these assessments are somewhat different. LD has a focus on educational outcomes (Saçak et al., 2022), whereas UX focuses on the level of satisfaction and success of a user interacting with a product (Hinderks et al., 2022). On the LD side, exercises such as needs assessment, organizational analysis, operational analysis, and individual analysis all work together to find gaps in performance and to develop training interventions to address them (Agnaia, 1996). UX, on the other hand, looks at the instrumental, emotional, and experiential feelings that users have when interacting with a product, software, or interface (Hassenzahl & Tractinsky, 2006). Professionals of both disciplines attempt to create optimal conditions for the success of the end user. Therefore, it is important to study how to leverage the expertise of the members of both professional groups to enhance the approaches to improve user/learner experience with software learnability. Table 1 describes the roles, goals, and audiences for each professional group.

Table 1

Comparison of Learning Design and User Experience Design Professionals

	Learning Design	**User Experience Design**
Sample Titles	Instructional Designer, Learning Experience Designer, Technical Trainer, etc.	User Experience Designer, Interaction Designer, Experience Strategist, etc.
Audience Terminology	Learner	User
Primary Focus	Educational outcomes	Level of satisfaction and interaction success
Assessment Tools	Needs assessment, gap analysis, organizational analysis, operational analysis	Heuristic evaluation, usability assessments, questionnaires, automatic evaluation programs
Tries to Improve	Learner performance interacting with a system	System performance to be used effectively by a user

Collaboration between UX and LD professionals could be quite beneficial. LD professionals could bring their expertise on how people learn into software development practices, which could help design products that are easier to understand and use (Soloway et al., 1994). UX professionals could share with LD professionals their arsenal of usability heuristic tools and assessments, which have proven validity over time (Lewis, 2014). In turn, LD professionals could analyze learning needs at the product level to supplement their initial analyses of learner needs (Agnaia, 1996). Both fields could contribute meaningfully to improving the user/learner experience with a product.

A challenge to this idea, however, is the lack of research that marries the two fields in respect to learnability. While both fields involve identifying how *learnable* something is, few studies have been conducted to look at the UX interpretation of learnability as it relates to the LD interpretation. There is a great deal of literature that addresses learnability in the context of UX design, but it is important to note that UX design is not a discipline rooted in learning and learning concepts (Bargas-Avila & Hornbæk, 2011; Jooste et al., 2014). This key caveat brings into question the epistemological merit of UX definitions of learnability. Elliot et al. (2002) noted that UX learnability has only been studied separately from learning concepts, apart from Davis and Wiedenbeck (1998), whose study discussed UX learnability in the context of Assimilation Theory. In their work, they discussed the idea that learning occurs when connections can be drawn between new information and the information already stored in long-term memory (Davis & Wiedenbeck, 1998).

Problem Statement

The gap in the research indicates that we do not yet know how similar (or different) the perceptions and definitions of learnability are between the two groups (user experience and learning design) of professionals. There is little evidence of value in cross-disciplinary collaboration on learnability, and differences in interpretation could indicate a foundational problem in how LD and UX professionals approach the usability/learnability of a software. Until we better understand how the two professional groups perceive learnability, we will not be able to find commonalities of practice. Not understanding the perceptions of learnability between and within professional groups could reduce the ability to collaborate in an interdisciplinary manner.

In addition, this issue affects the user/learner of the software that is being developed/learned because if the basis of assessment for learnability, or the assessment of the learning need are incongruent, then the holistic user experience may suffer (Hassenzahl & Tractinsky, 2006). The current body of literature does not adequately compare the two fields' understanding of learnability and has only been explored in a limited capacity (Elliott et al., 2002). Unless the problem is investigated, we will not know if one or both professional fields are doing a disservice to themselves and the user/learner by misinterpreting learnability as it applies to software use.

Purpose of the Study

The purpose of this study is to better understand the perceptions of UX and LD professionals on learnability and its attributes, as identified in extant literature, in the software context so that a common set of definitions and metrics can be used between disciplines to enhance the user's learning process. To do that, this study is framed by the following research questions:

- RQ1: How do user experience design and learning design professionals perceive the importance of learnability factors as they pertain to a user's ability to learn and use a software product?
    - RQ1.1: What is the degree of consensus within the user experience design group on the importance of learnability factors?
    - RQ1.2: What is the degree of consensus within the learning design professional group on the importance of learnability factors?

- RQ2: What is the difference in how learnability factors are rated by importance between user experience design and learning design experts?

Background, Significance, and Theoretical Framework

UX and LD seem very compatible on the surface. In fact, a whole new profession that has been growing in popularity is learning experience design, where an individual is focused specifically on the experience of a learner who is navigating through some form of learning activity (Schmidt et al., 2020). On their parallel journeys, UX and LD have shared a similar focus and similar processes, though the literature may still be missing some key comparisons such as interpretation of learnability. If the gap remains, there could be both practical and theoretical implications for both fields.

Background

UX is a broad concept that is at the point of convergence of the instrumental (holistic, aesthetic, etc.) features of a software, the emotional response (subjective, positive, etc.) of the user, and the experiential (dynamic, situated, etc.) factors of a product (Hassenzahl & Tractinsky, 2006). Though the focus of this study was around usability specifically, user experience is a broader concept that expands past the bounds of usability alone and may be difficult to clearly differentiate between the two (Haaksma et al., 2018; Lewis, 2014).

At its core, LD is the systematic process in which the best training intervention is selected based on audience and educational content (Stefaniak & Xu, 2020). Instructional designers and educators are familiar with the various ways in which they can analyze, design, develop, implement, and evaluate their training in a way that ensures learners are getting what they need (Stefaniak & Xu, 2020). One tool, the needs assessment/analysis, also referred to as a TNA (Agnaia, 1996; Hyasat et al., 2022; Lee, 2018; Mahmud et al., 2019; Mamun, 2021; Vivian &

Jedidiah, 2019), has been utilized to determine the needs of learners at various organizational levels. Most often applied at the course or subject level, needs analysis has also been utilized at the programmatic level to determine what is needed to develop and professionalize a training program (Hyasat et al., 2022; Pauli, 2020; Wangchuk & Wetprasit, 2019).

Significance

This research topic is important for both practical application in the corporate context as well as implications for the two professional fields of UX and LD. In the corporate context, there are many organizations that do not have an in-house education team. According to Training Magazine's *2022 Training Industry Report* (Freifeld, 2022), which included respondents from small, mid-size, and large companies across various industries, 60% of organizations outsourced at least some of their education needs. If an organization does not have learning professionals to evaluate and make recommendations, there is not currently an alternative route to begin assessing training needs within the organization. However, if an organization can leverage usability/learnability assessments, which could be utilized by existing product development resources, then the organization would be coming from a more informed starting point in evaluating learning needs and could gain a general idea of the type of support their users/learners may need.

In addition to the practical industry application, this study could have major implications for both the UX and LD fields. It has already been acknowledged that usability and UX have origins outside of education/instruction (Bargas-Avila & Hornbæk, 2011; Jooste et al., 2014), whereas LD's origins are the opposite. If, on the one hand, results indicate that both UX and LD professionals are fairly aligned in their understanding of learnability and the attributes that compose it, the implication is that 1) UX professionals' understanding of learnability is aligned with learning theory, and 2) LD professionals can utilize some of the many usability/learnability assessments to assist in initial product complexity analysis. This would be a positive finding that could lead to increased collaboration and the proliferation of new assessment tools/models to evaluate learnability in both UX and LD spaces.

Alternatively, if the study shows a disconnect between UX and LD's understanding of learnability and its attributes, the implications are worrisome. First, it would mean that the UX profession's understanding of learnability does not align with those whose expertise is in learning and education. The UX field would be forced to re-evaluate what it knows and how it understands learnability, which could substantially change how usability is measured in their context. Second, this finding would leave those organizations attempting to establish a learning team without a viable method in which to do so. In either case, this study will provide the opportunity for communication and collaboration across both professional fields, whether it be sharing assessment tools that have proven valid (Lewis, 2014), or if it is to share knowledge around learning theory and working to better align perception and understanding.

Theoretical Framework

The primary theoretical framework that influenced this study was domain ontology. Domain ontology is a way in which disciplines formalize the terms that they use (McDaniel & Storey, 2019). While it has not been specifically applied to learnability, studies that apply ontology to similar topics, such as usability, show that a connection may be drawn from this study and similar works.

Domain Ontology and Human-Computer Interaction

Domain ontology has been used by many disciplines and for many subjects, including machine learning, the Internet of Things (IoT), robotics, natural language processing, biomedical informatics, database management, and climate science (McDaniel & Storey, 2019). Originally developed for the sake of interoperability between computer systems, the use of ontologies in the information technology landscape has been present in a variety of fields dealing with computers, including Human-Computer Interaction (HCI).

HCI began in the mid-1980s and can be described as the study of how individuals work with computers, with a focus on effectiveness and efficiency (Kotzé & Johnson, 2004). HCI as a field was influenced by areas including ergonomics, computer sciences, and psychology at first, and later the social sciences as well (Dix, 2017). HCI has been studied through various lenses, including science, design science, and engineering (Elliott et al., 2002).

Domain ontology has also been connected to HCI through a variety of studies. Costa et al. (2021) conducted a systematic review of HCI-related ontology studies. In their research, 35 ontologies were identified, three of which involved usability:

- HCI frame-based ontology (Bakaev & Avdeenko, 2012)
- Usability guideline ontology (Robal et al., 2017)
- PersonasOnto (Negru & Buraga, 2013)

In addition, Perminov and Bakaev (2019) assessed web user interface quality via domain ontologies. While none of these studies have gone deeper than studying usability itself, the interconnectedness of learnability and usability lends credence to the idea that learnability could be classified through domain ontologies as well.

Domain Ontology Creation

The development of ontologies has taken place over decades, and it continues to grow as the need for new common understandings are identified (McDaniel & Storey, 2019). There are a variety of methods in which ontologies are created, which can be problematic from a consistency and quality perspective (McDaniel & Storey, 2019). Despite the challenges that arise, there are resources and methodologies that may be adopted in the development of new ontologies.

One resource for tools and models around domain ontology creation is the Laboratory for Applied Ontology (OntoLab; Gangemi, 2003). Rooted in computer science, linguistics, and philosophy, OntoLab conducts research on ontological foundations and their connection to conceptual modeling, knowledge engineering, and more. They also provide models and methods for the development of ontologies, including the Descriptive Ontology for Linguistic and Cognitive Engineering (DOLCE), The OntoClean methodology and metaproperties, and The Ontological Integration of Naïve Sources (ONIONS) methodology (Gangemi, 2003).

Sattar et al. (2020) conducted a systematic review that compared methodologies of ontology development. In their work, they noted that few articles described their methodologies in enough detail for replication. Despite the lack of detail, Sattar et al. did note that most methodologies identified in their review did follow a similar overarching process:

1. Domain analysis (establishing what currently exists)
2. Conceptualization (development of the new ontology)
3. Implementation (enacting the new ontology)
4. Evaluation (assessing the fit and validity of the ontology)
5. Instantiation (formalizing the new ontology)

The current study, if framed in the overarching process of domain ontology creation, fell in the early stages of phase one, if not prior. The current research questions were intended to help identify how close (or far) the two professional groups were in their understanding of terms and importance. By learning this, it may help determine the appropriateness of a common ontology between the professional groups. It is valuable to use domain ontology as a framework in this study as it may serve as a foundation for future ontological work.

Limitations and Assumptions

Limitations and assumptions must be accounted for during a new research study to define the boundaries for the study and the assumptions that the researcher brings to the study. The following section details the conceptual and methodological limitations of the study, as well as the researcher's assumptions as they related to the study.

Limitations

This study was limited by the following boundaries:

1. Learnability was the only factor explicitly studied; all others (e.g., memorability, understandability, simplicity, etc.) were out of scope.
2. The study was limited to participants with access to the survey via the internet and who were made aware of the survey via the communication channels in which the call for participation was shared.
3. The study was limited to the timespan in which the survey was available.
4. Participants were asked to voluntarily participate in the study, which may limit the number of responses and the potential for selection bias.

Assumptions

The assumptions for this study were as follows:

1. There is some inherent level of common understanding of "learnability" between the two participant professional groups.

2. A participant, through personal knowledge or by reading the operational definitions that accompanied the survey, would be able to make an estimate of importance for each learnability attribute.
3. Individuals that participated in the study were of the appropriate professional groups identified in the call for participation.
4. Adequate time was allotted for participant response, and participants were genuine in their survey responses.

Procedures

To answer the study's research question, a survey was constructed with open-ended (qualitative), multiple-choice categorical (quantitative), and Likert-type questions related to demographics, perceptions of usability and learnability, and the level of importance of certain learnability attributes as identified in the literature. The open-ended questions were collected for future research and only the quantitative data were analyzed as a part of the study. The survey underwent an initial pilot study via think-aloud protocol that took place over Zoom with subject matter experts reviewing the survey and providing recommendations. Based on the pilot study, changes were made to the instrument to address any issues. The survey was then made active, and requests for participation were disseminated via email, listserv, and post to various UX and LD communities across various social and community sites (Facebook, LinkedIn, Salesforce Trailblazer Community, etc.). The call for participation also implored potential participants to share the post in hopes of garnering additional responses via snowball sampling. Data were then analyzed with IBM SPSS Statistics (Version 28; IBM Corp, 2021).

Population, Sample, and Setting

The target population for this study was individuals that worked in either learning design or user experience design fields. Based on population data from the National Center for O*NET Development (O*NET, 2022, 2023) and the U.S. Bureau of Labor Statistics (BLS, 2023), the hope was to obtain proportional respondents from each professional group.

Instruments and Data Collection

The survey was constructed and conducted using the Qualtrics survey platform. The instrument had a total of 37 questions, including free text and multiple-choice options. The link was shareable, and the survey was configured so that responses were anonymous. The only possibility of identifying data was with the final question, which was clearly listed as optional and asked respondents to provide their contact information if they were interested in being included in future research. Once the survey was closed, data were exported into an Excel file for interpretation.

Data were analyzed through a variety of methods to answer the research questions. First, a Kaiser-Meyer-Olkin and Exploratory Factor Analysis (EFA) were run to view potential relationships and patterns between attributes (Kaiser, 1974). As Research Question 1 sought to learn about both professional groups' perceptions of learnability and its attributes, descriptive statistics (means and standard deviation) were used to describe standout item-level responses, as described by Cooksey (2020). Krippendorff's Alpha (KAlpha) was selected to address Research Questions 1.1 and 1.2 because the KAlpha was primarily used to establish reliability and consistency (i.e., degree of consensus) when there are multiple raters, as outlined in Krippendorff (1970).

Research Question 2 was answered through attribute-level analysis between the two professional groups. An independent samples *t*-test was performed on the entire scale composite to compare the differences in response between groups, as supported by Field (2009). In addition, a chi-square analysis was performed on each individual attribute to serve as a sensitivity test to item-level differences between group responses, which aligns with the guidance of Patten and Newhart (2018).

Definitions of Terms

Awareness (learnability attribute): Making the user aware of information and/or functionality (Grossman et al., 2009).

Consistency (learnability attribute): Uniformity in the user interface and how the system functions operationally (Chimbo et al., 2011; Dix et al., 2004; Folmer et al., 2003; Payne & Green, 1986; Seffah et al., 2006; Senapathi, 2005; Tan et al., 2013).

Continuity of task sequences (learnability attribute): The ability to complete a task in a continuous process rather than having to navigate through multiple menus and steps (Linja-aho, 2005).

Design conventions (learnability attribute): How similarly or differently a system is designed in comparison to other common systems (Linja-aho, 2005).

Engagability (learnability attribute): "The extent to which a software application can fully engage the user by providing a complete and satisfying user experience" (Chimbo et al., 2011, p.401).

Error prevention (learnability attribute): Where design of the interface prevents users from making common mistakes (Linja-aho, 2005).

Familiarity (learnability attribute): How easily an application can be mapped to prior experiences into the new system (Chimbo et al., 2011; Dix et al., 2004; Seffah et al., 2006; Senapathi, 2005).

Feedback (learnability attribute): How a system responds to user actions (Ammar et al., 2016; Ammar, 2019; Folmer et al., 2003; Rafique et al., 2012; Senapathi, 2005).

Generalizability (learnability attribute): The user's ability to extend their knowledge of interaction in and across other applications to new but similar situations (Chimbo et al., 2011; Dix et al., 2004).

Information presentation (learnability attribute): Detailed descriptions of components via dialog box (Linja-aho, 2005).

Interface understandability (learnability attribute): How easy the interface is to understand without prompting (Rafique et al., 2012; Hornbæk, 2006).

Learnability attribute: a specific description or feature that contributes to the overall learnability of a product.

Learning design (LD) professionals (professional group): Professionals that work or conduct research in educational roles. Job titles may include Instructional Designer, Learning Experience Designer, Technical Trainer, etc.

Locating (learnability attribute): The user's ability to find functionality within the system (Grossman et al., 2009).

Mental effort (learnability attribute): The mental effort or amount of information that must be kept in mind to complete a task (Hornbæk, 2006; Seffah et al., 2006; Tan et al., 2013).

Minimal action (learnability attribute): The software's ability to help the user complete their tasks in the least number of steps (Seffah et al., 2006; Tan et al., 2013).

Navigability (learnability attribute): How easy it is to navigate through the system (Tan et al., 2013).

Operational momentum (learnability attribute): "The degree to which the software helps the user to guide on to the next stage, iteratively if necessary" (Rafique et al., 2012, p. 2445).

Predictability (learnability attribute): How well a user can predict their next action (Ammar et al., 2016; Ammar, 2019; Dix et al., 2004; Folmer et al., 2003; Rafique et al., 2012; Senapathi, 2005).

Professional group: the category in which respondents identify themselves as belonging to, either learning design or user experience design professions.

Prompting (learnability attribute): The ability to orient/provide in-app guidance (Ammar et al., 2016 Ammar, 2019).

Simplicity (learnability attribute): "Whether extraneous elements are eliminated from the user interface without significant information loss" (Seffah et al., 2006, p. 171).

Synthesisability (learnability attribute): When the system provides an observable notification about internal changes of state (Chimbo et al., 2011; Dix et al., 2004).

System guidance appropriateness (learnability attribute): The guidance provided to a user to assist when errors occur or to improve the user's experience in completion of tasks (Rafique et al., 2012; Seffah et al., 2006; Tan et al., 2013).

Task complexity (learnability attribute): The level of challenge in completing a task, which may include complexity in structure, resources, or interaction (Liu & Li, 2012).

Task flow (learnability attribute): Knowing what is needed to accomplish a certain task (Grossman et al., 2009).

Task match (learnability attribute): "The degree to which an application is able to provide exactly the information and functionality that the user needs in order to accomplish his tasks with the product" (Rafique et al., 2012, p. 2445).

Transitions (learnability attribute): When a user can move into more efficient behavior (Grossman et al., 2009).

Understanding (learnability attribute): Knowing how to use the functionality of the system (Grossman et al., 2009; Hornbæk, 2006).

User experience (UX) design professional (professional group): Professionals that work or conduct research in User Experience design roles. Job titles may include User Experience Designer, Interaction Designer, Experience Strategy Designer, etc.

Visibility of operations (learnability attribute): The ability to see possible operations in the system and what is required to perform them (Linja-aho, 2005).

Summary and Overview of Chapters

Chapter 1 introduced the concept of usability in software development, and how important it is for the success of a product. There are many factors that comprise the concept of usability, one of particular interest to this study being learnability. Learnability is one of the few factors that can be addressed not only in the design of the product, but afterward, as well, through proper training/education. Because of this duality, it was appropriate to look at the professional groups that would be addressing learnability, either through the design and evaluation of the product itself (user experience designers) or by those who would assist and support users/learners in being successful with their use of the product (learning design professionals).

A current gap in the literature is how these two groups understand the concept of learnability and which attributes of learnability are the most important contributors to the learning of a product. This study sought to understand the perceptions of learnability, both in totality of the sample, as well as in individual professional groups. The researcher hoped to find answers to the research questions by conducting a virtual survey consisting of open-ended, multiple-choice, and Likert-type questions asked about personal definitions of usability and learnability, the level of importance of learnability attributes, and how learnability is gauged. The current study interpreted the results of the multiple-choice and Likert-type responses, while the open-ended questions were collected for future research.

Chapter 2 will review the literature on usability and learnability, including definitions of each term, facets and attributes of each, and how both items are assessed. From the literature review, a cluster of common definitions were identified. Eight factors of usability were identified, and 37 primary attributes of learnability were identified. Assessment methods and metrics were described, first from the usability standpoint, then followed by the assessment methods and metrics also used for learnability. Chapter 3 will describe the methodology of the study, including population, research variables, instrument design, procedures, methods of data collection, statistical analysis, and summary. Chapter 4 will describe the results of the study. Chapter 5 will summarize the results of the research, draw conclusions on the research findings, and describe implications and future research on the topic.

CHAPTER 2
REVIEW OF LITERAURE

Using the current literature as the foundation of this study was important because it established what scholars have already discussed around the usability concept, the learnability factor, and the attributes that comprised learnability. Because this study was a precursor to the establishment of a shared domain ontology, and with the apparent lack of interdisciplinary literature on the topic of definition, the focus of the literature review turned to the establishment of current understanding of the concepts of usability and learnability within the context of User Experience (UX) and Learning Design (LD).

First, it was important to identify the current definitions of both usability and learnability in the literature to establish the varied understanding of the two concepts. As different definitions were identified, individual attributes emerged which often served to further describe the overarching concepts of usability and learnability. It was important to include these attributes in the literature review because they served as the base items that were rated in this study. Finally, assessment methods for usability and learnability were explored to establish qualitative and quantitative ways in which the concepts had been studied. Identifying these assessment methods within the literature helped the researcher see how the concepts were both theoretically and practically studied, which reinforced the notion that current studies did not address the current research questions.

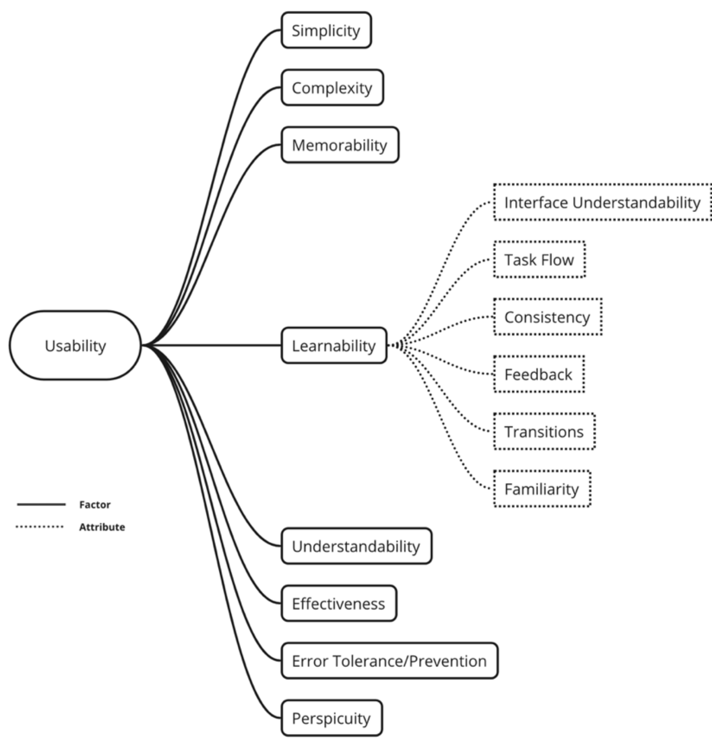
To this end, the researcher explored the literature on usability and learnability, including the definitions used, attributes thereof, and tools available for measurement and assessment. This chapter reviewed the literature as it related to the research questions at hand.

Usability

Usability has a history rooted in ergonomics and ease-of-use and has been studied across various disciplines (Grossman et al., 2009; Hornbæk, 2006). Usability is a broad concept that can be further broken apart through analysis of various factors, and the factors are further divided into attributes. These stratifications can be visually depicted as a hierarchical relationship, a sample of which is displayed in Figure 1.

Figure 1

Hierarchical Relationship Sample of Usability Factors and Attributes



Note. This figure is for illustrative purposes and does not include the full breadth of usability factors or learnability attributes, which are discussed in more detail in this chapter.

Many studies have shown the benefits of good usability, including user satisfaction and increased productivity (Capilla et al., 2020; Donahue, 2001; Dumas & Redish, 1999; Rajanen, 2003). There are numerous methods of usability assessment as well as tools that have been employed by User Experience (UX) professionals, such as the System Usability Scale (SUS; Brooke, 1996) or the Computer Usability Satisfaction Questionnaire (CUSQ; Lewis, 1995). The following section provides an overview of the various definitions in use and describes the most common assessment methods and tools used in usability assessment.

Definitions of Usability

Defining usability was a noted challenge throughout the literature, with many authors observing a lack of consensus (Abran et al., 2003b; Capilla et al., 2020; Gediga et al., 1999; Grossman et al., 2009; Laakkonen, 2007; Lewis, 2014; Lindgaard & Kirakowski, 2013; Luther et al., 2020). Beyond that, many of the definitions were not easily quantifiable nor directly measurable (Haaksma et al., 2018; Hornbæk, 2006; Lewis, 2014). In addition, Hornbæk (2006) noted that definitions tend to change based on what and how usability was being measured. Despite the variation, these definitions can be grouped into three primary clusters: the International Organization for Standardization (ISO), Nielsen’s (1993) definition, and Other. Table 2 depicts the various usability definitions and the authors that cited them.

Table 2

Usability Definitions and the Authors That Used or Discussed Them

Usability Definition	Authors Cited
International Organization for Standardization (ISO)	Abran et al., 2003a; Almansour, 2017; Ammar, 2019; Choi et al., 2008; Czerniak et al., 2017; Goulão & Abreu, 2002; Hornbæk, 2006; Jokela et al., 2003; Lew et al., 2010a; Lew et al., 2010b; Linja-aho, 2005; Losavio et al., 2003; Maguire, 2001; Paz et al., 2015; Paz & Pow-Sang, 2016; Rafique et al., 2012; Rawashdeh & Matalkah, 2006; Senapathi, 2005; Sharma et al., 2008; Sousa & Martins, 2021; Wahyuningrum, 2017

Usability Definition	Authors Cited
Nielsen	Abran et al., 2003a; Ammar, 2019; Baytiyeh, 2011; de Kock et al., 2008; Grossman et al., 2009; Linja-aho, 2005; Quiñones et al., 2018
Other	Agarwal et al., 2017; Bertoa & Vallecillo, 2004; Dumas & Redish, 1999; Feng & Wei, 2019; Hassenzahl & Tractinsky, 2006;

International Organization for Standardization (ISO) Standards

The International Organization for Standardization (ISO) is an organization whose purpose is to gain consensus on standards, including definitions (ISO, n.d.-a). When a need has been identified in the market for standardization, the ISO brings together experts to gain consensus on the topic. ISO definitions were frequently cited in the literature; however, even then there was no set ISO standard that was used uniformly. Table 3 depicts the various ISO standards, the authors who cited them, and their focus.

Table 3

ISO Usage and Focus

ISO Standard	Citation(s)	Focus
~~9126~~	Abran et al., 2003a; Ammar, 2019; Choi et al., 2008; Goulão & Abreu, 2002; Losavio et al., 2003; Paz et al., 2015; Paz & Pow-Sang, 2016; Rawashdeh & Matalkah, 2006; Sharma et al., 2008; Wahyuningrum, 2017	Product Quality
9241	Almansour, 2017; Czerniak et al., 2017; Hornbæk, 2006; Jokela et al., 2003; Lew et al., 2010a; Linja-aho, 2005; Paz et al., 2015; Paz & Pow-Sang, 2016; Senapathi, 2005; Sousa & Martins, 2021	Human-system interaction
~~13407~~	Abran et al., 2003a; Maguire, 2001	Human-centered design processes for interactive systems
14598	Abran et al., 2003a	Software engineering and information technology

ISO Standard	Citation(s)	Focus
25010	Lew et al., 2010a; Lew et al., 2010b; Rafique et al., 2012	Software quality
25012	Lew et al., 2010a; Lew et al., 2010b	Data quality

Note. ISO standards with a strikethrough indicate standards that have been withdrawn.

ISO standard 9126 was one of the most cited standards in literature. It was originally written in 1991 and revised in 2001 (ISO, n.d.-b). It was later withdrawn and changed to ISO 25010. This change shifted the standard from looking at usability specifically, but in doing so extended the definition to include operability (ISO, n.d.-b; Lew et al., 2010a). Abran et al. (2003a) discussed the merits of 9126, highlighting the fact that it was product-oriented and could measure both internal and external attributes.

ISO standard 9241 differed from 9126 in that it was process-oriented rather than product-oriented (Abran et al., 2003a). This code went beyond 9126 in that it discussed user experience (Agbozo, 2023). While 9241 did not specifically discuss learnability beyond non-touch gestures (ISO, nd.-c), it included the term *suitability for learning*, which connected it to the factor (Abran et al., 2003a; Bevan, 1995; Gediga et al., 1999). ISO standard 13407 was a predecessor of ISO standard 9241 and focused on human-centered design (ISO, n.d.-d).

ISO Standard 14598 was also product-oriented, with standards around information technology and the documentation of evaluation models (Abran et al., 2003a; ISO, n.d.-e). According to the ISO site, it was meant to be used in the context of 9126, though the 9126 standard has since been withdrawn.

ISO standard 25010 is a quality standard for software products and falls under the *operability* category (ISO, n.d.-f; Lew et al., 2010a). In addition, Lew et al. (2010a) noted that this standard includes additional breakouts for quality in use and usability. An interesting point to note is that the shift from 9126 to 25010 is an acknowledgement of the broadening definition of usability; ISO changed the terminology from *usability* to *operability*, which also included information quality (Lew et al., 2010a).

Finally, ISO standard 25012 is a standard that focuses on data quality. Lew et al. (2010a; 2010b) noted that while it does not directly speak to usability, it could still fit into the discussion on usability definitions from the perspective of information quality.

While these definitions all have pieces and parts of usability, it is understandable that researchers may have chosen varied definitions based on ISO standards. 25010 is the current standard that ISO and its expert panels have approved, but even now the standard is set to be replaced by ISO 25002 and 25010 which are under development (ISO, n.d.-f). Another item to note when reviewing the standards is that there are different focuses within the standards, including product quality, human-system interaction, software quality, and data quality. This may be an indicator that the concept of usability is one that touches many aspects of a product, and therefore must be considered through a variety of lenses.

Nielsen

Another popular definition of usability came from Nielsen (1993), whose work defined usability as the combination of five factors: learnability, effectiveness, tolerance for errors, satisfaction, and memorization (Abran et al., 2003a). Nielsen's definitions have shifted slightly depending on the citation. For example, Nielsen (1994b) defines learnability, efficiency, memorability, error prevention, and satisfaction, which is slightly different than his earlier work (Baytiyeh, 2011). Nielsen has also been cited by authors Abran et al. (2003a) and Grossman et al. (2009). Interestingly, Quiñones et al. (2018) compared the ISO standards to Nielsen's definition and believed that Nielsen's definitions are "more complete than those that were proposed by the ISO standard" (p.13). Despite that idea that Nielsen's definitions enhanced the ISO standards, there are still problems. Nielsen's primary definition talked about usability as a concept, but the definition relied on the factors that comprise it (learnability, memorability, etc.) rather than standing on its own.

Other Definitions

While most researchers used some version of ISO standards or Nielsen's definition of usability, still others ventured their own definitions. For example, Dumas et al. (1999) explained that "usability means that the people who use the product can do so quickly and easily to accomplish their own tasks" (p. 4). Usability has also been adapted for specific use cases, such as component-based software systems (CBSS). Agarwal (2017) used Bertoa & Vallecillo's (2004) definition of usability, describing it as "the capability of the component to be understood, learned, used, and attractive to the user, when used under specified conditions" (p. 245).

Factors of Usability

Usability has been comprised of various factors, such as those identified by Nielsen (1994b), and have been used to evaluate different aspects of a product or its interface. For example, Nielsen (1994b) originally identified the five factors that contributed to usability as: learnability, efficiency, memorability, error prevention, and satisfaction. Nielsen and Schneiderman (in a non-English translated publication) modified the list of facets to be learnability, effectiveness, tolerance for errors, satisfaction, and memorization (Abran et al., 2003b). Additional factors have been proposed over time, including understandability (Bertoa & Vallecillo, 2004), complexity (Bertoa & Vallecillo, 2004; Rawashdeh & Matalkah, 2006;

Sharma et al., 2008), perspicuity (Saputra et al., 2022) and simplicity (Larsson, 2004), just to name a few. A sample of these factors and the authors that used them are listed in Table 4.

Table 4

Usability Factors and the Authors That Used Them

Usability Factor	Authors Cited
Simplicity	Larsson, 2004
Complexity	Bertoa & Vallecillo, 2004; Rawashdeh & Matalkah, 2006; Sharma et al., 2008
Memorability	Almansour, 2017; Ammar, 2019; Mari & Elia, 2003; Nielsen 1993; Preece et al., 2002
Understandability	Alvaro et al., 2005; Andreou & Tziakouris, 2007; Ammar et al., 2016; Ammar, 2019; Bertoa & Vallecillo, 2004; Carvalho et al., 2009; Choi et al., 2008; Preiss et al., 2001; Larsson, 2004; Losavio et al., 2003; Mari & Elia, 2003; Rawashdeh & Matalkah, 2006; Sharma et al., 2008; Thapar et al., 2014
Effectiveness	Nielsen, 1993
Error Tolerance/Prevention	Abran et al., 2003a; Baytiyeh, 2011
Perspicuity	Saputra et al., 2022
Learnability	Agbozo, 2023; Almansour, 2017; Ammar et al., 2016; Ammar, 2019; Andreou & Tziakouris, 2007; Bertoa & Vallecillo, 2004; Chimbo et al., 2011; Chistyakov et al., 2016; Choi et al., 2008; Coyle & Peterson, 2016; Czerniak et al., 2017; Elliott et al., 2002; Faizan, 2018; Goulão & Abreu, 2002; Gould & Lewis, 1985; Grossman et al., 2009; Hoffman et al., 2010; Law et al., 2007; Linja-aho, 2005; Losavio et al., 2003; Löwgren, 1995; Mari & Elia, 2003; Paymans et al., 2004; Preece et al., 2015; Rafique et al., 2012; Rawashdeh & Matalkah, 2006; Santos & Badre, 1995; Senapathi, 2005; Sharma et al., 2008; Stickel et al., 2007; Thapar et al., 2014

It may be argued that many of these facets could contribute to the ease or difficulty in which a product can be learned. While these factors are valuable to explore in future studies, the scope of this study is restricted to looking at learnability specifically as it is most explicitly connected to learning design.

Assessing Usability

Usability assessment has been conducted in a variety of methods and with an array of tools over the years. It has often been described interchangeably with User Experience (UX) measurement (Quiñones et al., 2018). Some authors have looked at different attitudes around usability measurement. Law et al. (2014) found that attitudes around usability measurement were overall positive, and that there were different complexities and considerations for measurement specifics. Law and Van Schaik (2010) noted that UX communities were divided on the necessity of measurement, as well as the level of granularity in which the assessment should be completed, indicating consensus has yet to be attained.

The variety of approaches to measuring usability has also been discussed in the literature. Følstad (2010) discussed two main approaches to UX measures: complex models such as Nielsen's work, and ad-hoc measures that focused on specific needs and relevance. They argued that the ad-hoc measures may serve to bridge the gap of UX and software development in practical application, whereas the complex models are more appropriate for systems with multiple components and greater complexity (Følstad, 2010).

Challenges and Considerations

The literature has indicated a variety of challenges that arise when assessing usability and including conceptual issues, contextual issues, timing issues, and instrument/measurement issues. Conceptually, Lindgaard and Kirakowski (2013) noted:

> The ambiguity of the, still not well defined, constructs is evident in the papers presented here. Experts disagree on many of the important issues, longevity is rarely an objective, and it is hard for researchers and practitioners to select the scale(s) best suited to their particular purposes. (p. 276)

Chistyakov et al. (2016) and Law et al. (2014) noted that definitions and measurement methods were not consistent in usability assessment. Many authors also noted the subjectivity of many of the measures (Ammar, 2019; Bañuelos-Lozoya et al., 2021; Chistyakov et al., 2016; Hertzum & Jacobsen, 2001; Hoffman et al., 2010; Hornbæk, 2006; Lindgaard & Kirakowski, 2013; Quiñones et al., 2018). Without a solid common understanding of constructs and definitions, it may be difficult to ensure a united path forward.

The topic of context has been discussed, particularly through the lens of novice versus expert evaluation. Bertini et al. (2006) noted that context may not be appropriately captured when relying on expert evaluation alone. Fu et al. (2002) pointed out that novice users are more likely to have identified actual usability issues whereas experts will be more likely to have identified performance issues. In addition, Jacobsen (1999) pointed out that individual traits such as "motivation, expertise, cognitive abilities, skill acquisition, skill transferal, personality, and cognitive style" could have affected (and explained the differences in) the results of usability assessment (p. 69).

In terms of timing, it has been noted that usability assessment may not align with a product's software development life cycle (SDLC), which can be problematic. Ammar (2019) stated that assessment is often conducted after the product is finished, which results in rework if issues are found. There was also uncertainty in the timing of conducting measurement. For example, Mahmud et al. (2020) conducted both the System Usability Scale (SUS) and NetQ@l assessments in a 60-second timeframe instead of a traditionally longer timeframe. They found no difference in the results of the SUS; however, there was a difference in results for the NetQ@l score. This reinforced how timing can affect assessment, but the implications may not be consistent.

A fourth challenge identified in the literature was around the instruments themselves. When discussing the use of scales in the Human Computer Interaction (HCI) community, Lindgaard and Kirakowski (2013) stated the following:

> The sheer number of available rating scales shows that many in the HCI community are seriously concerned about measurement and by sharing the fruits of their labor, we are confident that this aspect of the field will mature in its own good time. (p. 276)

This statement may also be interpreted as a veiled indicator that we are still at the early stages of operationalizing usability measurement. Quiñones et al. (2018) echoed that sentiment, stating that there was no formal process at that point that encompasses the formulation, validation, and refinement of current measures. Other authors, however, such as Lewis (2014) have stated that many of the standard scales have demonstrated validity over time and could be used reliably.

Methods

There are numerous methods used to assess usability throughout the literature, either as discussion points or used in research directly. Understanding major usability assessment methods was valuable because the method chosen may be a contributing factor to findings in the research. Fu et al. (2002) pointed out that each evaluation method may have brought different perspective to usability, and therefore may identify different usability problems in different ways, depending on the method chosen. De Kock (2008) similarly acknowledged that different tests were different in goal, data processing, and granularity of data gathered. Reviews have been conducted over the years to identify common usability inspection methods. Hollingsed and Novick (2007) reviewed usability inspection methods over the past 15 years and identified heuristic testing and cognitive walkthrough as the most prominent methods. Eight years later, Paz and Pow-Sang (2016) conducted a systematic mapping review of usability evaluation methods and found that the most common assessment methods at the time were heuristic evaluation, user testing, and survey or questionnaire. The following will discuss the most salient assessment methods, whereas Appendix B provides a more comprehensive list of assessment methods and the authors who discussed and/or used them in their study.

Heuristic-Based Evaluation. Heuristic-based evaluation is where an individual reviews a software program and compares it to a set list of usability principles (i.e., heuristics; Paz & Pow-Sang, 2016). Its primary benefit is that it can directly identify problems with the interface (Hollingsed & Novick, 2007). It is worth noting, however, that Bailey et al. (1992) reported that heuristic evaluation found many problems, only some of which were valuable (e.g., 10 non-issues for every 1 issue). Overall, heuristic evaluation has been used and/or discussed by multiple researchers, as depicted in Table 5.

Table 5

Heuristic Evaluation Used or Discussed in Usability Research

Heuristic Evaluation Use	Heuristic Evaluation Discussion
Bailey et al., 1992; Bertini et al., 2006; De Kock et al., 2008; Faizan, 2018; Fernández et al., 2013a; Hussain et al., 2018	Agbozo, 2023; Almansour, 2017; Ambarwati & Mustikasari, 2021; Dix et al., 2004; Folmer et al., 2003; Fu et al., 2002; Hollingsed & Novick, 2007; Jeffries et al., 1991; Jooste et al., 2014; Kim, 2015; Lin et al., 1997; Nielsen, 1994a; Nielsen, 1994b; Paz et al., 2015; Paz & Pow-Sang, 2016; Quiñones et al., 2018; Wilson, 2013

Cognitive Walkthrough. Cognitive walkthrough is a process where a user (or usability specialist) completes tasks as a novice user, identifying potential issues along the way (Agbozo, 2023). According to Dix et al. (2004), requirements to complete a cognitive walkthrough included a system prototype, task descriptions, written actions to be followed, and user experience. Variations on cognitive walkthroughs include advanced cognitive walkthrough (proposed by Bligård & Osvalder, 2013; used by Ambarwati & Mustikasari, 2021) and cognitive jogthrough, where usability specialists asked themselves questions throughout task completion (Paz & Pow-Sang, 2016). Challenges to cognitive walkthrough assessment included the inability to evaluate efficiency (Ambarwati & Mustikasari, 2021), and the fact there was often a need to pair the assessment with other tests to measure different aspects of usability (Bligård & Osvalder, 2013). An interesting note upon reviewing the literature, the proportion of authors that discussed cognitive walkthrough was substantially higher than the number of researchers that used it in their study alone. Table 6 displays the citations of authors who used or discussed cognitive walkthrough, jogthrough, or advanced cognitive walkthrough in their work.

Table 6

Cognitive Walkthrough and its Variations Used or Discussed in Usability Research

Cognitive Walkthrough Use	Cognitive Walkthrough Discussion
Ambarwati & Mustikasari, 2021; Jeffries et al., 1991	Agbozo, 2023; Dix et al., 2004; Hollingsed & Novick, 2007; Hussain et al., 2018; Jacobsen, 1999; Kim, 2015; Nielsen, 1994b; Paz et al., 2015; Paz & Pow-Sang, 2016; Preece et al., 2015; Santos & Badre, 1995; Wilson, 2013

User Testing. User testing is broadly defined as a test where a population sample of end users interact with the software by following a list of tasks (Paz & Pow-Sang, 2016). As users complete the tasks, they are observed by the researchers, who identify the usability issues that the users encounter. There are multiple methods that can be considered user testing, including think-aloud studies (Almansour, 2017; Paz & Pow-Sang, 2016), usability testing (Bailey et al., 1992; Czerniak et al., 2017), observations (Tan et al., 2013), and lab experiments (Czerniak et al., 2017; Lewis, 1995; Zec & Matthes, 2018). Identified advantages of user testing included the ability to test in the real world with real participants, identifying task-based problems, and finding issues directly related to performance and user acceptance issues (Almansour, 2017). Table 7 depicts a sample of user tests and the authors who discussed and/or used them.

Table 7

User Testing Assessment Methods and Citations

Method	Used By	Discussed By
Usability testing	Bailey et al., 1992; Chimbo et al., 2011; Coyle & Peterson, 2016; Czerniak et al., 2017; Jacobsen, 1999	Almansour, 2017; De Kock et al., 2008; Fu et al., 2002; Hollingsed & Novick, 2007; Jeffries et al., 1991; Lin et al., 1997; Paz & Pow-Sang, 2016
Think-aloud	Carroll et al., 1985; Law et al., 2007; Mack & Robinson, 1992	Almansour, 2017; Dix et al., 2004; Lin et al., 1997; Paz & Pow-Sang, 2016
Observation	Chimbo et al., 2011; Coyle & Peterson, 2016; Linja-aho, 2005; Santos & Badre, 1995; Senapathi, 2005; Tan et al., 2013	Dix et al., 2004; Mitta & Packebush, 1995
Lab experiments	Czerniak et al., 2017; Elliott et al., 2002; Lewis, 1994; Zec & Matthes, 2018	Ammar, 2019; Dix et al., 2004; Kim, 2015

Surveys/Questionnaires. Surveys/questionnaires were also very popular for usability testing. This type of assessment consists of a formal set of questions used to gather specific information (Van Velsen et al., 2008). Many surveys/questionnaires have been turned into popular assessment tools such as the Questionnaire for User Interface Satisfaction ([QUIS], Hornbæk, 2006; Lewis, 2014; Mahmud et al., 2020) and the Computer System Usability Questionnaire ([CSUQ], Law et al., 2007; Lewis, 1995; Mahmud et al., 2020). The next section, Tools, will provide greater detail on the survey instruments employed in usability assessment. Table 8 depicts the authors who discussed and/or used surveys/questionnaires in their work.

Table 8

Survey/Questionnaire Used or Discussed in Usability Research

Survey/Questionnaire Use	Survey/Questionnaire Discussion
Agarwal et al., 2017; Almansour, 2017; Ammar, 2019; Elliott et al., 2002; Gediga et al., 1999; Jooste et al., 2014; Linja-aho, 2005; Naumann & Wechsung, 2008; Paymans et al., 2004; Rafique et al., 2012; Santoso & Schrepp, 2018; Senapathi, 2005; Sharma et al., 2008; Tan et al., 2013	Dix et al., 2004; Kim, 2015; Lewis, 2014; Paz & Pow-Sang, 2016

Tools

There are numerous tools that have been used, validated, and recommended for standardization over the years. As mentioned earlier, Lewis (2014) noted that many of the standard scales have proven their validity and therefore it was recommended that future studies use what already exists. An observation from Hollingsed and Novick (2007) was that additional usability tests have the tendency to get integrated into existing tests or lose favor over time. The majority of the available usability assessment tools are manual, though there are a few automatic ones being tested as well (Ivory & Chevalier, 2002; Soui et al., 2022). Describing each tool in detail is not in scope of answering the current research questions, however table 9 lists the assessment tools identified in the literature and their related citations.

Table 9

Manual Usability Assessment Tools and the Authors That Used Them

Usability Assessment Tools	Author(s) Cited
After-Scenario Questionnaire (ASQ)	Lewis, 1995
Computer System Usability Questionnaire (CSUQ)	Law et al., 2007; Lewis, 1995; Mahmud et al., 2020
Computer Usability Satisfaction Questionnaire (CUSQ)	Chistyakov et al., 2016

Usability Assessment Tools	Author(s) Cited
Domain Ontology	Perminov & Bakaev, 2019
Image-Based UI Analysis with Feature-based Neural Networks	Bakaev et al., 2022
IsoMetrics Questionnaire	Gediga et al., 1999
Metric-based assessment of web user interface (WUI) quality attributes	Bakaev et al., 2018
Metric-based Usability Evaluation (INUIT)	Speicher et al., 2013
NASA-TLX (Task Load Index)	Hart & Staveland, 1988
NetQu@l	Mahmud et al., 2020
Post-Study System Usability Questionnaire (PSSUQ)	Lewis, 1995; Lewis, 2014;
Quality in Use Integrated Measurement (QUIM)	Seffah et al., 2006;
Questionnaire for user interface satisfaction (QUIS)	Mahmud et al., 2020; Hornbæk, 2006; Lewis, 2014
Samsung s/w Component Quality evaluation Model (SCQM)	Choi et al., 2008
Scenario-based architecture level usability analysis (SLUTA)	Capilla et al., 2020; Folmer et al., 2003
Self-evaluation manikin (SAM)	Bañuelos-Lozoya et al., 2021
Software usability measurement inventory (SUMI)	Chistyakov et al., 2016; Følstad, 2010; Jooste et al., 2014; Kirakowski et al., 1993; Lewis, 2014; Santoso & Schrepp, 2018
Structured Heuristic Evaluation Method (sHEM)	Kurosu et al., 1997
System usability scale (SUS)	Almansour, 2017; Ambarwati & Mustikasari, 2021; Bañuelos-Lozoya et al., 2021; Brooke, 1996; Chistyakov et al., 2016; Lewis, 2014; Mahmud et al., 2020; Saputra et al., 2022; Zec & Matthes, 2018
UI evaluation with USE model	Fatta & Mukti, 2018
Usability Model for CBSS (UMCSS)	Agarwal et al., 2017
Usability Metric for User Experience (UMUX)	Mahmud et al., 2020
User experience questionnaire (UEQ)	Ambarwati & Mustikasari, 2021; Mahmud et al., 2020, Saputra et al., 2022; Santoso & Schrepp, 2018

Learnability

The previous section outlined the concept of usability in detail because it was also the starting point to understand learnability. Learnability serves as a facet of usability, a piece of the whole. Parallels were easily seen between usability and learnability, and the format of the following section is structured to call out the same major points discussed for usability (definitions, considerations, assessment) through the narrower lens of learnability. For example, three of the ISO standards used to define usability also had learnability implications. As another example, the list of 13 methods for assessing learnability originated from the list of 26 usability assessment methods.

Definitions of Learnability

Definitions of learnability have varied across the literature in the same way that usability has, and there were parallels in the definitions cited by many of the authors. As with usability, authors have noted that definitions of learnability were often unclear and undefined (Abran et al., 2003a; Ammar et al., 2016; Bertoa & Vallecillo, 2004; Laakkonen, 2007; Michelsen et al., 1980). Some definitions could have benefited from greater specificity. For example, Nielsen's (1993) definition of *easy to learn* may not have been particularly illuminating, however, many other definitions added dimension to the term.

It is important to note that standards such as the ISO looked at learnability as a part of the quality of a product. Because of this, the definitions may not have been inclusive of the learning process nor the contexts in which a user may have been learning (Lew et al., 2010a). Law et al. (2007) also noted that learnability of a system (i.e., how easy it is to learn) is different than how suitable a system is for learning (i.e., the systems underlying the instructional design). This was only mentioned as a footnote in their paper, but it is certainly worth bringing to the forefront during this conversation. The following section will describe the learnability implications for the ISO standards as well as other definitions that were specific to learnability.

International Organization of Standardization (ISO) Standards

The three primary ISO standards where learnability came into play were standards 9126, 9241, and 25010. Learnability was not discussed in the literature as a part of standards 14598, 13407, or 25012 (i.e., the three additional standards that applied to usability).

ISO standard 9126 was frequently discussed in respect to learnability because it included implications to learnability such as comprehension, instructional readiness, and message readiness (Abran et al., 2003a, Ammar et al., 2016; Seffah et al., 2006; Wahyuningrum, 2017). Standard 9126 was withdrawn in 2012 (ISO, n.d.-b). Its principles were moved to standard 25010, which was defined as "the degree to which the software product enables users to learn its application" (Lew et al., 2010a, p. 221). Rafique et al. (2012) used ISO standard 25010 as the base definition for their study.

Standard 9241 was also referenced in relation to learnability because of its references to time of learning (Abran et al., 2003a) as well as suitability for learning (Lew et al., 2010a). Table 10 describes the ISO standards, citations, and learnability implications seen in the literature. As with usability, ISO definitions of learnability spanned across various standard focuses, which lends credence to the notion that it is important to learn how the different professional groups interpret and incorporate learnability into their areas of focus.

Table 10

ISO Usage and Learnability Implications

ISO Standard	Citation(s)	Learnability Implication
~~9126~~	Abran et al., 2003a, Ammar et al., 2016; Seffah et al., 2006; Wahyuningrum, 2017	Related to comprehension, instructions readiness, and message readiness
9241	Abran et al., 2003a, Lew et al., 2010a	Time and suitability of learning
25010	Lew et al., 2010a; Rafique et al., 2012	How the product enables users to learn

Note. ISO standards with a strikethrough indicate standards that have been withdrawn.

Other Definitions

There seemed to be a greater variety in learnability definitions, as the authors tended to individualize their context and description. In the various individual definitions, there were still overarching concepts on learnability, including: time, capability, and effort. In terms of time, Dix et al. (2004) and Nielsen (1993) both used a simple definition of the time it takes to learn. Another time-based definition came from Folmer et al. (2003), who defined it as "how quickly and easily users can begin to do productive work with a system that is new to them, combined with the ease of remembering the way a system must be operated" (p. 12). Dix et al. (2004) mixed a little bit of timing along with the concepts of the shift from novice to expert, stating that "Learnability concerns the features of the interactive system that allow novice users to understand how to use it initially and then how to attain a maximal level of performance" (p. 261).

Definitions related to capability may have applied to either the system's capability or the capability of the user. Agarwal et al. (2017) cited Bertoa and Vallecillo (2004) in their definition that described the capability of the component to enable the system developer to learn the application. Ammar (2019) described learnability as how well the system allowed its users to learn the application.

Definitions that focused on effort correlated effort and ease to learnability. For example, Nielsen stated that a product should be easy to learn (1993). Chistyakov et al. (2016) described learnability as “the effort needed to become proficient with a system” (p. 504).

Overall, the definitions point to learnability being related to the time, effort, and skills involved in learning a product. However, these definitions do not tend to go into much detail, nor did they talk about how to achieve learning. Also, many definitions used the word *learn* as a part of their definition, which did not clarify the concept.

Considerations for Learnability

According to Wahyuningrum (2017), learnability was one of the most cited factors of usability in their systematic mapping study. This may be one of the reasons there was such rich discussion about learnability and the considerations that come with it. Authors described various factors in complexity, context, and initial versus extended learnability as they explored learnability descriptions.

Complexity

The complexity of a system certainly affects how learnable it is. Many authors noted that the easier it was to learn a system, the better (Gould & Lewis, 1985; Lew et al., 2010a; Lew et al., 2010b; Linja-aho, 2005; Santoso & Schrepp, 2018). Gould and Lewis (1985) stated that something is easy to learn if no training is required. This notion was still prevalent in the idea that systems and web applications should be able to be learned without needing user guides (Lew et al., 2010a). Multiple authors also noted that just because something may be easy to learn, that did not speak to how effective or efficient it was at accomplishing a task (Lew et al., 2010a; Lew et al., 2010b; Linja-aho, 2005; Santoso & Schrepp, 2018).

Additionally, there were systems where complexity is required to serve its function properly (Almansour, 2017, Hoffman et al., 2010; Lew et al., 2010a; Licklider, 1976; Santoso & Schrepp, 2018). Liu and Li (2012) highlighted the following dimensions of task complexity that may have affected the learnability of a system: size, variety, ambiguity, relationship, variability, unreliability, novelty, incongruity, action complexity, and temporal demand. A software required to complete niche tasks will have a higher learning curve than one that is used to complete simple tasks, for example comparing how easy it is to use a social media app (like Facebook) versus statistical computational software, such as SPSS. Because of this, there is a level of relativity in comparing learnability, so that like-complexity tools are compared to each other. In other words, it is not fair to compare the learnability of Facebook to the learnability of SPSS, but it will be more fruitful to compare SPSS to SAS software instead.

Context

Like usability, context plays a role in the learnability of a software as well. Individual differences affected learnability (Lew et al., 2010b; Maguire, 2001; Santos & Badre, 1995). User-based considerations for a software's learnability included experience with computers, related domain knowledge, experience with the interface, experience with similar software, and mental modeling (Grossman et al., 2009; Lew et al., 2010a; Moran, 1983; Linja-aho, 2005). In addition, the frequency of use of a system may have impacted the importance of learnability; the less a system was used, the more intuitive it should have been (Law et al., 2007).

Initial Versus Extended Learnability and Repeated Testing

Multiple authors noted that there may be differences between initial learnability (i.e., learning something for the first time) and extended learnability (i.e., longer-term learning and mastery of the software), which could have shown differences in the learning curve over time (Grossman et al., 2009; Law et al., 2007; Lew et al., 2010a; Lew et al., 2010b; Santos & Badre, 1995). Davis and Wiedenbeck (1998) also discussed the difference between initial and subsequent learning in their work. Hoffman et al. (2010) expanded on the notion by discussing the distinction between re-learning trials (where retention was demonstrated) and resilience trials (where the user adapted to unexpected changes in the processes).

An additional concept adjacent to initial and extended learnability is the idea of repeated testing or variance in testing. Coyle and Peterson (2016) indicated that repeated testing could help determine if a software was hard to learn overall (and over time), or if learnability was hindered by initial confusion, but overcome after repeated use. This idea may also be applied to usability over time (Hornbæk, 2006). Law et al. (2007) discussed how variance (changes to the tasks that were tested on) is a good way to test re-learnability as part of the long-term learnability of a product.

Attributes of Learnability

Learnability is described and expanded upon through attributes of learnability that may contribute to how easy or difficult it is to learn a software. Something to note, these attributes were originating from usability terms, and not the learning space (Laakkonen, 2007), which made these attributes worth exploring from an education perspective.

As with definitions, literature is rife with different learnability aspects. The literature review for this study resulted in 37 different learnability attributes, which were detailed in the upcoming Methods section. In addition to these main attributes, still more authors broke the attributes into further sub-attributes and tertiary attributes. For example, Laakkonen (2007) believed that learnability should be broken up into dynamic sub-categories including information search, data collection, knowledge management, knowledge form, knowledge build, and result of action. Linja-aho (2005) identified learnability factors related to training, including conceptual information, exercises, instructions for basic information, instructions for solving problems, motivational content, coverage of essential system functions, and material types. Rafique et al. (2012) developed a Learnability Attributes model that took six main characteristics and broke them down into sub-characteristics hierarchically – their current work was at eight levels of sub-categories as of publication.

A final consideration in the discussion of learnability attributes is the debate in the value of granularity in learnability attribute distinction. Law and Van Schaik (2010) noted that the UX community itself was divided between whether there is value in such specificity. They pointed out that measurement may only be valuable as a basis for structural modeling and as an influence on system design.

Assessing Learnability

Learnability has been assessed less frequently than usability, but there was literature that directly addressed methods used to study learnability. In addition, something that was covered more in the learnability literature than the usability literature were specific metrics that could be used to assess learnability. The next section will describe the usability methods that are used to study learnability independently as well as specific metrics that were utilized.

Methods to Assess Learnability

Learnability has been assessed in a handful of methods, borrowing from already-established usability methods. It is worth noting that many authors used multiple assessment methods in their research, or conducted multiple studies within one study, hence the duplication of many citations. Table 11 depicts the methods used specifically for learnability assessment along with citations of use and discussion.

Table 11

Learnability Assessment Methods and Citations

Method	Used By	Discussed By
Automated Tools	Santos & Badre, 1995	
Cognitive Walkthrough	Santos & Badre, 1995	
Electroencephalogram (EEG)	Stickel et al., 2007	
Eye Tracking	Chimbo et al., 2011	
Field Study		Santos & Badre, 1995
Heuristic Evaluation	Faizan, 2018	
Interview	Chimbo et al., 2011; Faizan, 2018; Linja-aho, 2005	
Lab experiments	Elliott et al., 2002	
Observations	Chimbo et al., 2011 Coyle & Peterson, 2016; Linja-aho, 2005; Santos & Badre, 1995; Senapathi, 2005; Tan et al., 2013;	
Question-suggestion protocol	Grossman et al., 2009	
Survey or questionnaire	Elliott et al., 2002; Linja-aho, 2005; Paymans et al., 2004; Rafique et al., 2012; Senapathi, 2005	
Task-based assessment	Chistyakov et al., 2016	
Think aloud	Law et al., 2007	
Timing/Logging	Elliott et al., 2002; Law et al., 2007	
Usability testing	Chimbo et al., 2011; Coyle & Peterson, 2016	
Video recording	Chimbo et al., 2011, Law et al., 2007	

Tools to Determine Learnability

Certain assessment tools have also been used for both learnability and usability. The number is much smaller than usability tools alone. The Software Usability Measurement Inventory (SUMI) was discussed in a learnability context by Chistyakov et al. (2016), and the System Usability Scale (SUS) was used for learnability in a study by Zec and Matthes (2018). It is also worth noting that while only a few scales were directly used to evaluate learnability, many of the tools have questions/items related to learnability within them, including the Post-Study System Usability Questionnaire (PSSUQ; Lewis, 1995), After-scenario Questionnaire (ASQ; Lewis, 1995), User Experience Questionnaire (UEQ; Laugwitz et al., 2008), Computer Usability Satisfaction Questionnaire (CUSQ; Lewis, 1995), Software Usability Measurement Inventory (SUMI; Kirakowski et al., 1993), and System Usability Scale (SUS; Brooke, 1996). It is possible that the combination of these tools could be further explored for effective assessment of learnability.

Metrics to Determine Learnability

Another interesting pocket of literature included specific metrics that were used to assess different learnability attributes. These metrics were quantifiable (e.g., time it takes to complete a task), comparable (e.g., comparing novice to expert users), rating scales (e.g., Likert statements), and more. Table 12 lists the metrics used to measure learnability and the authors that cited them.

Table 12

Learnability Measurement Metrics and the Authors That Cited Them

Learnability Metric	Author(s) Cited
Ability to complete tasks after a certain time frame	Butler, 1985; Michelsen et al., 1980
Alpha versus beta waves in EEG patterns	Stickel et al., 2007
Change in chunk size over time	Santos & Badre, 1995
Comparing “quality of use” over time	Bevan & Macleod, 1994

Learnability Metric	Author(s) Cited
Comparing "usability" for novice and expert users	Bevan & Macleod, 1994
Confidence ratings	Coyle & Peterson, 2016
Decrease in average think times over certain time interval	Michelsen et al., 1980
Decrease in help commands used over certain time interval	Michelsen et al., 1980
Decrease in task errors made over certain time interval	Michelsen et al., 1980
Error rate/frequency	Hornbæk, 2006; Law et al., 2007; Linja-aho, 2005; Mitta & Packebush, 1995;
Error Recovery	Law et al., 2007
Increase in commands used over certain time interval	Michelsen et al., 1980
Increase in complexity of commands over time interval.	Michelsen et al., 1980
Learnability questionnaire responses	Elliott et al., 2002; Lin et al., 1997
Likert statements	Elliott et al., 2002
Mental Model questionnaire pretest and post test results	Paymans et al., 2004
Moderator Redirects	Coyle & Peterson, 2016
Multiple-choice test/standardized tests to determine understanding	Hornbæk, 2006
Number of learnability-related user comments	Michelsen et al., 1980
Number of rules required to describe the system	Howes & Young, 1991; Kieras & Polson, 1985
Open-ended questions	Coyle & Peterson, 2016
Perceived ease and efficiency	Law et al., 2007
Percent of commands known to user	Baecker et al., 2000
Percent of commands used by user	Baecker et al., 2000
Percentage of users who complete a task optimally	Linja-aho, 2005
Percentage of users who complete a task without any help	Linja-aho, 2005
Quality of work performed during a task, as scored by judges	Davis & Wiedenbeck, 1998
The efficiency of an ordinary user compared to an expert	Lew et al., 2010a; Lew et al., 2010b
Retention over time	Hornbæk, 2006
Success rate of commands after being trained	Carroll et al., 1985; Lew et al., 2010a; Linja-aho, 2005

Learnability Metric	Author(s) Cited
Task completion times	Coyle & Peterson, 2016; Hornbæk, 2006; Laakkonen, 2007; law et al., 2007; Lew et al., 2010a; Linja-aho, 2005; Mitta & Packebush, 1995; Lew et al., 2010b
Time to learn to use, configure, and administer	Andreou & Tziakouris, 2007; Hornbæk, 2006
Time to complete a task after reviewing documentation	Michelsen et al., 1980
Time until user completes a certain task successfully	Nielsen, 1993; Laakkonen, 2007
Time until user completes a set of tasks within a time frame	Nielsen, 1993
Time to review documentation until starting a task	Michelsen et al., 1980;
Trial-to-criterion	Hoffman et al., 2010
Usability problems identified	Law et al., 2007

In this chapter, usability and learnability were discussed. Current literature on usability identified many factors that contributed to the concept, including learnability. Usability has been assessed through a variety of methods throughout the years, often used interchangeably with user experience measurement. Challenges and considerations for usability assessment were identified including ambiguity of definitions, inconsistency of tool usage, and the subjectivity of many usability measures.

As a factor of usability, learnability literature tended to share similar information that was in the usability research, though only a subsect. In other words, while usability referenced six ISO definitions, learnability only mentioned three. The literature pointed out considerations for learnability including context, initial versus extended learnability, and repeated testing. Tools and metrics were defined for the assessment of learnability as well.

Usability and learnability are two interrelated pieces of a user/learner's experience with a software product. Many definitions have been adopted by various researchers and no consensus has been widely adopted. There are a variety of methods and tools to assess these factors as they relate to a product, however, a lack of consistent terminology poses a risk to an assumption of common understanding across UX and LD professionals. In addition, the current literature does not provide any ranking or hierarchy around definitions and attributes, which may make it difficult to define the importance of each attribute.

Exploring the definitions of usability and learnability was beneficial because it reinforced the belief that there appears to be a lack of common understanding of usability or learnability. This lack of consistency established the need to further explore understanding of the concepts, particularly within the context of UX and LD professions. Identifying the factors of usability led to the determination that learnability was the key factor that could be equally influenced both by LD and UX practitioners. Identifying the various learnability attributes in the literature led to the establishment of a baseline set of terms and definitions that would be given to experts for rating. Finally, establishing the current methods of assessment for usability, learnability, and learnability attributes displayed a wide variety of ways in which the concepts have been explored, but also highlighted a lack of agreement in what is important to measure as well as how it would be best to do so.

CHAPTER 3

METHODOLOGY

To better understand the perceptions of User Experience (UX) and Learning Design (LD) professionals, the researcher sought to interpret the opinions of individuals that identify as working or conducting research within the UX and LD fields. Based on this goal, a survey was designed to conduct a quantitative, nonexperimental study performed through construction and validation of a survey instrument. In addition, qualitative responses were collected for future research, but were not analyzed as a part of this study. The survey was an appropriate method for data collection because of its ability to be widely distributed, allowance of anonymity in responses, and a combination of quantitative and qualitative data could be captured for interpretation as supported by Leedy and Ormrod (2019). Prior to data collection, the study was determined as exempt from IRB Review through the Old Dominion University Education Human Subjects Review Committee.

In this chapter, the researcher will first describe the targeted population and sample. Next, the researcher will identify the research variables. The researcher will then explain the instrument (survey) design and procedures for validation, study execution, and data collection. Finally, the researcher will discuss the proposed statistical analysis to be performed on the data to address the following research questions:

- RQ1: How do user experience design and learning design professionals perceive the importance of learnability factors as they pertain to a user's ability to learn and use a software product?
    - RQ1.1: What is the degree of consensus within the user experience design group on the importance of learnability factors?

  - RQ1.2: What is the degree of consensus within the learning design professional group on the importance of learnability factors?
- RQ2: What is the difference in how learnability factors are rated by importance between user experience design and learning design experts?

Population

The populations that the researcher intended to study were UX and LD professionals that either worked or conducted research in their respective fields. For the sake of this study, the two roles were defined as follows:

- User Experience (UX) Designer: Professionals that work or conduct research in User Experience design roles. Job titles may include User Experience Designer, Interaction Designer, Experience Strategy Designer, etc.
- Learning Design (LD) Professional: Professionals that work or conduct research in educational roles. Job titles may include Instructional Designer, Learning Experience Designer, Technical Trainer, etc.

One job title that was carefully classified was that of the learning experience designer. It has roots in UX but objectives that align with LD. Ahn (2019) described learning experience design (LX) as the creation of engaging and effective learning experiences in a wide variety of settings and contexts. Quintana et al. (2020) described the bidirectional nature of learner and user experience design, noting that both intersect throughout a user's and learner's journey. The important distinction for the purpose of this study was to determine how UX was being leveraged. UX designers focus on the product they are developing (i.e. the subject to be learned), and LX designers use UX to focus on the way in which a learner gains knowledge (Quintana et al., 2020). Because of the LX focus on the learner, they were considered LD professionals who may be uniquely qualified to speak to UX.

To determine population size and demographics, the researcher reviewed data from the National Center for O*NET Development (O*NET, 2022; 2023) and the U.S. Bureau of Labor Statistics (BLS, 2023). While these sources did not directly report on the specific roles identified in this study (i.e., UX or LD), there were roles that could most likely be characterized as falling into one of the two populations. The following information included the terms that either O*NET or BLS used.

According to O*NET's entry for web and digital interface design, which was the closest role aligned to UX, there were 79,000 individuals employed in related roles (O*NET, 2022, Summary title). In addition, there were 200,000 individuals employed in the role of training and development specialists, which aligned with the LD role (O*NET, 2023, Summary title). Table 13 displays the roles and total employed persons.

Table 13

Employed Persons in UX and LD Occupations by Total Employed Persons

Occupation	Total Employed
Training & Development Managers	62,000
Training & Development Specialists	138,000
Web & Digital Interface Designers	79,000

Note. Information sourced from the U.S. Bureau of Labor Statistics (2023).

An a priori power analysis was conducted using G*Power version 3.1.9.6 (Faul et al., 2007) to determine the minimum sample size required based on Cohen's (1988) criteria. As each research question required different data analysis, two effect sizes were analyzed with a significance criterion of $\alpha = .05$, power = .80, and the effect size $d = .20$. The minimum sample sizes were $n = 74$ for chi-square and $n = 102$ for an independent samples t-test.

The population was reached through a variety of social and professional channels. The researcher contacted applicable professional associations and groups, such as the Association for Educational Communications & Technology (AECT) and User Experience Professionals Association (UXPA), for a call for research participation via email, social media post, and direct message, included in Appendix E. In addition, public and shareable posts were made on social media sites, including Facebook and LinkedIn. Colleagues and research participants were encouraged to share the posts and/or survey link as an additional word-of-mouth/snowball sampling technique. Snowball sampling was appropriate because it allowed respondents to share the survey within their professional networks beyond that of the individual researcher, which could garner additional respondents, as supported by Patten and Newhart (2018).

Research Variables

The focus of the research was to study the responses collectively as well as separately (i.e., each professional group as a unit). For RQ 1, the researcher interpreted the overall ratings of attribute importance by all respondents. For sub questions 1.1 and 1.2, the element of interest was the level of agreement of response within each professional group. In this case, there was no dependent variable. For RQ 2, the researcher sought to compare each professional groups' ratings of level of importance at the individual attribute level, both as a composite score and at the item level. In this case, the professional groups served as the independent variable for both the t-test and the chi-square. The dependent variable for the t-test was the mean composite score of importance. For the chi-square, the categorical values of each individual attribute's importance rating were the dependent variables.

Instrument Design

The instrument for this study was developed through a five-step process. First, a review of literature was conducted by the researcher to establish a list of learnability attributes that have been identified in other works. Overall, 221 works were reviewed. Seventy-one works were excluded based on relevance during screening, leaving 150 works that were included and analyzed.

Second, each attribute was evaluated to remove duplicate, ill-defined, and non-transferrable attributes. Throughout the review, a list of any learnability attributes (*n*) was compiled along with their corresponding citations (*n* = 37). Four attributes were aggregated due to similarity to a more well-defined attribute (*n* = 33). Five attributes were excluded for various reasons such as vague definitions or lack of being standardizable (*n* = 28). Table 14 lists the included attributes and their citations, and Table 15 lists excluded learnability attributes with aggregation or exclusion reasons.

Table 14

Included Learnability Attributes and the Authors That Used Them

Attribute	Reference(s)
Awareness	Grossman et al., 2009
Consistency	Chimbo et al., 2011; Dix et al., 2004; Folmer et al., 2003; Payne & Green, 1986; Seffah et al., 2006; Senapathi, 2005; Tan et al., 2013
Continuity of task sequences	Linja-aho, 2005
Design Conventions	Linja-aho, 2005
Engagability	Chimbo et al., 2011
Error Prevention	Linja-aho, 2005
Familiarity	Chimbo et al., 2011; Dix et al., 2004; Seffah et al., 2006; Senapathi, 2005

Feedback	Ammar et al., 2016; Ammar, 2019; Folmer et al., 2003; Rafique et al., 2012; Senapathi, 2005
Generalizability	Chimbo et al., 2011; Dix et al., 2004
Information presentation	Linja-aho, 2005
Interface Understandability	Rafique et al., 2012; Hornbæk, 2006
Locating	Grossman et al., 2009

Attribute	**Reference(s)**
Mental Effort	Hornbæk, 2006; Seffah et al., 2006; Tan et al., 2013
Minimal Action	Seffah et al., 2006; Tan et al., 2013
Navigability	Tan et al., 2013
Operational Momentum	Rafique et al., 2012
Predictability	Ammar et al., 2016; Ammar, 2019; Dix et al., 2004; Folmer et al., 2003; Rafique et al., 2012; Senapathi, 2005
Prompting	Ammar et al., 2016 Ammar, 2019
Simplicity	Seffah et al., 2006
Synthesisability	Chimbo et al., 2011; Dix et al., 2004
System Guidance Appropriateness	Rafique et al., 2012; Seffah et al., 2006; Tan et al., 2013;
Task complexity	Liu & Li, 2012
Task Flow	Grossman et al., 2009
Task Match	Rafique et al., 2012
Transitions	Grossman et al., 2009
Understanding	Grossman et al., 2009; Hornbæk, 2006
Visibility of Operations	Linja-aho, 2005

Table 15

Excluded Learnability Attributes with Aggregation or Exclusion Reasons

Attribute	**Reference(s)**	**Exclusion Reason**
Completeness of Information	Linja-aho, 2005	Merged into "Information Presentation" due to similarity.
Concept Clarity	Linja-aho, 2005	This may not be a transferrable or standardizable attribute because it could be due to functionality users aren't familiar with, or it could be domain specific.
Differences in Functionality	Linja-aho, 2005	The definition described the functionality of different systems (such as 2d versus 3d), which require different mental

		models. In this context, that is not a change that can be made to interfaces of a uniform product.
Differences in Interaction Styles	Linja-aho, 2005	These differences naturally occur between different software interfaces and could not be standardized based on functionality.

Attribute	**Reference(s)**	**Exclusion Reason**
Memorability	Tan et al., 2013	Most of the literature considers Memorability at a factor level (i.e., the same level as learnability), and not at the attribute level.
Minimal Memory Load	Seffah et al., 2006 ; Tan et al., 2013	Merged with "Mental Effort" due to similarity
Self-descriptiveness	Seffah et al., 2006 ; Tan et al., 2013	Merged with "Interface Understandability" due to similarity
User Assistance	Linja-aho, 2005	The description was too vague to define
User Guidance	Seffah et al., 2006 ; Tan et al., 2013	Merged with "System Guidance Appropriateness" due to similarity

The third step in instrument construction was converting each attribute to a five-point Likert-type scale that measured level of importance. Fourth, expert review was conducted via a pilot test to establish content and face validity. Finally, the instrument was revised based on the expert feedback provided via the pilot. In addition to the attribute-based questions, additional questions were included in the study to collect for future research, including open-ended questions. The result was an instrument with four subscales: participant demographics, personal definitions of usability and learnability, learnability attributes and level of importance, and wrap-up.

Survey Contents

Questions in section one of the survey established to which professional group the participant was affiliated (UX or LD), how many years they had been working in their respective field (less than one year, 1-2 years, 2-4 years, 4-6 years, more than 6 years, don't know/not sure) and what industry they worked in. The industry list was compiled from a study conducted by the Nielsen Norman group (Rosala & Krause, n.d.), which described the current conditions in the UX field. While this list is targeted toward UX, Rosala and Krause (n.d.) appear to capture a list that is appropriate for both professional fields. In addition, an *other* option with space to add any missing industry was included in the survey list. The initial list of industries was as follows: computing, software, and IT; finance and insurance; consultancy; education; government and military; healthcare; retail; media, publishing, and printing; advertising; telecommunications; business; entertainment; aerospace and automotive; non-profit; emerging technologies; and other. Section two of the survey asked participants to provide their interpretations of usability, learnability, and how learnability is gauged. This information was collected for future research and was not analyzed as a part of this study.

The third section of the survey asked participants to rate the importance of individual learnability attributes to the overall learnability of the software. In other words, how important was X as a factor in how easy or difficult it is to learn to use a software? Each attribute was listed next to a 5-point unipolar scale, the values of which indicated the importance of the attribute. Scale values were as follows: not at all important, slightly important, important, very important, and extremely important**.** The survey itself only included the attribute name, e.g., awareness, consistency, etc., and the importance scale. The justification for doing so was for the participants to initially consider what each term meant to them outside of operational definitions. However, the researcher anticipated that some participants may want to use the definitions from the literature to guide their decision-making. Because of this, a list of attribute definitions was made available for participants to view alongside the survey if they preferred.

The fourth section of the survey was intended for participants to provide any additional insight or information related to their perception of learnability attributes. In this section, participants were given the opportunity to add attributes and rate their level of importance, as well as additional open-ended questions that were collected for future research and were not analyzed as a part of this study.

The final question in the survey allowed participants to voluntarily include their contact information if they were interested in being invited to future research. This question was clearly marked as optional so that participants would not feel obligated to include their contact information. Appendix C is a copy of the survey instrument in its entirety, and Appendix D is the operational definition supplement to the survey.

Survey Validation

Initial validation of the instrument was completed via pilot test and think-aloud protocol to provide content and face validity. This method was used to determine if items were interpreted by participants in the way that was intended, as supported by Trenor et al. (2011). Two participants from each professional field (UX and LD) were asked to pilot the survey virtually. These participants were identified through the researcher’s professional network and considered experts because of their practitioner experience within their respective fields. Participants were contacted through personal communication (text, direct message, etc.) and invited to participate in the pilot.

For participants who conducted the pilot via Zoom, each participant was invited to an individual 60-minute meeting, which allowed for ample time to talk through the questions beyond the predicted survey completion time of 10-20 minutes. Three SMEs participated in the think aloud synchronously, and a fourth participant provided feedback in an asynchronous format. Participants were given a preview link to the survey on the Qualtrics platform, which allowed them to take the survey in a realistic fashion. The survey itself included the questions as well as a link to the supplementary list of definitions as appropriate. Participants were asked to share their screens so that signs of hesitation on certain questions could be noted as well as use of the supplementary material. In addition, participants were asked to describe their thoughts, questions, and decisions as they completed the survey. Participants went through the survey, answering all questions while the researcher documented all suggestions. A fourth participant conducted the pilot asynchronously. The same preview link that was provided to the synchronous pilot study participants was provided via direct message, and feedback was provided via a shared Google document, and included in Appendix F.

Procedures

The survey was constructed in the Qualtrics survey platform. The survey was configured to first show an informed consent statement prior to the survey, and responses were configured to be anonymous (apart from those who voluntarily included their contact information). An initial pilot was conducted, and the survey was modified to reflect suggestions in question formatting and navigation, if any. After all viable pilot feedback had been addressed, the survey was set as active in Qualtrics so that a link could be shared across various platforms during the outreach phase.

Next, outreach was performed by contacting various listservs and professional associations and requesting the call for participation be sent out to their members. Calls for participation were also shared in profession-based communities in LinkedIn, Facebook, and Reddit. In addition, the survey was added to SurveySwap to garner additional responses. Appendix E includes the calls for participation and social media posts that were utilized.

Throughout the survey timeframe, Qualtrics was monitored for participation and responses. Throughout the study period, reminder communications were sent out to the previous groups, listservs, sites, and social media platforms. The survey remained open until an adequate sample size was achieved.

Methods of Data Collection

Participants were able to access the survey by following the link provided in the various calls for participation, or through word-of-mouth if they had been recruited as part of the snowball sampling approach. The survey was administered electronically, and all information was stored within the secure software survey application Qualtrics. Upon closing the survey, responses were extracted into Microsoft Excel for data screening, model diagnostics, and restructuring needed for analysis.

Statistical Analysis

Data were analyzed using IBM SPSS Statistics, Version 28; IBM Corp, 2021. Because the survey was original, it was appropriate to examine construct validity to ensure that the instrument measures what it intended to measure to support validity. A Kaiser-Meyer-Olkin test was performed to determine whether the data were suited for factor analysis, in this case an exploratory factor analysis (Kaiser, 1974).

To answer the research questions, the data were interpreted in three different data sets. RQ1 was answered by analyzing the data both in totality and within groups (individual UX responses compared to each other, and individual LD responses compared to each other). RQ2 was addressed by examining responses between groups (UX responses compared to LD responses). Analysis methodology was influenced by the literature as well as Santoso and Schrepp (2018), who conducted a study with similar objectives to the current one. They evaluated the importance of user experience aspects for different product categories using Likert-type data. They utilized standard deviations to evaluate the level of agreement, a two-tailed *t*-test to compare groups, and multi-dimensional scaling to visualize the similarity of responses with groups (Santoso & Schrepp, 2018).

Section 1 of the survey consisted of demographic data, which were analyzed through descriptive statistics, as supported by Patten & Newhart (2018). As supported by Leedy and Ormrod (2019), results of survey items one and three were analyzed for percentage values. Because of the ratio scale, Item 2 was analyzed via frequency distribution and mean. After demographic data were established, statistical analysis was conducted to address the two research questions.

Research Question 1 asked how UX and LD professionals perceived the importance of learnability attributes as they pertained to a user's ability to learn and use a software product. Sub-questions sought to determine the degree of consensus within the UX and within the LD professional groups on the importance of learnability factors. To answer these questions, data were analyzed first through tabulation of item response frequencies, done through descriptive analysis. Item means and standard deviations were reported for each item (for total sample and by group) to reveal how values are dispersed among the three groups for each item, which is a more traditional method of examining item level responses, as described by Cooksey (2020). Krippendorff's Alpha (KAlpha) was conducted to determine degree of consensus within each group (Krippendorff, 1970). This statistic was selected because it could be used regardless of sample size and presence/absence of data.

Research Question 2 sought to determine the difference in how learnability factors were rated by importance between UX and LD professionals. An independent samples *t*-test was performed to compare the difference between the composite means of the two groups, which was supported in the literature (Chen & Liu, 2020; Field, 2009). The composite score was calculated through use of the compute variable functionality. A numeric expression was written that included the means of the responses for each of the 27 attribute items, adding a mean composite column to the data. In addition, a chi-square analysis was completed which allowed the researcher to treat the data as nominal, and to view the data through the lens of observed and expected frequencies rather than means alone as supported by Patten and Newhart (2018). In this case, the professional groups served as the variable for the *t*-test, and the categorical values of each individual attribute's importance rating was the variable being explored via chi-square. Table 17 provides a complete breakdown of each survey question, the type of data it was, and the analysis that was conducted on the data.

Table 17

Survey Question by Data Type and Analysis Method

Question(s)	Data Type	Analysis
1	Multiple (2) choice, nominal scale	Frequency, percent
2	Multiple (6) choice, ratio scale	Frequency, percent
3	Multiple (16) choice, nominal scale with possibility of open-ended response	Frequency, percent, structural coding
4-6	Open-ended	*Collected for future research, was not analyzed*
7-33	Likert (importance), ordinal scale	Mean, Standard Deviation, chi-square, Independent Samples *t*-test
34-36	Open-ended	*Collected for future research, was not analyzed*
37	*Contains voluntary contact information and will not be reported/analyzed*	

Summary

This quantitative, nonexperimental, descriptive study was performed through construction and validation of a survey instrument that asked questions about usability and learnability. A sample of UX and learning design LD professionals were asked to participate in the study through random and snowball sampling of the identified population, with the need to obtain at least 102 survey responses per group to reach a statistically significant number based on population size.

The focus of this research was to see responses collectively as well as separately. RQ1's characteristics of interest were the overall responses related to each attribute's level of importance, and its sub-questions examined the level of agreement of response within each professional group. RQ2's characteristics of interest were a comparison of each attribute's level of importance as rated by each professional group.

An original survey instrument was created to capture both qualitative and quantitative data based on the perceptions related to usability, learnability, and learnability attributes in software. It included four sections that covered participant demographics, personal definitions of usability and learnability, learnability attributes and level of importance, and wrap-up. Initial survey validation was performed with a pilot study, where the survey was iteratively adapted based on feedback obtained during the validation. The survey was then prepared for wider dissemination.

Calls for participation were sent out to relevant listservs, professional associations, and social media groups to reach a wide audience of potential participants. The calls included a link to the survey, which included an informed consent statement prior to being directed to the instrument. Reminder calls were sent out after the initial call. The survey was closed after response rates declined.

Finally, statistical analysis was completed, first to validate the instrument, and second to answer the study's research questions. Data were interpreted in totality, within groups, and between groups to gain insight on how usability and learnability is perceived across multiple data sets. Kaiser-Mayer-Olkin and exploratory factor analysis were conducted to test the validity of the data. Demographic responses were analyzed through frequency and percentage descriptive statistics. RQ1 was addressed by finding the mean and standard deviation both within and between groups and its sub questions were addressed by performing a Krippendorff's Alpha. RQ2 was addressed by conducting a chi-square on each learnability attribute, and an independent *t*-test was performed to compare attributes between and within groups.

CHAPTER 4

RESULTS

The purpose of this study was to better understand how User Experience (UX) and Learning Design (LD) professional groups perceive learnability to explore potential commonalities of practice. Understanding the perceptions of learnability between and within professional groups may increase the ability to collaborate in an interdisciplinary manner. To this end, an online survey was developed, validated, and disseminated through email, listserv, and various online, profession-based platforms.

Survey Validation

After the survey was initially constructed, a pilot test was conducted to support content and face validity. The pilots were conducted virtually. While the intention was for all four pilots to take place synchronously, scheduling conflicts required one of the four pilots to be conducted asynchronously. Synchronous feedback was recorded in real time by the researcher, and asynchronous feedback was provided via a shared Google document. Overall, feedback was minor and related to grammatical preference. A few question phrasings were modified, and Question 34 was supplemented with a list of the prior attributes that were rated, as well as the rating scale, so that participants did not have to remember the attributes already listed.

Calls for Participation

After the survey was finalized post-pilot, the survey was disseminated through email, listserv, and various online, profession-based platforms. Initial and reminder calls for participation were sent out at various points to increase visibility on social feeds. After the survey was live for a month without reaching the targeted sample size, additional social groups were targeted on Reddit, direct appeals were made via email and direct message, and the survey was added to SurveySwap to garner additional responses. Table 18 includes a list of the avenues for reach out with number of individuals or groups contacted. Appendix E includes the calls for participation and social media posts that were utilized.

Table 18

Outreach Avenues for Requests for Participation

Avenue	# Contacted
Listserv	1
Personal Email	10
Facebook Group(s)	5
LinkedIn Group(s)	12
LinkedIn Direct Message	34
Subreddit Group(s)	4
Salesforce Trailhead Community	1
Slack Group(s)	1
Microsoft Teams message(s)	2

Findings

Data Screening and Transformations

264 responses were recorded in the Qualtrics system. Because this study analyzed the Likert-type portion of the survey, responses that were not at least partially complete were removed from the data set. This left 109 responses for analysis. During the data screening process, all responses that did not at least begin the attribute rating portion of the survey were removed. Next, all questions to be interpreted in future studies were removed from the data set. After initial cleanup was completed, responses were reviewed for outliers, data entry errors, and entry reconciliation. No outliers or data entry errors were identified; however, it was appropriate to either re-classify or add new categories into the industry portion of the demographic data

based on what respondents filled in when they selected *other* for their industry. Table 19 describes how each free-text response was handled for data analysis.

Table 19

Industry Free-Text Response Handling

Response	Action Taken	Final Categorization
Agriculture and Food	Added Category	Agriculture and food
IT Training for both military and healthcare	Reassigned	Computing, Software, & IT
EdTech	Added Category	EdTech
All, Whatever the content provided by the client	Reassigned	Consultancy
ITES	Reassigned	Computing, Software, & IT
Tech	Reassigned	Computing, Software, & IT
Marketing Research	Added Category	Marketing
University	Reassigned	Education
Sales	Reassigned	Marketing (Added category)

Attribute data were transformed by categorical variable encoding where the professional groups and Likert-type response values were given a numerical format for analysis. Missing data were identified and addressed based on requirements of the calculation tools. For data run in SPSS, incomplete responses were left blank and excluded from analysis. In addition, data were saved and formatted to meet the requirements of the data analysis platform. For example, KAlpha analysis required transposition of the rows and columns, no headers, marking all incomplete responses as *N/A,* and a .csv format.

Population and Response Rate

264 responses were recorded in the Qualtrics system, however only 109 respondents completed or partially completed the Likert-type portion of the study, which was the portion to

be analyzed. Of the 109 responses, 39 (35.8%) were in the UX group, and 70 (64.2%) were in the LD group, which is in alignment with the proportions of the O*Net data.

The highest percentage of years of experience both across and within groups was more than 6 years (*n* = 61, 56.0%), with a larger percentage belonging to LD professionals (*n* = 47, 67.1%) than UX professionals (*n* = 14, 35.9%). The second highest years of experience varied by professional group. While the overall second highest was 1-2 years, (*n* = 15, 13.8%), this aligned with UX (*n* = 7, 17.9%), whereas the second highest response for LD was 4-6 years (*n* = 10, 14.3%).

Computer/Software/IT was the predominant industry sector to be represented both across and within groups (*n* = 35, 32.1%), with a larger percentage belonging to LD professionals (*n* = 24, 34.3%) than UX professionals (*n* =11, 28.2%). Other notable industries were Education for both UX professionals (*n* = 8, 20.5%) and LD Professionals (*n* = 16, 22.9%). The Healthcare industry was also standout in the LD group (*n* = 10, 14.3%). Table 20 displays demographic data for all respondents, divided by professional group.

Table 20

Demographic Data for Respondents

		User Experience		Learning Design		Total	
		Professional Group					
		n	%	*n*	%	*n*	%
Years of Experience	Less than 1 year	10	25.6	0	0.0	10	9.1
	1-2 Years	7	17.9	8	11.4	15	13.8
	2-4 Years	5	12.8	5	7.1	10	9.1
	4-6 Years	3	7.7	10	14.3	13	11.9
	More than 6 Years	14	35.9	47	67.1	61	56.0
	Don't Know/Not sure	0	0.0	0	0.0	0	0.0
Industry	Advertising	2	5.1	0	0.0	2	1.8
	Aerospace & Automotive	1	2.6	3	4.3	4	3.6
	Agriculture & Food	0	0.0	1	1.4	1	.91
	Business	2	5.1	1	1.4	3	2.8
	Computing/Software/IT	11	28.2	24	34.3	35	32.1
	Consultancy	1	2.6	6	8.6	7	6.4
	EdTech	0	0.0	2	2.9	2	1.8
	Education	8	20.5	16	22.9	24	22.0
	Emerging Technologies	1	2.6	0	0.0	1	.91
	Entertainment	0	0.0	0	0.0	0	0
	Finance/Insurance	2	5.1	1	1.4	3	2.8
	Government and Military	0	0.0	2	2.9	2	1.8
	Healthcare	2	5.1	10	14.3	12	11.0
	Marketing	1	2.6	1	1.4	2	1.8
	Media/Publishing/Printing	2	5.1	1	1.4	3	2.8
	Non-Profit	1	2.6	2	2.9	3	2.8
	Retail	3	7.7	0	0.0	3	2.8
	Telecommunications	2	5.1	0	0.0	2	1.8

Fitness of Data

A Kaiser-Mayer-Olkin (KMO) and Bartlett's were performed to determine fitness of data for exploratory principal components analysis (PCA). For the total sample, the KMO value of .79 was indicative of reasonable sampling adequacy. Bartlett's test yielded an approximate chi-square value of 1018.98 with 351 degrees of freedom and a significance level of $< .001$, which indicated that the variables were correlated and therefore suitable for factor analysis. Figure 2 displays the KMO and Bartlett's results for the total sample.

Figure 2

KMO and Bartlett's for Total Sample

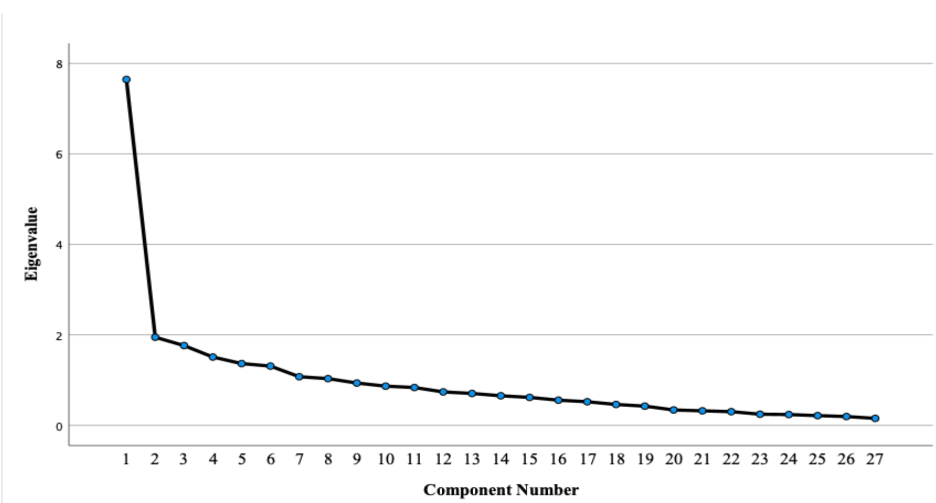
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.794
Bartlett's Test of Sphericity	Approx. Chi-Square	1018.984
	df	351
	Sig.	<.001

Exploratory Principal Components Analysis

An exploratory principal components analysis (PCA) was conducted to determine the number of factors with significant communalities. Extraction was initially conducted based on attributes with eigenvalues greater than 1, with a varimax rotation and a suppression of small coefficients below .40. Based on the scree plot (Figure 3), it was determined that variance was minimal after six factors, and therefore the data should be analyzed with a fixed number of six factors.

Figure 3

Scree Plot of PCA Based on an Eigenvalue of 1 or Greater



The PCA was then re-conducted on a fixed number of six factors. Extraction communalities were computed after extracting the principal components. Six components displayed high communalities, with the highest being task flow (.76). One component, Mental effort displayed low communality (.36). The remaining components displayed moderate communality. Figure 4 shows the communalities for the total sample.

Figure 4

Communalities for Components Analysis

	Initial	Extraction
Awareness	1.000	.463
Consistency	1.000	.633
Continuity of task sequences	1.000	.560
Design conventions	1.000	.614
Engagability	1.000	.490
Error Prevention	1.000	.597
Familiarity	1.000	.466
Feedback	1.000	.476
Generalisability	1.000	.430
Information Presentation	1.000	.537
Interface Understandability	1.000	.441
Locating	1.000	.460
Mental Effort	1.000	.362
Minimal Action	1.000	.407
Navigability	1.000	.560
Operational Momentum	1.000	.579
Predictability	1.000	.525
Prompting	1.000	.577
Simplicity	1.000	.647
Synthesisability	1.000	.406
System Guidance Appropriateness	1.000	.685
Task Complexity	1.000	.456
Task Flow	1.000	.716
Task Match	1.000	.659
Transitions	1.000	.419
Understanding	1.000	.500
Visibility of Operations	1.000	.571

Extraction Method: Principal Component Analysis.

A review of the rotated component matrix indicated that design conventions, system guidance appropriateness, predictability, consistency, minimal action, information presentation, and navigability may be a part of more than one construct. Most attributes loaded on only one component, indicating six different constructs that could be explored in the future. The results of the rotated component matrix are displayed in Figure 5.

Figure 5

Rotated Component Matrix

	Component					
	1	2	3	4	5	6
Awareness	.673					
Feedback	.658					
Continuity of task sequences	.583					
Design conventions	.534		.451			
System Guidance Appropriateness	.492		.482			
Task Flow		.818				
Task Match		.669				
Task Complexity		.542				
Understanding		.505				
Transitions		.432	.417			
Prompting			.705			
Synthesisability			.598			
Operational Momentum			.531	.493		
Familiarity				.672		
Visibility of Operations				.561		
Predictability			.455	.540		
Generalisability				.536		
Consistency	.502			.533		
Minimal Action				.421		.417
Simplicity					.751	
Error Prevention					.596	
Engagability					.588	
Information Presentation			.464		.486	
Mental Effort						.785
Locating						.587
Interface Understandability						.586
Navigability	.411					.527

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 21 iterations.

Research Question 1

Research Question 1 asked how UX and LD professionals perceived the importance of learnability attributes as they pertained to a user's ability to learn and use a software product. Sub-questions sought to determine the degree of consensus within the UX and within the LD professional groups on the importance of learnability factors. To answer these questions, data were analyzed first through descriptive analysis, identifying the mean and standard deviation of each attribute as supported by Patten and Newhart (2018).

Based on attribute means, learnability attributes were perceived differently within the total sample. Four attributes were categorized as very important or extremely important, including navigability ($M = 4.34$), interface understandability ($M = 4.29$), consistency ($M = 4.17$), and understanding ($M = 4.04$). While no means fell below the categories of important to very important, the lowest-rated attributes were generalizability ($M = 3.23$), transitions ($M = 3.29$), and synthesisability ($M = 3.31$).

Standard deviations for each attribute were less than 2.00, indicating a minor variance of individual responses. The attributes with the smallest standard deviations were navigability ($SD = .78$), interface understandability ($SD = .83$), and operational momentum ($SD = .88$). Attributes with the greatest level of variance were familiarity ($SD = 1.06$), visibility of operations ($SD = 1.07$), and information presentation ($SD = 1.07$). Table 21 displays means and standard deviations for each attribute by professional group.

Table 21

Means and Standard Deviations by Attribute

	Professional Group					
	User Experience		Learning Design		Total	
	Mean	*SD*	Mean	*SD*	Mean	*SD*
Awareness	3.38	0.96	3.54	1.00	3.49	0.99
Consistency	4.03	1.06	4.24	0.89	4.17	0.96
Continuity of task sequences	3.51	1.07	4.10	0.92	3.89	1.01
Design Conventions	3.38	0.94	3.76	1.04	3.62	1.02
Engagability	3.23	1.01	3.91	0.85	3.67	0.96
Error Prevention	3.56	1.10	3.83	1.01	3.73	1.04
Familiarity	3.85	0.90	3.39	1.11	3.55	1.06
Feedback	3.82	1.14	3.94	0.95	3.90	1.02
Generalizability	3.31	0.80	3.19	1.02	3.23	0.94
Information presentation	3.51	1.00	3.59	1.12	3.56	1.07
Interface Understandability	4.10	0.79	4.39	0.84	4.29	0.83
Locating	3.49	0.91	4.17	0.82	3.93	0.91
Mental Effort	3.72	0.92	4.07	0.98	3.94	0.97
Minimal Action	3.26	0.97	3.36	1.07	3.32	1.03
Navigability	3.95	0.90	4.56	0.61	4.34	0.78
Operational Momentum	3.46	0.77	3.50	0.94	3.49	0.88
Predictability	3.76	0.88	3.74	1.07	3.75	1.01
Prompting	3.50	0.92	3.64	0.87	3.59	0.89
Simplicity	3.79	1.02	4.04	1.03	3.95	1.03
Synthesisability	3.34	0.94	3.29	0.92	3.31	0.92
System Guidance Appropriateness	3.50	0.92	3.69	0.97	3.62	0.95
Task Complexity	3.25	0.97	3.70	0.95	3.54	0.98
Task Flow	3.58	0.97	4.00	0.99	3.85	0.99
Task Match	3.38	1.01	3.85	0.77	3.68	0.89
Transitions	3.16	0.96	3.36	0.98	3.29	0.97
Understanding	3.94	0.86	4.09	1.00	4.04	0.95
Visibility of Operations	3.73	0.93	3.52	1.13	3.60	1.07

Because the standard deviations were no lower than .78 and no higher than 1.07, the researcher calculated the coefficient of variance for each attribute based on group to better understand the variability between data sets. Overall, results showed moderate to high variability by attribute in totality, as well as within professional groups. The LD group tended to have higher variability at the attribute level than the UX group. Table 22 displays the standard deviations and coefficient of variances by attribute.

Table 22

Standard Deviations and Coefficient of Variances by Attribute

	Professional Group				Total	
	User Experience		Learning Design			
	SD	*CV*	*SD*	*CV*	*SD*	*CV*
Awareness	0.96	28.4%	1.00	28.3%	0.99	28.3%
Consistency	1.06	26.4%	0.89	21.0%	0.96	23.0%
Continuity of task sequences	1.07	30.5%	0.92	22.4%	1.01	26.0%
Design Conventions	0.94	27.6%	1.04	27.7%	1.02	28.0%
Engagability	1.01	31.1%	0.85	21.6%	0.96	26.2%
Error Prevention	1.10	30.7%	1.01	26.3%	1.04	27.9%
Familiarity	0.90	23.5%	1.11	32.7%	1.06	29.8%
Feedback	1.14	29.9%	0.95	24.2%	1.02	26.2%
Generalizability	0.80	24.2%	1.02	31.9%	0.94	29.2%
Information presentation	1.00	28.4%	1.12	31.0%	1.07	30.0%
Interface Understandability	0.79	19.2%	0.84	19.2%	0.83	19.4%
Locating	0.91	26.2%	0.82	19.7%	0.91	23.3%
Mental Effort	.916	24.6%	0.98	23.9%	0.97	24.5%
Minimal Action	0.97	29.7%	1.07	31.8%	1.03	31.0%
Navigability	0.90	22.8%	0.61	3.3%	0.78	18.0%
Operational Momentum	0.77	22.2%	0.94	26.8%	0.88	25.2%
Predictability	0.88	23.5%	1.07	28.7%	1.01	26.8%
Prompting	0.92	26.4%	0.87	23.8%	0.89	24.6%
Simplicity	1.02	26.9%	1.03	25.4%	1.03	26.0%
Synthesisability	0.94	28.1%	0.92	27.8%	0.92	27.8%
System Guidance Appropriateness	0.92	26.4%	0.97	26.2%	0.95	26.2%
Task Complexity	0.97	29.8%	0.95	25.8%	0.98	27.6%
Task Flow	0.97	27.0%	0.99	24.6%	0.99	25.8%
Task Match	1.01	29.9%	0.77	20.0%	0.89	24.1%
Transitions	0.96	30.3%	0.98	29.2%	0.97	29.6%
Understanding	0.86	21.8%	1.00	24.4%	0.95	23.5%
Visibility of Operations	0.93	25.0%	1.13	32.2%	1.07	29.6%

To answer Research sub questions 1.1 and 1.2, Krippendorff's Alpha (KAlpha) was used to determine the degree of consensus within each group (Krippendorff, 1970). The K-Alpha Calculator (Marzi et al., 2024) was used to calculate the KAlpha while treating the data as nominal. Results indicated that inter-rater reliability was very low for both the UX (α = 0.106) and LD (α = 0.036) professional groups, indicating that neither professional group agreed on importance amongst themselves.

Research Question 2

Research Question 2 sought to determine the difference in how learnability factors were rated by importance between UX and LD professionals. An independent samples *t*-test was performed to compare the composite mean scores on the level of importance between UX and LD professional groups as supported in the literature (Chen & Liu, 2020; Field, 2009). Prior to conducting the *t*-test, Levene's test for equality of variances was examined, indicating that the assumption of equal variances was met, $f(1,107) = 1.305$, $p = .256$. The results of this analysis indicated a statistically significant difference in mean scores between the two groups, $t(107) = -2.012$, $p = .047$. The mean difference between the UX and LD groups was -0.20215, with a standard error of 0.10048, 95% CI [-0.40134, -0.00297]. These findings suggest that there was a significant difference between the two groups, with the UX group rating attributes with lower importance on average than the LD Group. Figure 6 displays the results of the independent samples *t*-test.

Figure 6

Independent Samples t-test

		Levene's Test for Equality of Variances		t-test for Equality of Means							
						Significance				95% Confidence Interval of the Difference	
		F	Sig.	t	df	One-Sided p	Two-Sided p	Mean Difference	Std. Error Difference	Lower	Upper
impcomp	Equal variances assumed	1.305	.256	-2.012	107	.023	.047	-.20215	.10048	-.40134	-.00297
	Equal variances not assumed			-2.080	86.679	.020	.040	-.20215	.09717	-.39531	-.00900

Additionally, a chi-square test was conducted on each individual attribute, as supported by Chen and Liu (2020). Of all attributes, only continuity of task sequences, engagability, interface understandability, locating, navigability, and task match had a significance rating of >

.05, thus indicating a significance in the chi-square test. Because six attributes were identified as statistically significant, a Cramér's V was also run to determine effect size of each attribute, as supported by Cohen (1988). Table 23 displays each attribute, the Pearson Chi-Square significance, and Cramér's V.

Table 23

Pearson Chi-square Significance with Cramér's V

Attribute	Significance	Cramér's V
Awareness	.761	.131
Consistency	.144	.251
Continuity of Task Sequences	**.045**	**.299**
Design Conventions	.192	.236
Engagability	**.006**	**.363**
Error Prevention	.542	.168
Familiarity	.091	.271
Feedback	.854	.112
Generalizability	.166	.245
Information presentation	.454	.156
Interface Understandability	**.036**	**.281**
Locating	**< .001**	**.424**
Mental Effort	.170	.216
Minimal Action	.526	.172
Navigability	**<.001**	**.396**
Operational Momentum	.692	.146
Predictability	.544	.171
Prompting	.202	.238
Simplicity	.585	.164
Synthesisability	.978	.066
System Guidance Appropriateness	.613	.159
Task complexity	.264	.225
Task Flow	.194	.194
Task Match	**.050**	**.304**
Transitions	.647	.155
Understanding	.469	.186
Visibility of Operations	.387	.200

The calculation of Cramér's V resulted in moderate association strength for continuity of task sequences, interface understandability, navigability, and task match. Engagability and locating demonstrated relatively strong associations. Table 24 highlights the statistically significant attributes, the Cramér's V value, and the association strength.

Table 24

Statistically Significant Attributes with Cramér's V and Association Strength

Attribute	Cramér's V	Association Strength
Continuity of Task Sequences	.299	Moderate
Engagability	.363	Relatively Strong
Interface Understandability	.281	Moderate
Locating	.424	Relatively Strong
Navigability	.396	Moderate
Task Match	.304	Moderate

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

Chapter 5 begins with a summary of the problem statement, research goals, and significance of the study which sought to better understand the perceptions of user experience (UX) and learning design (LD) professionals in their understanding of learnability in the software context. Next, results will be interpreted, and conclusions drawn. Finally, both practical and future research recommendations will be made based on the findings of this study.

Summary

UX and LD professionals share commonalities of purpose through their desire to support the success of their audiences. The potential symbiosis of these professional groups may be seen in the similarities of their audiences, focus, and assessment tools. While UX professionals refer to their audience as users, that same audience is described as a learner in the LD space (Soloway et al., 1994). Assessment tools in the UX space include heuristic evaluation, questionnaires, and usability assessments (Lewis, 2014), whereas LD assessment tools include needs assessment, gap analysis, and operational analysis (Agnaia, 1996). The primary goal of UX is to improve system performance for effective use, satisfaction, and interaction success (Hinderks et al., 2022), and LD focuses on successful educational outcomes and learner performance interacting with a system (Saçak et al., 2022).

Because of these similarities, the idea of collaboration between the two professional groups is promising. Hints of such synchronicity can be seen in the Learning Experience Design profession, which focuses on the experience of a learner as they navigate through a learning activity (Schmidt et al., 2020). In addition, there are markets where these professional groups can both contribute meaningfully to the success of a product, such as software development.

In the software development space, there are many factors that can impact the marketability and success of a product, with usability being often-cited as a major contributor (Feng & Wei, 2019; Fernández et al., 2013b; Paz & Pow-Sang, 2016). Usability is often determined through evaluation of different factors including satisfaction, error prevention, memorability, efficiency, and learnability (Nielsen, 1994b, Quiñones et al., 2018). While many of these factors are established through the design and implementation of the software itself, learnability stands out because it can be affected, or potentially overcome, by interventions outside of the software development lifecycle. In other words, software can be made more learnable if the user/learner is equipped with educational support. To contextualize this professionally, UX professionals may work to ensure the product they develop is usable, and LD professionals may further improve the use of software through additional training interventions.

Problem Statement

While this opportunity for interdisciplinary collaboration is promising based on the common audience and goals, there are potential issues. One of the primary barriers to encouraging more cross-disciplinary work is the lack of research that explores how the two professions share understanding and definitions of learnability. While LD professions are rooted in the study of how people learn (NASEM, 2018), UX does not share the same epistemological origins (Bargas-Avila & Hornbæk, 2011; Jooste et al., 2014). Indeed, the act of judging learnability exists in both professional spaces, but it is unknown how similar or dissimilar these interpretations of learnability are. Up to this point, few studies have sought to understand the definitions of learnability in both professional contexts, and what has been written merely discussed the overlap and opportunity for collaboration without formally studying these notions (Elliott et al., 2002; Li et al., 2023). Agreement in understanding between the professions could support greater interdisciplinary collaboration. Disagreement, however, could expose that learnability may not be properly addressed throughout the software development lifecycle.

Research Goals

The purpose of this study was to better understand the perceptions of UX and LD professionals on learnability and its attributes, as identified in extant literature, in the software context so that a common set of definitions and metrics could be used between disciplines to enhance the user's learning process. To do that, this study was framed by the following research questions:

- RQ1: How do user experience design and learning design professionals perceive the importance of learnability factors as they pertain to a user's ability to learn and use a software product?
    - RQ1.1: What is the degree of consensus within the user experience design group on the importance of learnability factors?
    - RQ1.2: What is the degree of consensus within the learning design professional group on the importance of learnability factors?
- RQ2: What is the difference in how learnability factors are rated by importance between user experience design and learning design experts?

Significance

Learning how these professional groups understand learnability and rate the importance of learnability attributes could have major implications for both UX and LD fields. If results are positive, i.e., the importance of learnability factors are similar between and within groups, then new opportunity for collaboration is possible. For example, LD professionals may be able to leverage UX assessment tools and vice versa. Organizations that may not have a learning department yet could use the same UX tools to determine the level of need their customers may have for educational support, and thus influence their business-related hiring.

If, however, results are negative, i.e., the importance of learnability factors between and within professional groups is incongruent, then the UX field would find itself at odds with the profession that is rooted in education and learning theory. It would force the UX field to re-examine its interpretation of learnability and re-define its assessment tools and metrics to better reflect learnability through educational best practice.

Limitations

The goal of this study was to begin to learn about the perceptions of UX and LD professionals as they pertained to learnability and the importance of individual learnability attributes. Because of this, other usability factors that may show relationships to learnability, such as memorability, understandability, etc., were not explored.

Because the study was conducted via online survey, the study was limited to participants with access to the internet and who were made aware of the survey through the communication channels used throughout the survey period. In addition, participants were asked to voluntarily participate in the study, which may introduce response and selection bias (Leedy & Ormrod, 2019). In addition, if a respondent has experience in both UX and LD professions, their self-selection of professional group may not align with the researcher's intended grouping.

Population

The populations studied for this research were UX and LD professionals that either worked or conducted research in their respective fields. Examples of job titles for the UX group were User Experience Designer, Interaction Designer, and Experience Strategy Designer. Examples of titles for the LD group included Instructional Designer, Learning Experience

Designer, and Technical Trainer. Total population for individuals in these professional groups in the United States according to O*Net data were over 100,000 UX professionals (O*NET, 2022, Summary title) and over 350,000 LD professionals (O*NET, 2023, Summary title).

Instrument

A survey instrument was developed that included demographic questions, open-ended questions about definitions of usability and learnability, and a Likert-type portion that listed learnability attributes and asked participates to rate the importance of each attribute in terms of learnability. A pilot study was conducted to establish face and content validity before the survey was disseminated through various calls for research participation.

Data Collection

Participants were able to access the survey by following a link that was included in all personal communication and calls for participation. Communications were sent via email, direct message, and group message boards on social sites such as LinkedIn, Facebook, and Reddit. Multiple calls for participation and reminders were sent through the various channels over a period of two months until an appropriate sample size was met to conduct statistical analysis.

Statistical Procedures

Statistical analysis was conducted using IBM SPSS Statistics, Version 28; IBM Corp, 2021. Construct validity was established via Kaiser-Meyer-Olkin (Kaiser, 1974) and exploratory Principal Components Analysis (PCA) was conducted to explore possible constructs for the learnability attributes, as well as provide preliminary psychometric evidence of validity, which could be explored further in future research.

Mean, standard deviation, and coefficient of variance were explored both within and between groups to answer RQ1. To address RQ1's sub-questions, the K-Alpha Calculator (Marzi et al., 2024) was used to calculate Krippendorff's Alpha (Krippendorff, 1970), which determined inter-rater reliability for each professional group. An independent samples *t*-test was performed on the composite mean scores of levels of importance between UX and LD professional groups, and a chi-square test and Cramér's V were conducted at the individual attribute level to answer RQ2.

Conclusions & Discussion

Results indicated variance both within and between professional groups in terms of rating the importance of individual learnability attributes in relation to the learnability of a product. A lack of strong consensus indicated that the development of a domain ontology may be beneficial to establish shared understanding of learnability and its attributes, as supported by the research of McDaniel and Storey (2019).

RQ1: How do user experience design and learning design professionals perceive the importance of learnability factors as they pertain to a user's ability to learn and use a software product?

Overall, UX and LD professionals categorize different learnability attributes as very important or extremely important, with the lowest rated attributes still rated as important to very important. This supported the idea that all the attributes that have been identified in the literature as aspects of learnability were valid. The three most important attributes identified by both professional groups were that of navigability (UX $M = 3.95$, LD $M = 4.56$), interface understandability (UX $M = 3.95$, LD $M = 4.1$), and consistency (UX $M = 4.03$, LD $M = 4.24$). This is a promising sign as it shows at least some alignment in terms of agreement on the most important parts of how a system is learnable. When comparing level of importance to number of citations within the literature, consistency was the most often-referenced attribute (Chimbo et al., 2011; Dix et al., 2004; Folmer et al., 2003; Payne & Green, 1986; Seffah et al., 2006; Senapathi, 2005; Tan et al., 2013) which aligns with its high importance rating. The same could not be said for the other top attributes, with interface understandability being referenced twice (Rafique et al., 2012; Hornbæk, 2006) and navigability only being referenced once (Tan et al., 2013). This may be due to the historical emphasis of consistency in the HCI literature (Nielsen, 1993) or the fact that terms such as interface understandability and navigability are more specific than a generalized term such as consistency (Hassenzahl & Tractinsky, 2006; Hornbæk, 2006)

However, some of the attributes importances were rated relatively differently. For example, UX professionals rated familiarity as important to very important (*M* = 3.82) whereas LD professionals rated familiarity lower in the same bracket (*M* = 3.39). Similar disparities were seen in other attributes, such as visibility of operations and locating. This may indicate that there is a lack of alignment in how all attributes are understood and rated between the professional groups (Bourges-Waldegg et al., 2000; Li et al., 2024).

It is important to learn about these nuances as it assists in the early stages of the development of a domain ontology, namely domain analysis and conceptualization (Sattar et al., 2020). By learning how close, and in some cases how far, the professional groups are in their understanding of the terminology can serve as the foundation for future ontological work.

RQ1.1: What is the degree of consensus within the user experience design group on the importance of learnability factors?

Conducting Krippendorff's Alpha on the UX group showed a low level of reliability (α = 0.106) between raters. While the KA is indicative of low agreement, there is a greater level of agreement in the UX group when compared to the LD group. In terms of coefficient of variance, attributes that had the smallest variance in their ratings were interface understandability (19.2%), familiarity (23.5%), and generalizability (24.2%). The highest level of variance was in the importance of transitions (39.0%), task flow (40.5%), and task complexity (42.6%). These results were supported in the literature, where other researchers have acknowledged disputes between terminology and concepts for UX professionals (Luther et al., 2020). Similar studies have found low levels of consensus among UX design professionals on the topics of methodology selection (Borgholm & Madsen, 1999) as well as the overall subjectivity of UX roles and responsibilities (Law et al., 2014).

RQ1.2: What is the degree of consensus within the learning design professional group on the importance of learnability factors?

Conducting Krippendorff's Alpha on the LD group showed a low level of reliability (α = 0.036) between raters when looking at their collective ratings of importance on all attributes. Such a low rating indicates that there is virtually no agreement among raters. This lack of agreement can also be seen in the coefficient of variance of individual attributes. Attributes that had the smallest variance in their ratings were consistency (21.0%), engagability (21.6%), and navigability (21.9%). The highest level of variance was in the importance of generalizability (34.4%), transitions (36.7%), and visibility of operations (39.2%). Challenges of reaching consensus within LD professional groups have been discussed in other contexts, including lack of agreement in evaluation (Williams et al., 2011) and expectations in roles and responsibilities (Pollard & Kumar, 2022).

Importance of findings in RQ1.1 and 1.2. Both sub-research questions highlighted the lack of consensus within groups. This indicates that both professional groups could benefit from standardization of terminology and shared understanding of definitions. This assertion is supported by the work of Vargo et al. (2003), in which consensus issues were recommended to be addressed by the introduction of prior training, collaborative assessment practices, and clear rubrics for rating systems. In addition, other studies have noted the importance of consensus of terminology specifically within both the UX (Luther et al., 2020) and LD (Gardner & Allen, 2021) professional groups. This compliments the purpose of domain ontologies, in which disciplines formalize the terms that they use (McDaniel & Storey, 2019). Domain ontology touts many benefits that could help align understanding both within and between the professional groups. First, the establishment of a common vocabulary can reduce misunderstandings (Gruber, 1995). This would be key in encouraging the two professional groups to work together more seamlessly as they would have the same understanding of the domain. This benefit could be seen within the first two overarching steps of the domain ontology creation process: domain analysis and conceptualization (Sattar et al., 2020).

Ontology establishment also enhances interoperability and integration. While this benefit is generally discussed in the context of system integration in domain ontology, it can also be applied to the use of shared tools and data sources (Noy & McGuinness, 2001; Uschold & Gruninger, 2004). In the case of UX and LD, this could encourage shared assessment and evaluation tools, such as usability heuristics and learning measurement methodologies. This benefit would be seen during the third and fourth steps of the domain ontology creation process: implementation and evaluation (Sattar et al., 2020).

Establishment of ontologies also supports future research by improving data quality and improving search and retrieval. Because of the added clarity that ontologies provide, data would become more consistent over time (Smith & Welty, 2001). With a common set of terms in place, information queries may become more focused and produce more targeted results due to the structured representation of the ontology (Guarino, 1998). These benefits would be seen during the final overarching phase of the ontology creation process: instantiation (Sattar et al., 2020).

RQ2: What is the difference in how learnability factors are rated by importance between user experience design and learning design experts?

The results of the *t*-test produced a statistically significant difference in the mean scores between the two groups, $t(107) = -2.012$, $p = .047$. This result indicates that the two professional groups are different in how they rate the importance of attributes, with LD professionals generally rating higher importance on average.

The chi-square test was also conducted on each individual attribute to determine item-level differences in group responses. This due diligence of treating the data differently than looking at only composite means allowed the researcher to identify individual attributes that demonstrated statistical significance, which is influenced by the conclusions of Law et al. (2009), who described the identification of individual attributes assisting in the development of user-centered design. Of the 27 attributes, only continuity of task sequences, engagability, interface understandability, locating, navigability, and task match were of statistical significance. These identified attributes have been highlighted as important parts of learnability in the literature (Chimbo et al., 2011; Grossman et al., 2009; Hornbæk, 2006; Linja-Aho, 2005; Nielsen, 1993; Rafique et al., 2012; Tan et al., 2013). In addition, Cramér's V indicated relatively strong association for engagability and locating, while continuity of task sequences, interface understandability, navigability, and task match demonstrated moderately strong associations. Table 25 displays each statistically significant learnability attribute, the number of respondents from each professional group, and the response percentage for each attribute's level of importance.

Table 25

Statistically Significant Learnability Attribute Importance by Professional Group

	Attribute Importance									
	Not at all Important		Slightly Important		Important		Very Important		Extremely Important	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%
Continuity of Task Sequences										
UX (*n*= 39)	1	2.6%	6	15.4%	12	30.8%	12	30.8%	8	20.5%
LD (*n*= 70)	1	1.4%	3	4.3%	11	15.7%	28	40.0%	27	38.6%
Engagability										
UX (*n*= 39)	2	5.2%	5	12.8%	19	48.7%	8	20.5%	5	12.8%
LD (*n*= 70)	-	-	2	2.9%	22	31.4%	26	37.1%	20	28.6%
Interface Understandability										
UX (*n*= 39)	-	-	2	5.2%	4	10.3%	21	53.8%	12	30.8%
LD (*n*= 69)	-	-	3	4.3%	7	10.1%	19	27.5%	40	58.0%
Locating										
UX (*n*= 39)	2	5.2%	1	2.6%	16	41.0%	16	41.0%	4	10.3%
LD (*n*= 69)	-	-	3	4.3%	9	13.0%	30	43.5%	27	39.1%
Navigability										
UX (*n*= 38)	-	-	4	10.5%	4	10.5%	20	52.6%	10	26.3%
LD (*n*= 68)	-	-	-	-	4	5.9%	22	32.4%	42	61.8%
Task Match										
UX (*n*= 37)	2	5.4%	4	10.8%	13	35.1%	14	37.8%	4	10.8%
LD (*n*= 66)	-	-	1	15.4%	22	33.3%	29	43.9%	14	21.2%

These results are important because it allows future studies to focus on the attributes that were rated most differently between the groups. This research could contribute to reaching a more unified understanding of the terms, the refinement of which will be of great benefit to design endeavors (Rogers et al., 2011). Alternatively, it is also possible that perceptions of level of importance may contribute to the lack of consensus equally or more so than definition alone. Because of this, it may be valuable to explore multiple root causes prior to attempting to reach greater agreement.

Recommendations

This study serves as a foundational piece of understanding how UX and LD professionals understand learnability and how each learnability attribute is important to the concept of learnability. While interface understandability, navigability, and consistency were rated as the three most important attributes by both professional groups, most other attributes did not follow a consistent pattern of importance rating. In addition, there was little to no agreement within or between professional groups when it came to rating the individual attributes in terms of importance for learnability. There were statistically significant differences between rating both in terms of composite mean and individual attribute rating, indicating some level of difference in how the groups as a whole rate attribute importance.

Implementing Findings

The most practical use of this information is to begin the development of domain ontologies, as well as establishing a research agenda to explore future implications. The fact that all attributes were rated with some level of importance proves that the extant literature has captured many of the aspects of learnability attributes. However, this is only the first step in ontology development. While we have established what currently exists through literature review, a formal development of the new ontology has not taken place. Next steps may be to follow specific ontology models, such as Gangemi’s (2003) ONIONS lifecycle, HCI frame-based ontology (Bakaev & Avdeenko, 2012), or an adaptation of usability guideline ontology (Robal et al., 2017).

Future Research

This study opens the door for further exploration into the dynamics of the UX and LD professional groups and how they understand learnability. One of the underlying purposes of this study was to set a baseline of understanding of how the two professional groups understood learnability. The results established that UX professionals lack consensus in how they score importance of learnability attributes, and LD professionals encountered the same lack of agreement. Furthermore, there was also a statistically significant difference in how the professional groups rated learnability attributes as a whole. These results indicate the need to further research each professional group to better understand the lack of agreement. This could lead to future studies with a focus on facilitating shared understanding.

In addition, this study focused on learnability as a facet of usability, as well as the attributes that comprised it. The exploratory PCA indicated six constructs of learnability attributes that could be further explored. The composite means explored in the independent samples *t*-test and the attribute-level chi-square analysis indicated that the difference in some of the attribute ratings were statistically significant, which could also be further investigated. While this study focused on establishing if there was a difference in learnability attribute ratings, future studies could expand on this research by looking into why the differences presented.

Overall, this study established differences between and within professional groups, as well as differences in the importance of learnability attributes. Future research could focus on any of these facets of the study, including consensus amongst UX professionals, consensus amongst LD professionals, consensus between UX and LD professional groups, learnability as a facet of usability, and learnability attributes.

Professional Group Research

Because consensus was low or very low within professional groups, studying each professional group on its own would be beneficial. Incorporating qualitative or mixed-methods studies may provide more detailed insight than quantitative studies alone, as suggested by

Creswell and Clark (2017). In addition, because the scope of this study was focused on learnability, more general studies around how the two professional groups are similar or dissimilar could add new insight to interprofessional collaboration opportunities. Comparative case studies may be conducted to learn more about the attitudes and opinions of each group, particularly around their audiences, focuses, and assessment tools, as supported by Leedy and Ormrod (2019).

Learnability Research

Future studies on learnability and its attributes may help in unifying understanding across multiple domains. For example, utilizing a Q Methodology to rate learnability attributes may be a new way to rank and organize subjective opinions around learnability (Coogan & Herrington, 2011). In addition, the formal development of a domain ontology for learnability could prove beneficial for both UX and LD professions. Furthermore, the exploratory PCA was not a major focus of the present study but showed promising indicators for future research. Because the PCA resulted in six constructs, it may be of value to conduct confirmatory factor analysis to test specific hypotheses regarding the structure of the data.

Finally, because the primary focus of this study was around learnability attributes, additional research could be conducted around understanding the concept of learnability itself. The current study included open-ended questions related to personal definitions of learnability and usability, which could be further explored and coded thematically (Saldaña, 2021) for a richer definition of these terms beyond what has been identified in current literature or industry standards.

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APPENDIX A: HUMAN SUBJECTS REVIEW APPROVAL

OLD DOMINION UNIVERSITY

OFFICE OF THE VICE PRESIDENT FOR RESEARCH

aaalac INTERNATIONAL PROUDLY, AN AAALAC ACCREDITED PROGRAM

Physical Address
4111 Monarch Way, Suite 203
Norfolk, Virginia 23508
Mailing Address
Office of Research
1 Old Dominion University
Norfolk, Virginia 23529
Phone(757) 683-3460
Fax(757) 683-5902

DATE:	January 3, 2024
TO:	Mohan Yang
FROM:	Old Dominion University Education Human Subjects Review Committee
PROJECT TITLE:	[2141019-1] A Study of Learnability in Software as Perceived by Practitioners in User Experience and Learning Design Professions
REFERENCE #:	
SUBMISSION TYPE:	New Project
ACTION:	DETERMINATION OF EXEMPT STATUS
DECISION DATE:	
REVIEW CATEGORY:	Exemption category #2

Thank you for your submission of New Project materials for this project. The Old Dominion University Education Human Subjects Review Committee has determined this project is EXEMPT FROM IRB REVIEW according to federal regulations.

We will retain a copy of this correspondence within our records.

If you have any questions, please contact John Baaki at (757) 683-5491 or jbaaki@odu.edu. Please include your project title and reference number in all correspondence with this committee.

This letter has been electronically signed in accordance with all applicable regulations, and a copy is retained within Old Dominion University Education Human Subjects Review Committee's records.

APPENDIX B: MAJOR USABILITY ASSESSMENT METHODS AND CITATIONS

The following list contains usability assessment methods that have been discussed and used in the literature. Any articles in the used by column also discuss the assessment method, but they have been omitted from the discussed by column to avoid repetition.

Usability assessment methods and citations

Method	Discussed By	Used By
Action analysis	Paz et al., 2015	Zec & Matthes, 2018
Automated tools	Paz & Pow-Sang, 2016	Byrne et al., 1994; Ivory & Chevalier, 2002; Ivory & Hearst, 2001; Santos & Badre, 1995
Cognitive walkthrough	Agbozo, 2023; Dix et al., 2004; Hollingsed & Novick, 2007; Hussain et al., 2018; Jacobsen, 1999; Kim, 2015; Nielsen, 1994b; Paz et al., 2015; Paz & Pow-Sang, 2016; Preece et al., 2015; Santos & Badre, 1995; Wilson, 2013	Ambarwati & Mustikasari, 2021; Jeffries et al., 1991;
Diary method	Faizan, 2018	Rieman, 1996
Domain-specific inspection	Paz & Pow-Sang, 2016	
Electroencephalogram (EEG)	Bañuelos-Lozoya et al., 2021	Stickel et al., 2007
Eye tracking	Bañuelos-Lozoya et al., 2021; De Kock et al., 2008; Dix et al., 2004; Paz & Pow-Sang, 2016	Chimbo et al., 2011
Field study	Ammar, 2019; Dix et al., 2004; Paz & Pow-Sang, 2016; Santos & Badre, 1995	Czerniak et al., 2017
Focus groups		Preece et al., 2002; Kim, 2015; Paz & Pow-Sang, 2016;
Formal usability inspections		Agbozo, 2023; Nielsen, 1994b; Wilson, 2013
Formal modeling		Lin et al., 1997
Galvanic skin response (GSR)		Bañuelos-Lozoya et al., 2021
Guidelines	Paz & Pow-Sang, 2016	Jeffries et al., 1991; Lin et al., 1997
Heuristic evaluation	Agbozo, 2023; Almansour, 2017; Ambarwati &	Faizan, 2018; Bailey et al., 1992; Bertini et al., 2006; De

	Mustikasari, 2021; Bailey et al., 1992; Bertini et al., 2006; De Kock et al., 2008; Dix et al., 2004; Folmer et al., 2003; Fu et al., 2002; Hollingsed & Novick, 2007; Hussain et al., 2018; Jeffries et al., 1991; Jooste et al., 2014; Kim, 2015; Lin et al., 1997; Nielsen, 1994a; Nielsen, 1994b; Paz et al., 2015; Paz & Pow-Sang, 2016; Quiñones et al., 2018; Wilson, 2013	Kock et al., 2008; Fernández et al., 2013a; Hussain et al., 2018
Interview	Almansour, 2017; Dix et al., 2004; Kim, 2015; Paz & Pow-Sang, 2016	Chimbo et al., 2011; Faizan, 2018; Linja-aho, 2005; Rieman, 1996
Lab experiments	Ammar, 2019; Dix et al., 2004; Kim, 2015	Czerniak et al., 2017; Elliott et al., 2002; Lewis, 1994; Zec & Matthes, 2018
Narration approach		Tan et al., 2013
Observations	Dix et al., 2004; Mitta & Packebush, 1995	Chimbo et al., 2011; Coyle & Peterson, 2016; Linja-aho, 2005; Santos & Badre, 1995; Senapathi, 2005; Tan et al., 2013;
Question-suggestion protocol		Grossman et al., 2009
Survey or questionnaire	Dix et al., 2004; Kim, 2015; Lewis, 2014; Paz & Pow-Sang, 2016;	Agarwal et al., 2017; Almansour, 2017; Ammar, 2019; Elliott et al., 2002; Gediga et al., 1999; Jooste et al., 2014; Linja-aho, 2005; Naumann & Wechsung, 2008; Paymans et al., 2004; Rafique et al., 2012; Santoso & Schrepp, 2018; Senapathi, 2005; Sharma et al., 2008; Tan et al., 2013;
Task-based		Chistyakov et al., 2016
Think aloud	Almansour, 2017; Dix et al., 2004; Lin et al., 1997; Paz & Pow-Sang, 2016	Carroll et al., 1985; Law et al., 2007; Mack & Robinson, 1992
Usability testing	Almansour, 2017; De Kock et al., 2008; Fu et al., 2002; Hollingsed & Novick, 2007; Jeffries et al., 1991; Lin et al., 1997; Paz & Pow-Sang, 2016	Bailey et al., 1992; Chimbo et al., 2011; Coyle & Peterson, 2016; Czerniak et al., 2017; Jacobsen, 1999

Video recording		Chimbo et al., 2011, Law et al., 2007
Web Usability Evaluation Process (WUEP)	Paz & Pow-Sang, 2016	Fernández et al., 2013a

APPENDIX C: SURVEY INSTRUMENT

Introduction:
Thank you for taking the time to answer our questionnaire, we greatly value your contribution to this study.

The purpose of this study is to better understand the perceptions of user experience and learning design professionals on learnability factors in the software context. We invite those that work or conduct research in the fields of user experience (such as user experience designers, interaction designers, experience strategy designers, etc.) and learning design (such as instructional designer, learning experience designer, technical trainer, etc.) to complete a brief survey that will ask about personal definitions of usability and learnability, how important specific learnability attributes are to the learning process, and the importance of learnability as a factor in the design of a product or learning/training.

The survey is anonymous with the option to include contact information for future studies and should take 10-20 minutes to complete.

P.S.: This survey contains credits to get free survey responses at SurveySwap.io

Section 1: Demographics

The following section will allow the researcher to group and analyze responses appropriately based on professional group and years of experience in the field. For the purpose of this study, the following professional group definitions will be used:

- **User Experience Design (UX)** professionals work or conduct research in User Experience design roles and may include User Experience Designer, Interaction Designer, Experience Strategy, etc.
- **Learning Design (LD)** professionals work or conduct research in education roles and may include Instructional Designer, Learning Experience Designer, Technical Trainer, etc.

1. Please select your professional group.
   - o User Experience (UX)
   - o Learning Design (LD)

2. How many years have you been working in your respective field?
   - o Less than one year
   - o 1-2 years
   - o 2-4 years
   - o 4-6 years
   - o More than 6 years
   - o Don't know/Not sure

3. What industry do you work in?
   - o Computing, Software, and IT
   - o Finance and insurance
   - o Consultancy

- Education
- Government and Military
- Healthcare
- Retail
- Media, Publishing, and Printing
- Advertising
- Telecommunications
- Business
- Entertainment
- Aerospace and Automotive
- Non-profit
- Emerging technologies
- Other _________________

Section 2: Usability and Learnability

The overarching concept of usability (and its many attributes, including learnability) carries many different interpretations within current research.

The following section will ask you to provide your interpretation of usability, learnability, and how learnability is gauged.

4. What is your personal definition of Usability? Is it one you have made yourself, or do you follow a standard definition from industry or literature?

   ____

5. What is your personal definition of Learnability? Is it one you have made yourself, or do you follow a standard definition from industry or literature?

   ____

6. How do you determine how "learnable" a software is? Do you have personal guidelines?

   ____

Section 3: Learnability Attributes

The current literature identifies attributes of learnability. This section asks you to interpret each attribute individually and rate its overall importance to the learnability of a software. In other words, how important is __________ as a factor in how easy or difficult it is to learn to use software.

Select the importance of each attribute towards overall learnability of a software. To view definitions, you may refer to Learnability Attribute Operational Definitions. (1/4)

	Not at All Important	Slightly Important	Important	Very Important	Extremely Important
7. Awareness	○	○	○	○	○
8. Consistency	○	○	○	○	○
9. Continuity of Task Sequences	○	○	○	○	○
10. Design Conventions	○	○	○	○	○
11. Engagability	○	○	○	○	○
12. Error Prevention	○	○	○	○	○
13. Familiarity	○	○	○	○	○

Select the importance of each attribute towards overall learnability of a software. To view definitions, you may refer to Learnability Attribute Operational Definitions. (2/4)

	Not at All Important	Slightly Important	Important	Very Important	Extremely Important
14. Feedback	○	○	○	○	○
15. Generalizability	○	○	○	○	○
16. Information Presentation	○	○	○	○	○
17. Interface Understandability	○	○	○	○	○
18. Locating	○	○	○	○	○
19. Mental Effort	○	○	○	○	○
20. Minimal Action	○	○	○	○	○

Select the importance of each attribute towards overall learnability of a software. To view definitions, you may refer to Learnability Attribute Operational Definitions. (3/4)

	Not at All Important	Slightly Important	Important	Very Important	Extremely Important
21. Navigability	○	○	○	○	○
22. Operational Momentum	○	○	○	○	○
23. Predictability	○	○	○	○	○
24. Prompting	○	○	○	○	○
25. Simplicity	○	○	○	○	○
26. Synthesizability	○	○	○	○	○
27. System Guidance Appropriateness	○	○	○	○	○

Select the importance of each attribute towards overall learnability of a software. To view definitions, you may refer to Learnability Attribute Operational Definitions. (4/4)

	Not at All Important	Slightly Important	Important	Very Important	Extremely Important

28. Task Complexity	○	○	○	○	○
29. Task Flow	○	○	○	○	○
30. Task Match	○	○	○	○	○
31. Transitions	○	○	○	○	○
32. Understanding	○	○	○	○	○
33. Visibility of operations	○	○	○	○	○

Section 4: Wrap-Up

Thank you for your insight regarding learnability attributes. This final section is intended for you to provide any additional insight or information related to your perception of learnability attributes for software development and education.

34. In the previous section, you rated the following attributes on an importance scale:

    Awareness - Consistency - Continuity of Task Sequences - Design Conventions - Engagability - Error Prevention - Familiarity - Feedback - Generalizability - Information Presentation - Interface Understandability - Locating - Mental Effort - Minimal Action - Navigability - Operational Momentum - Predictability - Prompting - Simplicity - Synthesizability - System Guidance Appropriateness - Task Complexity - Task Flow - Task Match - Transitions - Understanding - Visibility of Operations

    Importance:
    Not at all Important - Slightly Important - Important - Very Important - Extremely Important

    What, if any, additional learnability attributes would you add to this list? Please include the corresponding importance level for each.

    ____

35. When developing a product or learning/training strategy, how does the learnability of a software impact your design decisions?

    ____

36. Are there any questions you wish we had asked that we didn't?

    ____

37. OPTIONAL: If you would be willing to participate in additional studies on learnability, please include your name and contact information below. Your information will only be used to invite you to participate, which will be optional. ____

APPENDIX D: LEARNABILITY ATTRIBUTE OPERATIONAL DEFINITIONS

SURVEY SUPPLEMENT

Learnability Attributes

Term	Definition	Reference(s)
Awareness	Making the user aware of information and/or functionality.	Grossman et al., 2009
Consistency	Uniformity in the user interface and how the system functions operationally.	Chimbo et al., 2011; Dix et al., 2004; Folmer et al., 2003; Payne & Green, 1986; Seffah et al., 2006; Senapathi, 2005; Tan et al., 2013
Continuity of task sequences	The ability to complete a task in a continuous process rather than having to navigate through multiple menus and steps.	Linja-aho, 2005
Design Conventions	How similarly or differently a system is designed in comparison to other common systems.	Linja-aho, 2005
Engagability	"The extent to which a software application can fully engage the user by providing a complete and satisfying user experience" (p.401).	Chimbo et al., 2011
Error Prevention	Where design of the interface prevents users from making common mistakes.	Linja-aho, 2005
Familiarity	How easily an application can be mapped to prior experiences into the new system.	Chimbo et al., 2011; Dix et al., 2004; Seffah et al., 2006; Senapathi, 2005
Feedback	How a system responds to user actions	Ammar et al., 2016; Ammar, 2019; Folmer et al., 2003; Rafique et al., 2012; Senapathi, 2005
Generalizability	The user's ability to extend their knowledge of interaction in and across other applications to new but similar situations.	Chimbo et al., 2011; Dix et al., 2004

Information presentation	Detailed descriptions of components via dialog box.	Linja-aho, 2005;
Interface Understandability	How easy the interface is to understand without prompting.	Rafique et al., 2012; Hornbæk, 2006
Locating	The user's ability to find functionality within the system.	Grossman et al., 2009
Mental Effort	The mental effort or amount of information that must be kept in mind to complete a task.	Hornbæk, 2006; Seffah et al., 2006; Tan et al., 2013
Minimal Action	The software's ability to help the user complete their tasks in the least number of steps.	Seffah et al., 2006; Tan et al., 2013
Navigability	How easy it is to navigate through the system.	Tan et al., 2013
Operational Momentum	"The degree to which the software helps the user to guide on to the next stage, iteratively if necessary" (p. 2445).	Rafique et al., 2012
Predictability	How well a user can predict their next action.	Ammar et al., 2016; Ammar, 2019; Dix et al., 2004; Folmer et al., 2003; Rafique et al., 2012; Senapathi, 2005
Prompting	The ability to orient/provide in-app guidance.	Ammar et al., 2016 Ammar, 2019
Simplicity	"Whether extraneous elements are eliminated from the user interface without significant information loss" (p171).	Seffah et al., 2006
Synthesisability	When the system provides an observable notification about internal changes of state.	Chimbo et al., 2011; Dix et al., 2004
System Guidance Appropriateness	The guidance provided to a user to assist when errors occur or to improve the user's experience in completion of tasks.	Rafique et al., 2012; Seffah et al., 2006; Tan et al., 2013
Task complexity	The level of challenge in completing a task, which may include complexity in structure, resources, or interaction.	Liu & Li, 2012
Task Flow	Knowing what is needed to accomplish a certain task.	Grossman et al., 2009

Task Match	"The degree to which an application is able to provide exactly the information and functionality that the user needs in order to accomplish his tasks with the product" (p. 2445).	Rafique et al., 2012
Transitions	When a user can move into more efficient behavior.	Grossman et al., 2009
Understanding	Knowing how to use the functionality of the system.	Grossman et al., 2009; Hornbæk, 2006
Visibility of Operations	The ability to see possible operations in the system and what is required to perform them.	Linja-aho, 2005;

APPENDIX E: CALLS FOR PARTICIPATION

Request email for professional associations and listservs

Subject: Call for Research Study Participation

Body:
Hello,
I am conducting a research study for my doctoral dissertation that targets those that work or conduct research in the fields of user experience (such as user experience designers, interaction designers, experience strategy designers, etc.) and learning design (such as instructional designer, learning experience designer, technical trainer, etc.). I seek to better understand their perceptions on learnability factors in the software context. This study has been reviewed and approved by Old Dominion University's IRB and should take 10-20 minutes to complete. Would it be possible for you to disseminate the following call for participation to your members?

Best,
Courtney N. Miller

Call for participation - Email

Subject: Call for Research Study Participation

Body:
Dear Colleagues,
I am conducting research to better understand the perceptions of user experience and learning design professionals on learnability factors in the software context. I am inviting those that work or conduct research in the fields of user experience (such as user experience designers, interaction designers, experience strategy designers, etc.) and learning design (such as instructional designer, learning experience designer, technical trainer, etc.) to complete a brief survey that will ask you about your personal definitions of usability and learnability, how important specific learnability attributes are to the learning process, and the importance of learnability as a factor in the design of a product or learning/training. The survey is anonymous with the option to include contact information for future studies and should take 10-20 minutes to complete. Your participation would be greatly appreciated, and I encourage you to share this call for participation within your professional networks if possible.

Questions? Contact: Courtney N. Miller

Direct Link: [Insert link here]

Call for participation – social media

Targeted sites: LinkedIn, Facebook

Post:

Call for Research Participation
Do you work or conduct research in a user experience (such as user experience designers, interaction designers, experience strategy designers, etc.) or learning design (such as instructional designer, learning experience designer, technical trainer, etc.) role? For my doctoral dissertation, I want to better understand the perceptions of user experience and learning design professionals on learnability factors in the software context. If this sounds like you, please take this brief (10-20 min) survey! If this doesn't sound like you, please consider sharing this post in your network for others that may fit the bill.

Questions? Contact: Courtney N. Miller

Direct Link: [Insert link here]

APPENDIX F: ASYNCHRONOUS THINK ALOUD FEEDBACK

Link: https://odu.co1.qualtrics.com/jfe1/preview/previewId/04d3320a-7077-4e27-a7e1-2227b155160a/SV_d12h5XO1NnuQowm?Q_CHL=preview&Q_SurveyVersionID=current

Feedback:

Intro page:
It's good that you've included how much time it might take for the participant to complete the survey. Also, maybe include information on data management for example - your data will be only used for the research purposes etc.

Section 2
Section 2: Usability and Learnability

The overarching concept of usability (and its many attributes, including learnability) carries many different interpretations within current research. This section asks you to provide your interpretation of usability, learnability, and how learnability is gauged.

The above text is a little confusing, maybe separate the general concept part and then in the next paragraph ask the participants what according to them is usability and learnability.

What is your personal definition of Usability? Is it one you have made yourself, or do you follow a standard definition from industry or literature?
While answering the above question, the user may not answer the highlighted part. If you are planning to have that data as well maybe an additional question will do. (Just a suggestion)

Section 3
The current literature identifies attributes that contribute to the learnability of a software.
Maybe make this line more simple to understand

To view definitions, you may refer to Learnability Attribute Operational Definitions.
Maybe you can use this line at the start of section 3 as well

Section 4

Importance:
Not at all Important - Slightly Important - Important - Very Important - Extremely Important

I do not know what to do for this part- maybe include that i need enter xyz information

How important is learnability as a factor in your design of a product or learning/training strategy?

Extremely important

Are there any questions you wish we had asked that we didn't?

Learner's guidance
Learner's confidence

For this part you've asked how important is learnability but there's no scale provided to the participant. It may confuse the other participants as well.

VITA

Courtney N. Miller

EDUCATION

M.L.I.S., Library & Information Science (May 2013), San Jose State University, San Jose, CA
B.A., Communication (May 2009), University of South Florida (Honors College), Tampa, FL

EMPLOYMENT

Director, Enterprise Learning (Mar 2022 – Present) *Togetherwork*
Director of Knowledge Development (and lower roles) (Feb 2020 – March 2022) *Fonteva (A Togetherwork Product)*
Education Consultant (May 2016 – Jan 2020*) Carilion Clinic*

RECENT PUBLICATIONS & PRESENTATIONS

Yang, M., Miller, C., Crompton, H., Pan, Z., & Glaser, N. (2024). The implementation of virtual reality in organizational learning: Attitudes, challenges, side effects, and affordances. *TechTrends, 68*(1), 111-135. https://doi.org/10.1007/s11528-023-00917-y

Yang, M., & Miller, C.N. (2023, October 15-19). *Digital transformation and organization training: Insights from L&D leaders* [Conference presentation]. Association for Educational Communications and Technology International Conference, Orlando, FL, United States.

Miller, C.N. (2023). Theories of workplace learning in changing times. *International Review of Education.* https://doi.org/10.1007/s11159-023-10032-y

PROFESSIONAL SERVICE & MEMBERSHIP

The Association for Educational Communications and Technology (AECT), *Member (June 2021 - Present)*

AWARDS

Certificate of Outstanding Service of Scholarly Peer Review, *Journal of Computing in Higher Education.*
"The Fire Walker" Cube award, *Fonteva*
Quality Award for Excellence in Advancing Care Delivery, *Carilion Clinic*

CERTIFICATES

Social and Behavioral Responsible Conduct of Research, *CITI Program*
Lean Sensei Certification, *Villanova University*
Jira Service Desk Administrator Training, *Hilsmier Consulting*
Crucial Conversations, *VitalSmarts*