# Usability Evaluation in Selecting Educational Technology

Sonja Dimitrijević*, Vladan Devedžić **
* Mihailo Pupin Institute, Belgrade, Serbia
** Faculty of Organizational Sciences, University in Belgrade, Belgrade, Serbia
sonja.dimitrijevic@pupin.rs, devedzic@gmail.com

**Abstract - Usability is important to consider when selecting technology for educational use in a learning environment. It can influence learning and teaching experience, and consequently adoption and retention of educational technology. The objective of this study is to (1) analyze and systematize usability methods and attributes that scholars have considered in the context of educational technology selection in higher education, (2) analyze pedagogical criteria, and (3) the learner/teacher perspective in the identified approaches, as well as to (3) identify future research perspectives in this regard. Therefore, a systematic research review has been conducted and 45 papers have been selected and analyzed. Analytical methods, particularly expert assessment, have been more often reported than empirical methods. The most frequent usability attribute is ease of use. Most of the studies have addressed pedagogical criteria to some extent. Almost a half of the studies have attempted to consider the learner/teacher perspective by involving actual or prospective users. There is a need for a relatively simple and efficient, yet effective enough, usability evaluation that fits well into the educational technology selection. However, it is mostly unverified how well the reported approaches meet this need. Notwithstanding, there are positive examples that deserve attention and further research.**

## I. INTRODUCTION

Higher Education Institutions (HEIs) face rapidly changing technological advancements. Through the use of Information and Communication Technology (ICT), educators in HEIs need to discover or adapt ways for enhancing student learning, performance and satisfaction [1]. However, in a myriad of ICT platforms and applications available today, choosing the appropriate ones for students is time-consuming, difficult and troublesome process for institutions and educators [2][3]. The selection process usually relies on a number of criteria such as functionality, pedagogical concerns, usability, etc. These criteria vary depending on the technology and the learning context.

Usability is an important, yet demanding selection criterion. Inadequate usability may make learning more difficult [4] and may even affect student's achievement [5]. Moreover, usability is seen as an important factor in mitigating learner frustration and anxiety [6][7]. Poor usability of educational technology can leave negative consequences on the learning experience and motivation of learners [6].

Consequently, usability may influence directly or indirectly educators' decision about educational technology integration [8] and students' willingness to use or to continue to use educational technology [9][10][11].

According to one of the most cited definitions, which was provided by International Organization for Standardization (ISO), usability is "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of us" [12]. Nielson has provided another highly cited definition of usability through its five attributes: learnability, efficiency, memorability, errors and satisfaction [13]. In addition to his vision of multidimensionality of this concept, many other attributes have been proposed in literature and used in practice to operationalize and evaluate/measure usability. According to another view, usability definitions may serve to explain what usability is, whereas the usability measuring techniques may be unrelated directly to usability elements (e.g., identification and description of usability problems) [14].

Consequently, a variety of evaluation methods have been employed to measure usability. One of the basic classifications includes analytical methods, which are conducted by usability experts (e.g., inspections), and empirical methods, which require participation of real users, thus involve usability testing and inquiry methods (questionnaires and surveys) [15].

Some authors have argued that usability of educational technology, i.e., technology employed for educational purposes, cannot be measured in the

same way as usability of other technology because of the specific nature of learning. On those grounds, several frameworks and methodologies that include both so-called technical and pedagogical usability have been proposed [16][17][18][19].

With the expansion of various types of ICT that are free, easy to access and useful for educational purposes, educators/teachers more and more become evaluators and decision makers in the selection process. A careful approach to usability when selecting or reconsidering technology already in use increase chances that users' effort is invested into teaching and learning effectiveness, and not into teaching and learning how to use technology. Yet, extensive usability evaluation is demanding and, thus, usually conducted or facilitated by usability experts in contexts rather different then technology selection. This brings up the question how the challenge of usability evaluation is met in learning environments of higher education when (re)considering the use of technology.

This systematic review aims at examining and analyzing what usability methods and attributes/criteria have been proposed or employed in studies on educational technology selection, and how they have been employed. Moreover, the review investigates whether and how pedagogical criteria have been addressed along with usability criteria, and how the learner and teacher perspective has been considered in the identified approaches.

The review highlights the need for fostering educators' competencies in evaluating, selecting and integrating educational technology. In this regard, the future research perspectives that have been identified or implied in the article can be worthwhile to consider. Moreover, it informs educators/teachers and interested parties on prospective usability approaches that can be taken when evaluating and comparing technology alternatives. At the same time, the review warns of disputable validity and effectiveness of some approaches that have been proposed in literature.

## II. METHOD

A systematic literature review has been conducted according to Kitchenham [20]. The following subsections describe the method details.

### *A. Research Questions*

The following research questions have been formulated:

RQ1: What methods have been proposed or employed in the context of educational technology selection to evaluate usability?

RQ2: What usability attributes, i.e. criteria, have been proposed or employed in the context of educational technology selection?

RQ3: How have pedagogical criteria been considered in the identified approaches?

RQ4: How has the learner and teacher perspective been considered in the identified approaches?

In addition, the types of studies, as well as the categories of educational technology have been reported.

### *B. Search Strategy*

The search for relevant studies has been performed by using the following recognized sources: SCOPUS, ACM, ISI (Web of Science & Web of Knowledge) and IEEE digital libraries.

All the papers published before 2019 have been considered. After testing several search strings for retrieving relevant studies, the resulting search string has been as follows:

(usability OR 'ease of use' OR 'easy to use') AND (educational OR learning OR e-learning) AND (software OR platform* OR system* OR technolog*) AND (evaluation OR evaluating OR assessment OR assessing) AND (selection OR selecting OR choosing).

The search has also involved following up the references and the citations of the selected papers.

### *C. Inclusion Criteria*

The following inclusion criteria have been defined:

- A paper introduces a novel approach of educational technology evaluation, reports on an application of the existing evaluation approach, or presents a comparative study of educational technology, all in the context of technology selection.
- The evaluation approach reported in a paper involves, or is based on, usability criteria and/or methods.
- The evaluation approach is well described and applicable in higher education.
- The paper is written in English.

### *D. Selection of Primary Studies*

First, the search and selection of primary studies have been conducted by using the selected digital libraries. Then, the backward and forward snowballing has been conducted.

In the first phase, the title, abstract and keywords have been examined for all of the papers. In the second phase, the whole paper has been read and assessed for consistency and precision in writing.

The selection process has been facilitated with a template that had been developed to register relevant information about each resulting paper (ID, Reference, Type of publication, Name of the conference or journal, etc.)

### *E. Data Extraction Strategy*

1178 studies have been obtained from the digital libraries. After inspecting the papers, 40 papers have been selected for the analysis phase based on the inclusion criteria.

In addition, the 306 references have been followed up after excluding books, standards, handbooks, website references, and renowned publications whose topic is not relevant for the review. The inspection of the referenced papers has resulted in selection of 7 additional papers.

The citations have been tracked by using Google Scholar. The large number of citations of some papers has been narrowed down by browsing within citations with the search terms 'select*', 'choose' and 'usability'. The inspection of the 480 retrieved citing papers has resulted in selection of 9 additional papers.

After excluding 6 duplicates and a paper whose full text is not available, 49 relevant papers have been obtained. Due to the quality issues, specifically inconsistencies and imprecision in the writing, 4 of the relevant papers have been discarded. This makes in total 45 papers obtained for analysis.

For the purpose of data extraction and analysis, a template has been created (Study Reference, Type of Educational Technology, Evaluation Criteria Proposed, Usability Evaluation Approach, etc.).

## III. RESULTS

This section presents the results of the data analysis.

### *A. Types of Studies*

The following types of studies have been distinguished:

- comparative study (35.6%) - evaluates and compares a set of educational technology with the primary or secondary purpose to help decision makers in technology selection;
- methodology proposal (33.3%) - introduces a method(ology) for educational technology evaluation and/or decision making for the purpose of selection;
- technology selection (15.6%) - a study on educational technology selection conducted in a specific learning environment;
- model proposal (8.9%) - introduces a quality, evaluation or decision-making model that encompasses aspects found relevant for selection of a certain type of educational technology;
- criteria investigation (6.7%) - comprised a correlational study on selection criteria and two empirical studies on criteria elicitation.

Most of the model and methodology proposals also include technology evaluation/selection case studies or comparative studies to demonstrate the applicability of the model/methodology.

### *B. Categories of Educational Technology*

Over 40% of the studies have focused on e-learning platforms. 8.9% of these studies have focused specifically on open source e-learning platforms.

The four studies (8.9%) have dealt with educational technology in general. The remaining 48.9% studies have addressed different types of educational technology, such as dictionaries on smartphones [21], MOOC platforms [22], tutorial creation software [23], virtual learning environments [24], etc.

### *C. Usability Evaluation Methods*

A usability evaluation method that has been most often reported in the studies is expert assessment (21 studies). The other reported methods are: mixed approach (7 studies), user testing (4 studies), questionnaire-based evaluation (3 studies), heuristic evaluation (2 studies), checklist-based evaluation (2 studies) and survey (2 studies). Finally, two papers have introduced a new method. The remaining two studies have not considered any evaluation method due to their focus on selection criteria investigation.

### *D. Participants in Usability Studies*

In more than a half of the studies (23 out of 45), participants such as students, faculty members and experts (other than the authors) have been reported.

Two papers have avoided reporting the category of participants.

Participants have been involved in all types of studies except for checklist-based evaluation. Students have been the most frequent participants since they have participated in 14 of the studies involving user testing, surveys and questionnaire-based evaluation.

### *E. Usability Attributes / Criteria*

61 usability attributes have been specified in 39 of the analyzed studies. The remaining 6 papers have dealt with heuristics.

The usability attributes considered in more than five of the analyzed studies are ease of use (12 studies), (perceived) usability (8 studies), satisfaction (7 studies), efficiency (6 studies), effectiveness (5 studies), learnability (5 studies). Ease of learning and learnability are considered as the same attribute.

Most of the usability attributes have been proposed in only one of the studies. They typically have the terms "ease" or "easy" in their names, e.g., ease of access, ease of finding information, easy and fast access to contents. Such attributes may be considered as a subcategory of ease of use.

In addition, over 60% of the studies have reported the use of at least one usability metric for measuring the specified usability attributes. Subjective metrics such as scores based on different scales (e.g., a 1-to-5 rating scale) have been dominantly employed. Several studies have used objective metrics such as task completion time and task completion rate for expressing efficiency and effectiveness.

### *F. Pedagogical Criteria and Concerns*

Two approaches have fully integrated usability and pedagogical criteria. Squires and Preece [19] have proposed the 'learning with software' heuristics by combining usability heuristics with socio-constructivist criteria for learning. Similarly, the checklist of Bednarik et al. [25] has comprised the consequent parts devoted to technology, usability and pedagogy to guide educators in selection of educational software.

Two studies have considered technological and pedagogical aspects in their model proposals for selecting e-learning platform [26][27]. Likewise, the methodology proposal for selection of software tools for IT programs by Parker [28] has involved pedagogical features. Furthermore, a quantitative evaluation model that assesses attributes of LMS platforms introduced by Osma, et al. [29] has encompassed pedagogical criteria.

In addition to usability, King and Newman [30] have considered pedagogic issues and potential enhancement of students' employability skills as selection criteria. Similarly, Albarrak, Aboalsamh, and Abouzahra [31] have considered "curriculum mapping and planning" criteria. Among other criteria, the comparative study by Bastos and Machado [21] has involved "student perception of the pedagogical potential".

2 out of 3 studies on criteria investigation have resulted in categories of both pedagogical and usability criteria [32][33].

In addition, the pedagogical concerns have been more or less marginally addressed in many of the studies by considering features/functionality (e.g., [34]) and usefulness/utility (e.g., [35]) of the given technology.

## IV. DISCUSSION

This section discusses the results according to the research questions. Usability evaluation methods, usability attributes/criteria, pedagogical criteria and learner/teacher perspective have been discussed respectively.

### *A. Usability Evaluation Methods Proposed or Employed (RQ1)*

The dominant approach used for usability evaluation in the selection context is expert assessment. Used as an umbrella term, expert assessment has comprised simple qualitative reviews, such as learner or teacher reviews, quantitative assessments, as well as mixed assessments. It has been mostly conducted by the authors themselves. If we assume that they have taken the expert position, users' perspective is rarely taken into account. In addition, there is no much evidence of systematic assessment activities, expertise, or the number of the assessors. Therefore, the effectiveness of such methods is questionable.

What is not questionable is the need for simple and efficient (yet effective enough) usability evaluation approaches. This is evident in both analytical and empirical categories. It might be a reason why heuristics have not been proposed or employed more often. Another reason might be unfamiliarity of researchers/educators with this approach. Moreover, the focus of some studies on multiple criteria decision analysis has arguably

contributed to the prevalence of quantitative assessment.

With regard to empirical methods, user testing, when conducted, has been mostly informal and has involved a small number of participants, dominantly students. The more formal methods have required expertise and experience, even resources such as equipment, which are presumably common in Human Computer Interaction (HCI) university departments, but rarely beyond that. Therefore, the rare use of formal usability evaluation methods in selecting educational technology is not surprising.

It is somewhat surprising though that inquiry method has not been more often employed as a relatively simple and fast way to collect learners' and teachers' perception towards usability problems, and even collect some subjective usability metrics. A reason could be a viewpoint that the selection process is over when educational technology is introduced into a learning environment. However, there have been several approaches that oppose this viewpoint. To this end, usability evaluation or verification in the second (post-implementation) phase of the selection process, as well as field studies within the selection process with teachers' and learners' direct involvement could be a feasible approach.

Metrics can be a useful aid in comparing multiple technology alternatives. However, they have to be carefully selected, collected and interpreted. The use of a single metric, i.e., a metric obtained from a single measuring technique, like in most of the analyzed studies, can be misleading.

Whether new or existing, effectiveness of the reported usability approaches in selecting educational technology is largely debatable. Most of the studies lack a scientific evidence of effectiveness and validity of the approach in the given context. More empirical studies are needed to address the identified research gap.

### *B. Usability Attributes / Criteria Proposed or Employed (RQ2)*

Ease of use and, to somewhat smaller extent, 'perceived usability' have been the most frequently considered attributes/criteria in the analyzed studies. Many specializations of 'ease of use' have been noted, each in only one (e.g., ease of peer interaction) or two (e.g., ease of discussion with other learners) of the studies. In most of the cases, it is not quite clear why the particular usability attributes have been chosen and how they have been defined. It is possible that different terms have been used for the same attribute, even when it is not so obvious, like navigability and ease of navigation.

As standard usability attributes, effectiveness, efficiency and satisfaction [12] have been employed in the selection context to some extent, mostly in user testing. Usability attributes have been selected according to ISO/IEC 25010 [36] in one of the studies. No other standards have been considered when selecting usability attributes.

### *C. Pedagogical Criteria Proposed or Employed (RQ3)*

More than a quarter of the studies have explicitly involved pedagogical criteria along with usability criteria in the educational technology selection process. Moreover, a considerable number of the studies have marginally addressed them through consideration of functionality and utility/usefulness of the technology. Some of the studies, however, have had a specific focus on 'common' usability, or usability with several technical criteria such as accessibility, personalization, etc.

Although usability and pedagogical appropriateness have been typically seen in literature as complementary, only a couple of earlier approaches has attempted to fully integrate usability and pedagogical usability. Most of the studies more or less acknowledge both these aspects and evaluate them by using simple assessment methods, or separate methods/practices. The latter allows some well-known usability evaluation practices to be applied when addressing usability criteria in the selection context. However, the analyzed studies have mostly failed to address complementarity of these two aspects more profoundly.

### *D. Learner and Teacher Perspective (RQ4)*

The authors of the analyzed studies recognize the importance of considering the end user perspective when selecting educational technology. This is why they have addressed the usability criteria at all. Nevertheless, most of them have not involved learners and educators/teachers in the selection process. It is understandable for teachers, since most of the studies have been small scale, and probably only the authors themselves have been involved in teaching.

University students have participated in more than a third of the analyzed studies. Participation of both students and teachers in usability studies on educational technology is highly advisable.

Most approaches for eliciting the learner/teacher perspective have been based on a single

method/practice, which, without questioning the validity, limits their potential. The promising results could be expected from the mixed approaches. The joint practices of user testing and inquiry ensures an insight into usability evaluation from two perspectives: objective and subjective. Such efforts are rare though, presumably due to educators' perceptions that they are difficult to take and time-consuming, or educators' unfamiliarity with this kind of approaches.

Although under-applied, inquiry practices could be quite useful for obtaining the learner perspective from a larger number of learners. This has proved as feasible in the two-phase approaches in which the second phase implies the use of a preselected technology in a learning environment. The learner perspective elicited in an actual learning environment could be more revealing. The inquiry practices can also be useful in complementing each other (quantitative vs. qualitative) and complementing other practices.

Interestingly, there have been some attempts to consider the learner perspective by engaging students as learner experts. Although the procedures have not been described in sufficient detail, this could be a practice worth investigating further.

The perspectives of students and teachers have been considered jointly in few studies. None of the studies investigating selection criteria has not involved both, the learner and teacher perspective.

## V. CONCLUSIONS AND FUTURE PERSPECTIVES

Analytical usability methods prevail over empirical methods when selecting educational technology. Moreover, less formal methods prevail over more formal ones in both analytical and empirical categories. Specifically, expert assessment, which comprises informal reviews, quantitative and mixed assessment, is dominantly employed. User testing, whether separately or within a mixed approach, is employed almost two times less than expert assessment. It is mostly informal and involves small number of participants, mainly students. The inquiry methods are more used on a small scale (to complement user testing and heuristics) than on a larger scale and separately. Although the use of a single usability practice is not recommended, mixed approaches are under-applied.

Consequently, a significant number of usability attributes are reported, but most frequently ease of use and (perceived) usability. However, selection of usability attributes is not fully corroborated theoretically or empirically in many of the approaches.

Pedagogical criteria are, if not fully or partially integrated in the identified selection approaches, then marginally considered within the selection criteria of functionality and usefulness/utility in most of the studies. Yet, complementarity of usability and pedagogical appropriateness should be better addressed.

Scholars recognize the need for considering the learner and teacher perspective in the given context, but this comes with many difficulties. Less than a half of the studies attempted to elicit the learner/teacher perspective by involving actual or prospective users. Nevertheless, there are some promising results worth further investigation.

There is a clear need for relatively simple and efficient, yet effective enough, usability evaluation approaches that fit well the process of educational technology selection. However, effectiveness of the reported usability approaches, whether new or existing, is mostly unexplored or disputable, and requires further research in the given context or in particular sub-contexts. There is also enough research space for proposals of new approaches, or adapted usability and HCI practices with careful consideration of the educational context. Simple tools that facilitate the evaluation and selection should be considered as a part of some of these proposals. In addition, research in this area would benefit of more focused studies investigating usability attributes and metrics.

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