A Set of Usability Heuristics and Design Recommendations for u-Learning Applications

Fabiola Sanz, Raúl Galvez, Cristian Rusu, Silvana Roncagliolo, Virginica Rusu, César A. Collazos, Juan Pablo Cofré, Aníbal Campos and Daniela Quiñones

Abstract Usability is one of the most relevant attribute when evaluating a software product, application or a website, as it is important to analyze how the interaction design facilitates or hinders the user to achieve an objective in concrete. Moreover, the user experience expresses its positive or negative perception of a particular application through a set of factors and elements relating to user interaction. The paper presents a set of heuristics to detect usability problems in u-Learning applications. It also proposes a set of design recommendations focused on the user experience.

Keywords Usability · User experience · u-Learning · Usability heuristics · Design recommendations

1 Introduction

Because of the emergence of new technologies and the need for humans to acquire knowledge in other ways, it arises in the first instance the Electronic learning

F. Sanz · R. Galvez · C. Rusu · S. Roncagliolo · J.P. Cofré · A. Campos · D. Quiñones(✉)
Pontificia Universidad Católica de Valparaíso, Valparaíso, Chile
e-mail: faby.sanz.b@gmail.com, raul.galvez.cabeza@gmail.com, jp.cofreuribe@gmail.com, anibal.campos.baez@gmail.com, danielacqo@gmail.com, {cristian.rusu,silvana}@ucv.cl

V. Rusu
Universidad de Playa Ancha de Ciencias de La Educación, Valparaíso, Chile
e-mail: virginica.rusu@upla.cl

C.A. Collazos
Universidad Del Cauca, Popayán, Colombia
e-mail: ccollazo@unicauca.edu.co

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(e-Learning), based on three fundamental criteria: “the e-Learning is networked, is delivered to the end user through the use of computers using standard Internet technology and focuses on the broadest view of learning that go beyond the traditional para- digms of training” [1]. Due to the expansion of the concept e-Learning new learning, encompassing activities such as: Classroom Learning (c-Learning), Electronic Train- ing (e-Training), Mobile-Learning (m-Learning).

A new concept emerges, known as u-Learning. It is defined as "a model of learning that takes place in an environment of ubiquitous computing, which allows you to learn the right thing at the place and right time, the right way" [2]. It allows to "… move learning beyond the classroom to different environments of everyday life supported by a flexible, invisible and omnipresent technology that provides us the information we need at all times" [3].

Due to the specific characteristics of u-Learning applications and the lack of specific heuristics, it is difficult and expensive to assess their usability. We did not found user experience - oriented design recommendations for u-Learning applications.

The paper presents a set of usability heuristics and a set of user experience - oriented design recommendations for u-Learning applications. Section 2 presents concepts related to usability and user experience. Section 3 describes the proposed heuristics, including the methodology that we used. Section 4 presents specific design recommendations. Section 5 highlights conclusions and future work.

2 Usability and User Experience

According to the ISO 9241-11 standard the usability is "the degree to which a product can be used by specific users to achieve certain specified goals with effectiveness, efficiency and satisfaction in a specified context of use" [4]. Nielsen defines usability in terms of: Learnability, Efficiency, Memorability, Errors, Satisfaction [5].

The ISO 9241-210 standard defines the user experience as a result of the percep- tions and responses of a person by use and anticipated use of a product, system or service [6]. Dillon proposes a model that defines the user experience as the sum of three levels: action that the user does; result, the user gets; and emotion that the user feels [7].

The user experience seeks to change user loyalty through an interaction that evokes positive emotions before, during and after using a software product. Usability is limited to the user’s goal achievement as easily and effectively as possible. User experience includes usability; it is a broader concept that includes the design, ergonomics, accessibility, emotional elements and usability, among other factors.

Helander et al. consider the usability evaluation as a process that measures the level of usability of a software product [8]. Assessing usability includes an application that is being evaluated, and a process by which one or more usability’s attributes are judged. Fernandez et al. affirm that a method of

evaluating usability is a procedure that is composed by a series of activities well defined for collecting data related to the interaction of an end user with a software product, and/or how the specific properties of this product software contribute to reach some degree of usability [9].

Usability inspections are based on the ability of evaluators to examine whether a particular interface fulfills a series of usability principles. These methods depend on the opinions, judgments and reports generated by evaluators [10]. Usability tests are methods where a user or a group of users is/are asked to use a prototype or a system. They provide direct information on how people use computers and their specific problems on an interface that is being tested [11].

The heuristic evaluation is a widely used usability inspection method. Jakob Nielsen proposes a set of 10 heuristics (principles) that allow identifying potential usability problems. However, general heuristics may neglect specific domain – related usability issues. Many authors propose set of specific usability heuristics.

Morville proposes the User Experience Honeycomb [12], which indicates that user experience is significant and valuable when information is:

- Useful: The content should be original and satisfy a need.
- Usable: The site must be easy to use.
- Desirable: Image, identity, brand and other design elements are used to evoke emotion and gratitude.
- Findable: The content has to be localizable and navigable internal and externally.
- Accessible: The content has to be accessible to people with disabilities.
- Credible: Users must trust and believe what they are told.

3 Developing Usability Heuristics for u-Learning

A methodology that facilitates the development process and/or particularization of usability heuristics was used [13]. It includes 6 stages:

- STAGE1: An exploratory phase, to collect bibliography related to u-Learning applications, their characteristics, general and/or related (if there are some) usability heuristics.
- STAGE2: A descriptive phase, to highlight the most important characteristics of the previously collected information, in order to formalize the main concepts associated with the research.
- STAGE3: A correlational phase, to identify the characteristics that the usability heuristics for u-Learning applications should have, based on traditional heuristics and case studies analysis.
- STAGE4: An explicative phase, to formally specify the set of the proposed heuristics, using a standard template.

- STAGE5: A validation phase (experimental) to check the new heuristics against traditional heuristic principles through experiments.
- STAGE6: A refinement phase, based on the feedback from the validation stage.

The set of usability heuristics for u-Learning was specified following the template proposed by Rusu et al. [13]:

- ID, Name and Definition: Heuristic´s identifier, name and definition.
- Description: The general concept that encompasses heuristics.
- Explanation: Explanation extended content and concepts covering heuristics, including tips and comparisons with other heuristics.
- Examples: cases are shown in which the heuristic has not been met, and in some cases positive examples of the application of heuristic principle.
- Benefits: Potential benefits of compliance with the principle.
- Anticipated problems: Potential difficulties foreseen in the implementation of heuristics.

3.1 A Set of Usability Heuristics for u-Learning

A set of 16 usability heuristics was built based on the distinctive features of U- Learning, the particularization of Nielsen's usability heuristics [14], and a set of preliminary heuristics proposed by Cofré [15]. The set of heuristics is presented below, in an abbreviated form (ID, Name and Definition).

- (UL01) Learning measurement: The application evaluates the user's learning progress, indicating the results.
- (UL02) Situated learning: The application solves doubts users in time when they arise
- (UL03) Collaborative learning: Users work together to maximize their own learning and that of others.
- (UL04) Continuity of learning resources: The application records all learning processes.
- (UL05) Connections and resources: The user has access to educational resources from their devices.
- (UL06) Synchronous and asynchronous interaction: The application provides synchronous and asynchronous communication.
- (UL07) Visibility state of the application: The application keeps users informed through feedback.
- (UL08) Coincidence between the application and the real world: The application speaks the language of the user.
- (UL09) User control and freedom: The application provides emergency exits, undo and redo.
- (UL10) Consistency and standards: The application follows the existing conventions, dependently on the device used.

- (UL11) Error prevention: The application warns of critical actions and irreversible.
- (UL12) Flexibility and efficiency of use: The application provides the ability to accommodate different work styles.
- (UL13) Minimize the user´s memory load: The user should not remember information from one part of the dialogue to another.
- (UL14) Aesthetic and minimalist design: The information displayed on the screen is relevant and is not overloaded with useless information or little used.
- (UL15) Help users recognize, diagnose and recover from errors: The application displays error messages simple, suggesting constructive solutions.
- (UL16) Help and documentation: The application provides the user documentation for the application.

Below is presented the full template of the heuristic "(UL01) Learning Measurement".

ID: UL01.

Name: Learning measurement.

Description: The application evaluates the user's learning progress, indicating the results.

Explanation: The application performs an initial evaluation, also has tools to measure the degree of achievement of learning, indicating its progress, approval or disapproval.

Examples:

- Fig. 1 shows the Level Test option, which allows users to select their English knowledge level or to make a test in order to identify it.
- Fig. 2 shows the evaluation test.

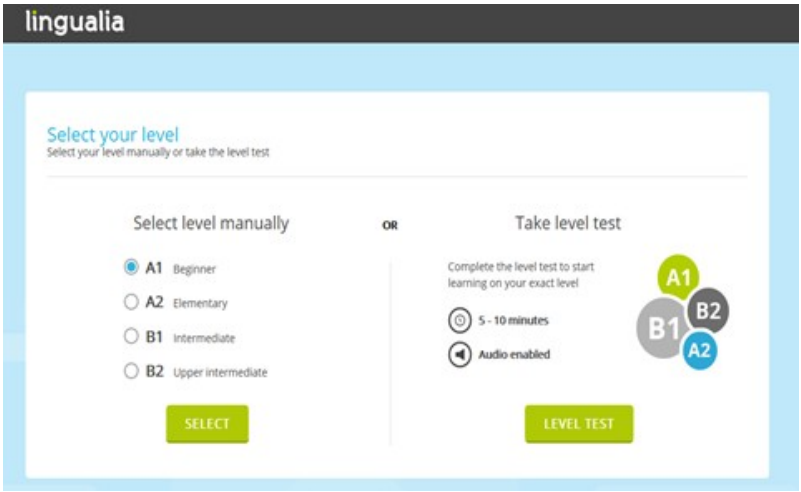

Fig. 1 Level Test

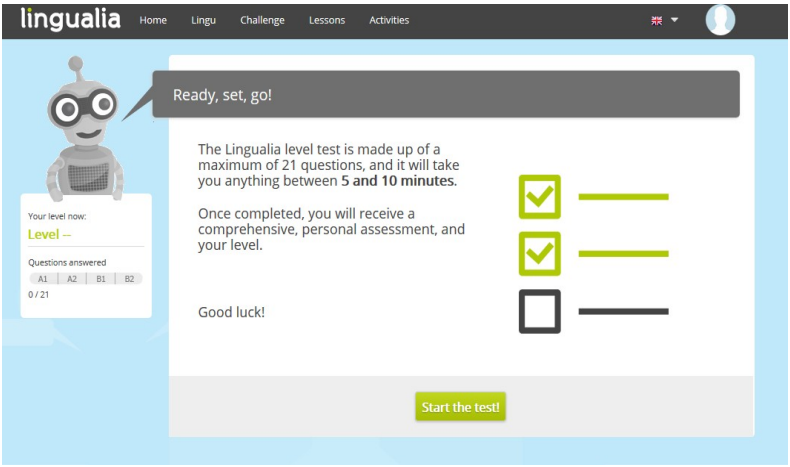

Fig. 2 Evaluation Test

Benefits:

- An initial evaluation of user knowledge allows particularizing the content according to his/her knowledge level.
- Provides quantitative data on the learning outcomes.

Anticipated Problem: The measurement of learning should be based on the results obtained after making any kind of evaluation, not indicate the number of daily, weekly and / or monthly hours performed.

3.2 Validating the Set of Heuristics

The proposed set of heuristics was refined in 2 iterations, through usability inspections, involving 4 expert evaluators. A semi-structured survey was also conducted, involving all evaluators. The experimental results allowed us to refine the set of heuristics.

Duolingo and *Lingualia* (desktop and mobile versions) were evaluated. Both applications meet u-Learning basic features: permanence, accessibility, immediacy, interactivity, adaptability.

A total of 34 problems were identified when evaluating *Duolingo*. 14 problems were associated with heuristics related to specific u-Learning characteristics (UL01 to UL06); the remaining problems were associated to general (Nielsen's) usability heuristics adapted to ubiquitous learning (UL07 to UL16). Fig. 3 shows the distribution of the problems encountered.

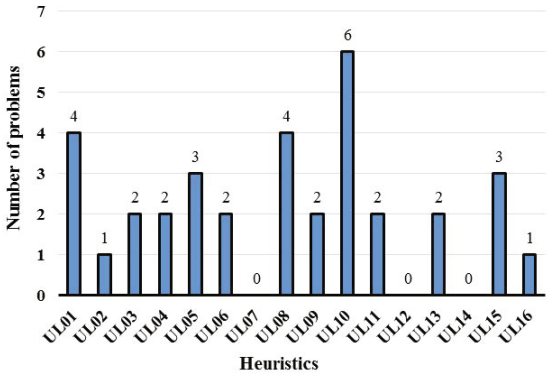

Fig. 3 Usability problems identified in *Duolingo*

Problems' criticality ranges from 3.25 to 7.0, in a 0 (minor) to 8 (sever) scale. Problems' severity varies between 1.50 and 3.37, in a 0 (minor) to 4 (sever) scale. Problems with higher criticality and severity were associated to heuristics:

- Measuring learning (UL01),
- Connection and resources (UL05),
- Synchronous and asynchronous interaction (UL06).

Problems with lower criticality were associated to heuristics:

- Consistency and standards (UL10),
- Minimize the burden of memory (UL13).

Problems with lower severity refer to:

- Coincidence between the application and the real world (UL08),
- Consistency and standards (UL10).

The heuristic evaluation of *Lingualia* allowed finding a total of 39 problems, of which 10 were associated with heuristics related to specific u-Learning characteristics (of UL01 to UL06); the remaining problems were associated general (Nielsen's) usability heuristics adapted to ubiquitous learning (UL07 to UL16). Fig. 4 shows the distribution of the problems encountered.

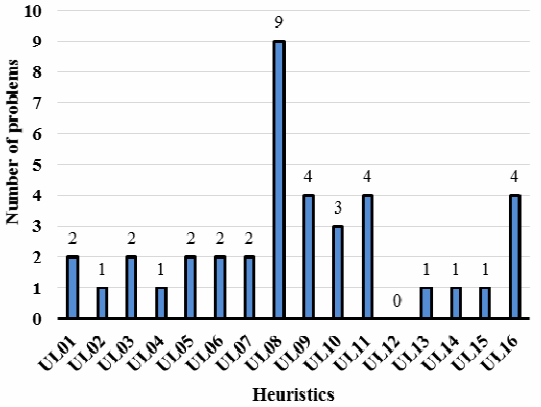

Fig. 4 Number of problems encountered in *Lingualia*

Problems' criticality ranges from 3.8 to 7.0. Problems with the highest criticality were associated to heuristics:

- Connection and resources (UL05),
- User control and freedom (UL09).

Problems with lower criticality were associated to heuristics:

- Coincidence between the application and the real world (UL08),
- Error prevention (UL11).

Problems' severity varies between 2.0 and 4.0. The most severe problems are related to:

- Connection and resources (UL05),
- Aesthetic and minimalist design (UL14).

Problems with lower severity refer to:

- Aesthetic and minimalist design (UL14),
- Error prevention (UL11),
- Coincidence between the application and the real world (UL08).

The experimental results prove that the set of u-Learning usability heuristics is a useful instrument. It allowed discovering additional problems, comparing to Nielsen's (particularized) heuristics. These problems are associated with the characteristics of u- Learning, directly related to the learning process, and they

have high levels of severity and criticality. Heuristic UL12 has no associated problems; both case studies adapt to different styles of work, so do not violate this heuristic.

4 Design Recommendations for u-Learning

A set of 10 design recommendations for u-Learning applications was developed, based and u-Learning characteristics, Peter Morville's user experience model, and usability issues identified in *Duolingo* and *Lingualia*. The set of recommendations is presented below.

(DR01) Learning Resources: The application should provide users educational activities through the course(s) that contain(s) units, lessons and support material for learning, considering an initial level test in order to suit your needs.

(DR02) Supporting the learning process: The application should provide users the opportunity to answer questions and conduct collaborative learning.

(DR03) Continuity and access to educational resources: The application must register all learning processes independently to the device used, since the user can access different devices, even without an internet connection.

(DR04) Interactivity: The application must allow communication with other users and / or experts, in real time, even if there is no coincidence in time.

(DR05) Ease of use and consistency: The ease and aesthetic consistency in the application are critical to providing independent of the device used satisfying experience.

(DR06) Error prevention and emergency exits: The application must warn of critical actions and irreversible. If the user reaches an undesired state, the application must provide emergency exits, undo and redo.

(DR07) User Help: When errors occur in the application must be given simple messages mistake, suggesting constructive solutions. Furthermore the application documentation is provided.

(DR08) Desirable application: images, icons, brand identity and other design elements are used to evoke emotion and gratitude. The application should keep users informed through feedback

(DR09) Findable resources: The content has to be localizable and navigable internal and externally, adapting to individual work styles that have users.

(DR10) Learning resources, educational and evaluative, should come from competent authorities, as users must trust and believe what they are told.

5 Conclusions

Because u-Learning has distinctive features, focusing on the process of learning that can take place anywhere, anytime, using various devices, it is vital to consider the characteristics of permanence, accessibility, immediacy, interactivity, activities education and adaptability located, when evaluating usability. Generic usability

heuristics may ignore domain – related usability issues. Specific u-Learning heuristics proved to work better.

Our research was based on a preliminary set of usability heuristics for u-Learning applications, proposed by Cofré and others [15]. The set of heuristics was experimentally validated through usability inspections, in two case studies: *Duolingo* and *Lingualia*. Experimental results and experts' opinion allow improving heuristics' definition.

Experiments proved the utility of the set of usability heuristics that we developed. It allows discovering problems associated with the characteristics of u-Learning not covered by the Nielsen's generic heuristics.

User experience aims to guide, control and improve the positive and negative feelings experienced by users. Based on the usability inspections' results, the u-Learning characteristics, and Peter Morville's user experience model, we proposed a set of user experience – oriented design recommendations for u-Learning applications.

As future work the set of heuristic usability for u-Learning applications will be validated in other case studies. The design recommendations will be validated through implementations of functional prototypes.

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