Model LEEM: Evaluating and improving the learner experience with the use of DICTs

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Abstract. *Learner eXperience (LX) can be defined as the perceptions and performance of learners interacting with learning environments, educational products, and resources. In this master's research, we proposed a model with different forms of assessment that allow the integration of most of the LX elements. The Learner Experience Evaluation Model (LEEM) aims to evaluate and improve LX using Digital Information and Communication Technologies. LEEM consists of three evaluation stages (pre, during, and post) to monitor and record LX progress continuously. In short, it is expected that LEEM will help educators rethink their teaching strategies when they notice that learners report difficulties with the resources adopted.*

1. Introduction

Learner eXperience (LX) is defined as the perceptions, responses, and performances of learners through interaction with a learning environment, educational products, and resources, among others [Huang et al. 2019]. Schmidt and Huang (2022) define LX as a specific class of user (the learner) engaged in a specific task (related to learning) while using a distinct type of technology (a technological tool designed for learning). Thus, for this work, the term LX was considered to be specifically related to the learner's experience using Digital Information and Communication Technologies (DICTs). Huang et al. (2019) state that LX is not only about achieving the intended results but also about satisfaction and other related subjective experiences, such as confidence and continued interest on the part of learners. The term Learner is used for students who are constantly learning or for professionals who put themselves in a position to learn, subjecting themselves to all the challenges faced when using DICTs [Soloway et al. 1994].

LX assessment is important because it allows different aspects of LX to be captured, allowing the diversity of learners and their learning preferences to be taken into account. Thus, Huang et al. (2019) recommend that LX be assessed holistically. The term holistic refers to considering different aspects of the experience in an integrated way [Huang et al. 2019]. For this evaluation to take place, it is necessary to observe and analyze which elements are most significant to the experience. In light of this, Huang et al. (2019) determine that LX with DICTs can be designed, improved, and evaluated through different elements, such as Value, Usability, Adaptability, Comfortability and Desirability [Huang et al. 2019]. The elements of LX refer to the components that guide the LX evaluation process, making it possible to verify various characteristics of the experience, including feelings and emotions in learning [Dos Santos et al. 2024a]. The consideration of various elements of LX can contribute to improving the experience of using DICTs

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[dos Santos et al. 2023]. However, the elements of LX can vary depending on the objective of the evaluation, the type of artifact chosen, and the learning theory adopted. We, therefore, felt the need to continue investigating these LX characteristics using a Systematic Mapping Study (SMS).

Through the results of the SMS [dos Santos et al. 2022], it was realized that there are also different ways of assessing LX, such as focus groups, word pairs, observations, and others. As a result, it was realized that no technology has been identified that assesses LX holistically, and that also covers different elements of LX and types of LX assessment. This is therefore a problem, as a holistic LX assessment technology tends to provide a pluralistic and more meaningful LX to learners by considering different elements of LX. In addition, LX assessment can enable better learner engagement and performance [Huang et al. 2019]. Thus, the research question defined was "How to evaluate LX considering as many elements as possible and using different types of evaluation?". It was decided to consider as many possible elements and types of LX assessment as possible to allow the educator to be adaptable at the time of the assessment, which makes it possible to personalize it to meet different objectives and needs. For this reason, a model was developed for the assessment of LX with the use of DICTs, which takes into account the characteristics presented by Huang et al. (2019). The Learner Experience Evaluation Model (LEEM) aims to evaluate and improve the learner experience when using DICTs. This model is aimed at educators who want to evaluate the learner experience when using DICTs. The LEEM has three stages of evaluation: a pre-evaluation, a during-evaluation, and a post-evaluation of the LX, due to the possibility of having continuous monitoring and recording of the LX's progress.

Research into the evaluation of LX with the use of DICTs makes a significant contribution to the Informatics in Education community by making it possible to capture different aspects of LX during an educational activity and also by making it possible to improve this LX during the same educational activity. This contribution is due to the concern to evaluate learners' experiences to facilitate learning and improve knowledge mastery [Magyar and Haley 2020]. The research also contributes by supporting Informatics in Education researchers and other specialists interested in providing learners with more engaging and memorable educational experiences [Huang et al. 2019]. Thus, this study presents a model for evaluating and improving LX with the use of DICTs, which also encompasses different elements and types of LX evaluation. The LEEM model helps educators rethink their teaching strategies when they notice that learners have reported difficulties with the resources adopted. Educators can also observe whether learners remain motivated in the educational activity and what could be improved. This is also important to avoid situations where learners don't feel comfortable with DICTs, promoting more effective interaction and a more positive learning experience [da Silva and Ziviani 2018].

In addition to this section, this paper is organized as follows: Section 2 presents the Related Work. Section 3 presents the methodology used in this research. Section 4 presents the results. Section 5 presents the final considerations and future work.

2. Related work

Ruiz et al. (2018) evaluate LX using an adapted model. The Kirkpatrick model is determined by learning environments where teaching is supported by didactic tools. The adaptation consists of using metrics and concrete instruments for the levels of the model. The metrics are measured using the elements of LX, which are: Learning, Behaviour, Reaction, and Results. Through the results of the LX elements of the different levels of the model, it is possible to properly assess the complexity of training programs and their effectiveness. The levels are considered the way to build and evaluate the evidence. The evidence makes it possible to assess the measure of training that contributed to the results and whether the results correspond to expectations. The model has a guide to evaluation questions and the appropriate criteria for evaluating the learning process.

Kawano et al. (2019) developed a training design methodology based on Design Thinking and LX, which makes it possible to define user-centered problems with empathy using the Learner Journey Map (LJM). The learner experience data are considered LX values and are used to evaluate LX in the LJM. A survey was carried out at the end of each learning unit to measure experiences. The authors assessed the elements of LX through indices of learning experiences: Satisfaction, Understanding, and Contribution. For example, for the Comprehension element, the researchers asked how well the learners understood the content of the learning unit. As a result, one of the learners reported that he understood the importance of setting goals and defining each activity in the subject.

Nygren et al. (2019) sought to evaluate learners' affective learning experiences of how the use of the mobile game enhanced the learning of fractions in mathematics. The authors assessed LX mainly about learners' attitudes towards mathematics through the elements of Value, Receive, Respond, Organise, and Internalise. For example, the Receive element can have several definitions, such as: Being open to experience; Experiencing emotions; among others. It can have illustrative verbs such as: Being open to experiences; Discussing; and Feeling; among others [Nygren et al. 2019]. As a result, one of the learners said that he liked working with numbers and that he liked maths a lot.

The studies mentioned have limitations. For example, in the study by Ruiz et al. (2018) the data was only collected during training. The ideal scenario would be for learners to continue using the tool for a longer period after training and to provide feedback. In the study by Kawano et al. (2019), no method was established for evaluating user experiences or behaviors in education and training programs, as learning in the training course was considered to be an experience. On the other hand, the study by Nygren et al. (2019) took place over seven years and used a snapshot evaluation. However, a longitudinal analysis could have provided deeper insights into LX. Thus, to be able to carry out holistic LX assessment and also consider different elements and types of LX assessment, concern should be given to assessing learners' experiences to facilitate learning and improve knowledge mastery [Magyar and Haley 2020]. In this sense, we do not identify in the literature the existence of a holistic LX assessment technology that also makes it possible to improve LX during an educational activity.

3. Methodology

Based on the aforementioned gap, the Learner Experience Evaluation Model (LEEM) was developed to evaluate and improve LX using DICTs. To carry out this research, the Design Science Research (DSR) methodology was used. DSR makes it possible to carry out rigorous scientific research linked to the development of innovative artifacts [Pimentel et al. 2019]. DSR has three research cycles and they are interrelated: Knowledge Cycle, Design Cycle, and Relevance Cycle. For the Knowledge Cycle, a Systematic Mapping Study (SMS) [dos Santos et al. 2022] was carried out, based on the guidelines proposed by Kitchenham et al. (2022), on technologies that evaluate LX and its elements that support the learning process using DICTs. For the Design Cycle, the LEEM model was built, seeking to fill the research gaps identified in the Knowledge Cycle (SMS). Finally, for the Relevance Cycle, two studies were carried out to validate the DSR, evaluate and improve the LEEM, and present evidence on the feasibility and applicability of this model.

3.1. Knowledge Cycle

For the Knowledge Cycle, the theoretical foundation of this work was carried out using a Systematic Mapping Study (SMS) [dos Santos et al. 2022]. The main question of the SMS was: "Which initiatives evaluate LX, and which use technological resources in the learning process?". The objective of the SMS was defined according to the GQM paradigm (*Goal-Question-Metric*), proposed by Basili and Rombach (1988), as follows: **Analysing** Scientific Publications; **For the purpose of** Characterising; **In relation to** technologies for evaluating the Learner Experience (LX); **From the point of view of** Informatic in Education and Human-Computer Interaction researchers; **In the context of** primary sources available on the ACM[1], IEEEXplore[2] and ERIC[3]. The results obtained in this SMS were published in the Brazilian Symposium on Informatics in Education [dos Santos et al. 2022].

To help answer the main question, eleven sub-questions (SQs) were defined: **SQ1** "What type of contribution is being proposed to evaluate LX?"; **SQ2** "What scenarios are being evaluated in LX?"; **SQ3** "What technological resources are being used in the LX evaluation initiatives? "; **SQ3.1** "What applications are being used in the technological resources?"; **SQ4** "What emerging technologies are being used in the LX evaluation initiatives?"; **SQ5** "What active methodologies have been adopted in the LX evaluation initiatives?"; **SQ6** "What elements of LX are being evaluated in the learning process?"; **SQ7** "How was/were the element(s) evaluated? "; **SQ8** "What types of experiments have been carried out with LX initiatives?"; **SQ9** "What types of analyses of experiments have been carried out with LX initiatives?"; **SQ10** "What is the target audience for LX evaluation initiatives".

The search string used was: ("learner eXperience") AND ("element*" OR "usability" OR "adaptability" OR "comfortability" OR "desirability" OR "value") AND ("tool" OR "framework" OR "technique" OR "method" OR "model" OR "process" OR "metric" OR "inspection" OR "heuristic" OR "methodology" OR "questionnaire" OR "checklist") AND ("evaluation" OR "assessment"). When running the string through the search engines, 584 studies were returned. In the first filter, 61 studies were selected by reading the title and abstract, while in the second filter, 18 studies were selected by reading the entire paper.

The answers to each sub-question provided an overview of the assessment of LX using technological resources. The data shows that: **(SQ1)** the main contribution to

[1] https://dl.acm.org/
[2] https://ieeexplore.ieee.org/
[3] https://eric.ed.gov/

assessing LX is focussed on Questionnaires; **(SQ2)** the most prominent scenario is the traditional classroom; (**SQ3**) In contrast, the main DICTs used are the computer, tablet and smartphone; **(SQ3.1)** the most used applications are YouTube and Google Drive; **(SQ4)** Emerging technologies can generate valuable experiences when used, such as digital games that provide fun learning; **(SQ5)** Active methodologies are used to encourage learners, highlighting Collaborative learning; **(SQ6)** There are a variety of elements present in LX assessment, such as Value, Outcome, Skills, among others. LX elements are used by different forms of assessment **(SQ7)**. LX can be evaluated through Focus Groups, Observations, and Administrative Data, among others. The main target audience for LX evaluation is undergraduates who have taken part in experimental and case studies (SQ9 and SQ10).

In general, the SMS contributed to the construction of the LEEM. Through the SMS, it was identified that there are few studies related to holistic LX assessment with the use of technological resources, suggesting a need to investigate this topic. Thus, it was realized that different forms and different elements have been used in the evaluation of LX, where depending on the evaluation technology, only certain elements are considered. In addition, evaluation technologies have different steps/stages to follow. Therefore, this master's research sought to develop an LX evaluation model (LEEM) that includes a greater number of elements and ways of evaluating LX.

3.2. Design Cycle

For the Design Cycle, LEEM was built to fill the research gaps identified in the Knowledge Cycle (Subsection 3.1). Firstly, it was decided that this would be a model, as this type of artifact provides questions to guide the evaluation, as well as the criteria that should be assessed [Ruiz and Snoeck 2018]. It was also decided that the LEEM model would be divided into three evaluation stages: (1) pre-evaluation, (2) during-evaluation, and (3) post-evaluation. This decision was made based on Nygren et al. (2019), as they also use different stages to assess LX at different times during learning. Types of LX assessment were selected to be integrated into LEEM to capture various aspects of LX throughout an educational activity using DICTs. It was also decided that different LX elements would be considered at each stage of the LEEM to guide the types of LX assessment (Figure 1). Artifacts were defined in the form of checklists and a set of questions to help collect feedback on the LX evaluation. Finally, the LEEM model was created to support LX assessment during the use of DICTs and is presented below. The final version of the LEEM is available at Figshare[4]. The construction process is detailed in dos Santos et al. (2023).

The first stage of LEEM called **pre-evaluation**, aims to identify the profile of the learners, considering their difficulties and needs about their learning experience, through pairs of opposing adjectives using experience criteria (Figure 2). The pre-assessment can help form groups to carry out collaborative activities at school or university. It is suggested that the teacher apply group formation techniques according to their familiarity.

In the second stage, called **during-evaluation**, the evaluation of LX occurs during the educational activity using DICTs. This evaluation aims to record the feelings and information from the learning experiences, both from the point of view of the learner

[4]https://figshare.com/articles/dataset/LEEM_Final_Version/26081029

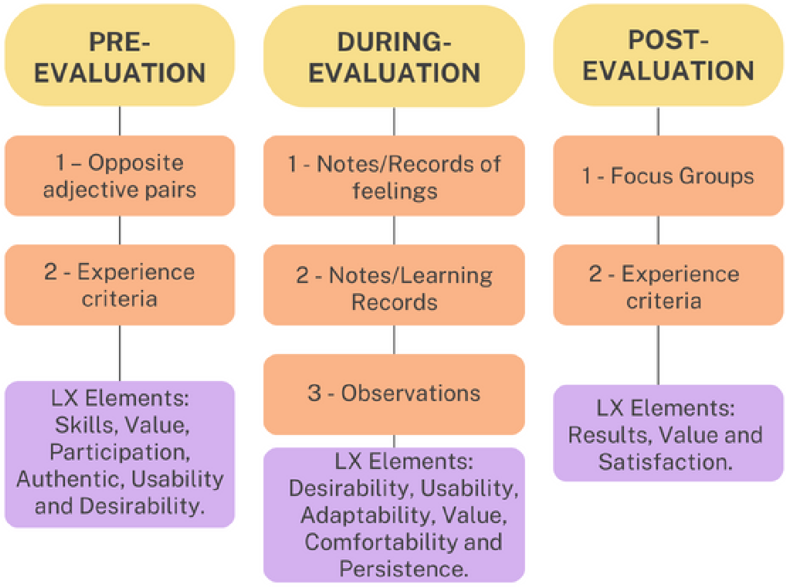


Figure 1. *Learner Experience Evaluation Model (LEEM)*

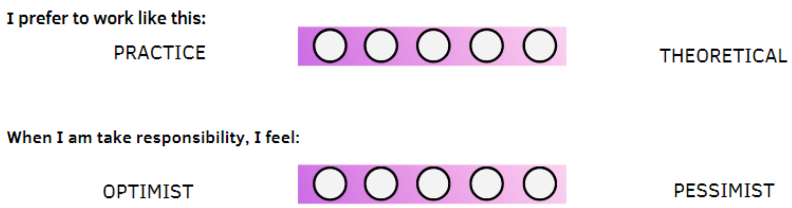


Figure 2. Part of the LEEM pre-evaluation checklist

(Figure 3) and the teacher (Figure 4). In this way, the checklists that the learner and teacher will answer have similar sentences, to evaluate their perspective on the learning process.

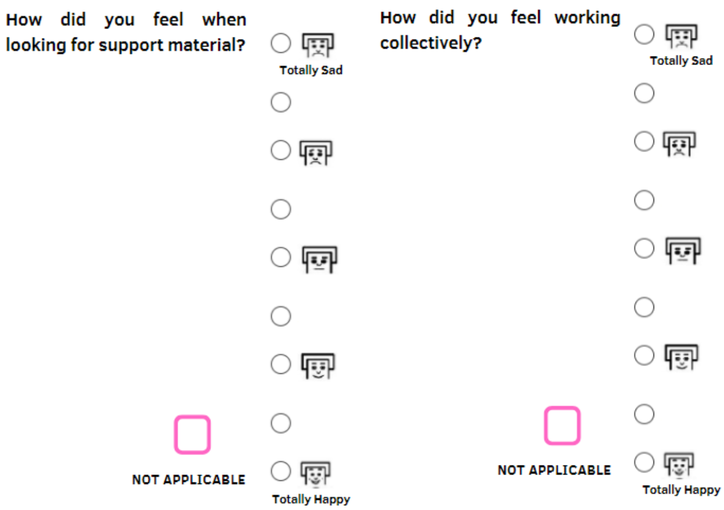


Figure 3. Part of the LEEM during-evaluation checklist (learner)

For the third and final stage of LEEM, called **post-evaluation**, the aim is to eval-

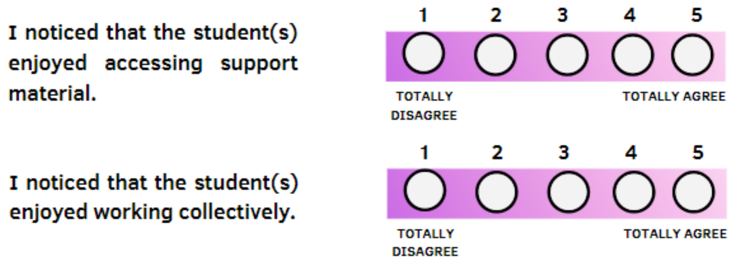


Figure 4. Part of the LEEM during-evaluation checklist (teacher)

uate the learner's experience of completing an educational activity using DICTs. This stage allows learners to reflect on and self-assess their learning, as well as have the freedom to be active and critical subjects in their learning. Focus groups are held at this stage, also applying experience criteria, as it was applied in the pre-evaluation. A set of eleven open questions has been developed that can be used to direct the focus group. For example, "Have you ever experienced a situation similar to the activity carried out? Please comment." and "Did you find the activity interesting, stimulating, or thought-provoking? Please comment."

One of the main advantages of LEEM is its adaptability, which allows it to be customized to suit different objectives. In this way, teachers can use the steps and elements they consider most pertinent according to the educational objectives of the subject. LEEM is an assessment model designed to be used at any level of education, such as primary and higher education. This model can be worked on regardless of the subject and can also be used with any DICTs, such as Kahoot!, Scratch, among others.

3.3. Cycle of Relevance

For the Relevance Cycle, two studies were carried out, a feasibility study and a case study. The first study was carried out with teachers from different levels of education to evaluate the LEEM and create a body of knowledge about this model. The second study was carried out with a teacher and a class of learners to evaluate LX in a real context. Through the results obtained in the studies, it was possible to validate and improve the LEEM.

The feasibility study was carried out with 19 teachers, including primary, secondary, undergraduate, and postgraduate teachers. The study was approved by the Research Ethics Committee (CEP)[5] and published at the XXII Brazilian Symposium on Human Factors in Computing Systems - IHC 2023, receiving the award for best paper in the Innovative Ideas and Emerging Results track [Dos Santos et al. 2024a]. A feasibility study was carried out to check that the objectives of the proposed technology could be met before applying it in a real context [Shull et al. 2004].

From the results obtained in the feasibility study, the difficulties identified by the teachers in the LEEM were verified, as well as the possibilities for improvement, such as making the items on the checklists clearer and more cohesive according to the objective of each LX element evaluated. In addition, the majority of teachers found the LEEM easy to use, and useful and intended to use it in the future. Based on the results, it was considered that the teachers fulfilled all the tasks requested in the study and contributed

[5]Federal University of Paraná (UFPR) - CAAE: 64733822.0.0000.0102, approval opinion nº. 5.877.611

to improving LEEM. Through this study, it was possible to create a body of knowledge about the application of LEEM and determine its feasibility.

The case study was carried out with 23 learners from the Computer Science and Biomedical Informatics course who were taking Software Engineering at the Federal University of Paraná (UFPR), and with the respective teacher of this course. The study was approved by the Research Ethics Committee (CEP)[6] and published in the *International Conference on Human-Factors in Computing Systems* - CHI 2024 [Dos Santos et al. 2024b]. It was decided that a case study would be carried out, as this type of study makes it possible to investigate a phenomenon in a real-world context, taking into account different variables of interest and multiple sources of evidence, as well as making it possible to collect and analyze the data [Yin 2014].

Through the results of the case study, it was observed that different LX reports were obtained for the same educational activity. Even though the learner's pre-assessment preference was one, what happened during the educational activity affected their experience, as they reported in the post-evaluation. It also emphasizes the importance of the teacher instructing and accompanying the learners throughout the educational activity so that the LX can be evaluated and improved, providing a more engaging and memorable experience. Finally, it can be said that the objective of the LEEM was achieved, as it was used to evaluate the LX throughout the educational activity. Moreover, it was observed that the LEEM was useful in supporting the improvement of the LX in the use of DICTs in an educational activity.

4. Results

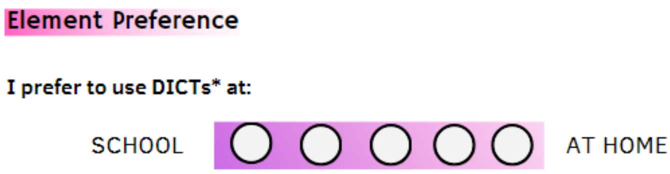
The first version of the LEEM (V1) was made based on the gaps identified in the SMS. The second version of the LEEM was adjusted and improved based on the results obtained through the feasibility study (V2). The third and final version of the LEEM was adjusted and improved based on the results of the case study (V3). Thus, we will highlight some improvements in the versions and evolutions of LEEM for this master's research.

In version V1, the LEEM pre-assessment *checklist* had six LX elements, namely: Skills, Value, Participation, Authenticity, Usability, and Preference. For this same *checklist*, the V2 version kept the same number of LX elements but replaced the LX element **Preference** with **Desirability**. The LX element Persistence refers to students' desires and choices in the learning process. The Desirability element refers to attractiveness and engagement and the pleasant perception of teachers and students. This adjustment was a suggestion for improvement from Participant 15 of the feasibility study. So this suggestion was taken into account and it was possible to make this substitution, as the LX element Desirability also assesses Preference. Figures 5 and 6 show the change.

Another change was made to the LEEM during-evaluation checklists in version V2. Participant 15 of the feasibility study suggested adding a new LX element, **Persistence**. The LX element of Persistence refers to students not giving up when encountering problems in an educational activity. So this new LX element was added, as well as new sentences for the teacher and learner checklists, as shown in Figures 7 and 8.

A change was also made to the set of questions in the LEEM post-evaluation in

[6]Federal University of Paraná (UFPR) - CAAE: 67603723.9.0000.0102, approval opinion nº. 5.971.754

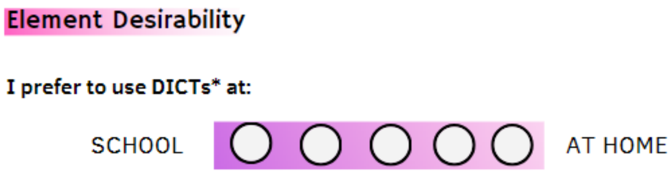


Element Preference

I prefer to use DICTs* at:

SCHOOL ○ ○ ○ ○ ○ AT HOME

Figure 5. Version V1 - Part of the LEEM pre-evaluation checklist

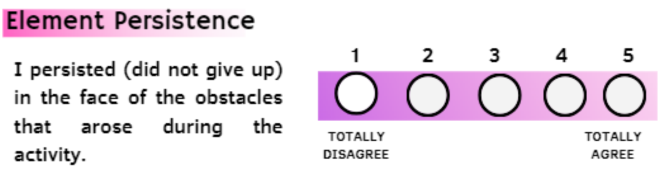


Element Desirability

I prefer to use DICTs* at:

SCHOOL ○ ○ ○ ○ ○ AT HOME

Figure 6. Version V2 - Part of the LEEM pre-evaluation checklist



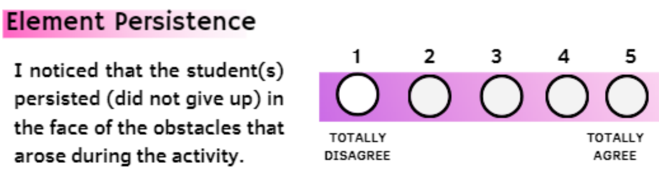
Element Persistence

I persisted (did not give up) in the face of the obstacles that arose during the activity.

1 2 3 4 5

TOTALLY DISAGREE — TOTALLY AGREE

Figure 7. Version V2 - Part of the LEEM during-evaluation (learner) checklist



Element Persistence

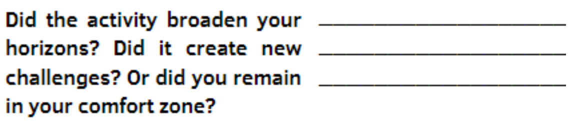
I noticed that the student(s) persisted (did not give up) in the face of the obstacles that arose during the activity.

1 2 3 4 5

TOTALLY DISAGREE — TOTALLY AGREE

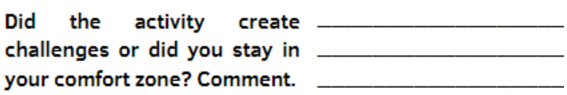
Figure 8. Version V2 - Part of the LEEM during-evaluation (teacher) checklist

version V2. Participant 17 of the feasibility study suggested a change to item nine, as there were three questions together (Figure 9). We, therefore, made the change to version V2 as suggested by the participant (Figure 10).



Did the activity broaden your horizons? Did it create new challenges? Or did you remain in your comfort zone?

Figure 9. Version V1 - Part of the LEEM post-evaluation question set



Did the activity create challenges or did you stay in your comfort zone? Comment.

Figure 10. Version V2 - Part of the LEEM post-evaluation question set

A change was also made to version V2 of LEEM. Participant 1 of the case study suggested that the LEEM checklists could be improved by better-explaining DICTs and citing examples. Thus, we changed the color of the definition of the acronym for DICTs, present in each footnote, to meet the request and make the learner more familiar with the term. In addition, examples of DICTs were added to the LEEM instructions. Therefore, we made the change and generated version V3 of LEEM (Figure 11). Other changes to the LEEM versions are available in the papers published in IHC 2023 [Dos Santos et al. 2024a] and CHI 2024 [Dos Santos et al. 2024b].

The **Value** element, is about the value of using Digital Information and Communication Technologies (DICTs) in the learning process, such as Kahoot! and Google Drive.

Figure 11. Version V3 - LEEM Improvements

5. Final considerations and Future Work

This paper presents the master's research into the methodology used to develop the LEEM, as well as the studies carried out to improve and evolve the LEEM. The LEEM was developed to evaluate and improve the learner experience with the use of DICTs. One of the advantages of using the LEEM is that it makes it possible to assess situations where learners are uncomfortable with DICTs, thus maximizing effective learning and a more engaging and memorable learning experience [da Silva and Ziviani 2018] [Huang et al. 2019]. Another distinguishing feature of the LEEM is its adaptability at the time of the LX assessment, which makes it possible to customize it to meet different objectives and needs in different contexts.

In general, the LEEM has an important role in LX assessment, allowing LX to be captured at different points in the educational activity through continuous monitoring. This makes it possible to bring LX and DICTs closer together, as it takes into account the diversity of learners and their learning preferences. Thus, LEEM contributes to the scientific community of Informatics in Education and Computing Education in terms of capturing different aspects of LX during an educational activity with DICTs. The evaluation of LX contributes directly by making it possible to assess and subsequently improve learners' interaction with DICTs. Understanding LX during the learning process is fundamental, as it provides educators with insights on the importance of reviewing and, if necessary, changing the DICTs used, according to the learners' individual needs [Martinelli and Zaina 2021].

There were some limitations to this master's research. For example, LEEM was only evaluated at the undergraduate level, even though it was suggested for different contexts. Even so, LEEM was previously trialed by teachers from different educational levels in the feasibility study, in which participants made suggestions and pointed out improvements. To overcome this limitation, the next steps are to apply LEEM in other contexts and scenarios with different audiences. In addition, the formation of groups for LX can be investigated, following the theory of collaborative learning. Another future work is to improve the instructions (tutorials) for teachers to use LEEM and to improve the instructions for learners.

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