USING INTERACTION TRACES FOR EVOLUTIONARY DESIGN SUPPORT

Application on the Virtual Campus VCIel

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Abstract: This article addresses evolutionary design in the context of e-learning devices. It proposes a design approach that takes into account the changing behaviours and needs of different actors (tutors, authors and learners) in order to evolve and adapt a training device to real practices. For this, our approach is to consider traces of interaction as knowledge sources that the designer can exploit in the design process. The principle technique of our proposal is to observe the quantitative and qualitative actions of actors on the learning platform and to represent them in modelled traces, to transform these traces in order to extract high level information on the actors activities, and finally, to propose visualisation tools of this information. We have applied our work in virtual campus VCIEL, where data for this study were obtained via participation of 2 designers, 13 tutors and 68 students from four classes that have been trained since 2006.

1 INTRODUCTION

In most methods of device design of online training, tasks and resources of actors are usually predefined by the designer according to a number of scenarios "presupposed", and do not take into account changing needs and behaviours of users. These methods suffer from many disadvantages because they cannot adapt themselves to different situations encountered in practice. Moreover, designing a system with a complete representation of user requirements with which he/she interacts is not always easy for the designer.

To address these problems, we propose an approach to control the design by analysis and visualization of interaction traces. The traces mentioned here are defined as a history of user actions collected in real time from their interaction with the system. Formally, a trace is a set of *observed elements* temporally located (Clauzel, Sehaba & Prié, 2009). Each observed element represents the user action on platform tools such as *opening a file, clicking on a hyperlink, posting a message on the forum, etc*. These traces, called *quantitative* traces, allow us to represent the user activity (designers, authors, tutors and learners) as computer data elements that we can transform, visualize, or share; in order to extract knowledge about the user activities. To analyze better and interpret these activities, we also define *qualitative traces*. These can represent the user's point of view of his/her own activities. Our approach is to consider these two types of traces as knowledge sources that the designer can use in order to evolve and adapt the training device. Traces can also be beneficial to learners in their learning process through reflexive learning.

The principle method of our approach is, during a first phase, the *collection phase*, to observe and to store the user's actions in the form of modelled traces. At a second phase, the *transformation phase*, traces of meaningful high-level representations to the user are calculated. At the third phase, the *visualisation phase*, we visualize, in an interactive way, the trace for the different actors of learning environment.

Our work relates to the training device VCIel (vciel.univ-lyon2.fr). This is a Master (Bac + 5) fully-online learning environment that aims to train professionals in the field of multimedia production, 2D-3D computer graphics, and project management. In this innovative framework, designers have few examples to which they can refer. We assume that the method might be improved by a scalable design approach based on traces. Thus, in the context of this work, we have traced and analyzed the activities of different actors involved in VCIel training since 2006. The traces that we considered in this study are both quantitative and qualitative. The data from this study are related to the participation of 2 designers, 13 tutors and 68 students from four classes that have been trained since 2006.

The article is organized as follows: Section 2 presents and discusses some methods of ergonomic design and introduces the concept of trace theory that form the theoretical framework of our research. Section 3 presents the principle of our design approach based on the interaction traces. Section 4 shows the change of design choices by observing the practice in the context of VCIel. The last section presents the conclusion and perspectives.

2 THEORETICAL FRAMEWORK

This section presents the theoretical basis of our approach. These are user-centered design methods in the ergonomics field and the concepts of traces on which our work is based.

2.1 The Design Process in Ergonomics

Design can be defined as an individual and collective activity, finalized by a project to develop a physical and symbolic artefact (Visser, 1991). Its peculiarity is that it always starts with not–well-defined problems. Recommendations are proposed to guide the actors in the process.

According to the French and international standardization body (AFNOR & ISO), for recommendations of ergonomic design, quality is defined as "the ability of a product or service to satisfy the needs of a user". This concept is used and applied particularly in the industrial design process to put the user at the center of the process of building products that are intended to be used by the user. It is the user-centered design considered by Norman (Norman, 1999) and others (Eason, 1987). The main idea is the participation of the end user of the product in the design process: the user is somehow incorporated into the design team.

Research has led to the introduction of ISO standards (ISO, 1999) that define the stages of the process: the planning process, understanding and specifying context of use, the user and organizational requirements, producing design solutions, and finally, assessing solutions in terms of pre-defined requirements. For each step, methods are recommended to define better the characteristics of users. This brief description of work around the design shows the complexity of both the work of designers as to the effectiveness of the approach.

2.2 The Modelled Traces Concept

In order to identify and better understand the needs and behaviours of different actors, we use the theory of interaction traces developed by the SILEX team (http://liris.cnrs.fr/silex). Indeed, the SILEX (Supporting Interaction and Learning by Experience) research team has been working on traces for several years, building applications and studying various usages (Clauzel, Sehaba & Prié, 2009) (Cram, Jouvin & Mille, 2007) (Settouti, Prié, Marty & Mille 2009). By definition, a trace is composed of *observed elements* representing the interaction between the user and the system. We call an observed element any structured information generated from the observation of this interaction. Formally, each observed element has a subject, the user that was observed during the collect, and set of attributes/values that is related to the temporal extension of the trace (*e.g.* it can be related to an instant or a temporal interval). Each trace is associated with a *trace model* that defines the types of observed elements (i.e the attributes that characterize them) and the types of relationships they can maintain them. The trace model also specifies how it is possible to understand and use the trace.

The SILEX team also has defined a Trace-Based Management System (TBMS) (Settouti, Prié, Marty & Mille 2009) (Clauzel, Sehaba & Prié, 2010) that manages the modelled traces, in paticullar transformation and visualisation of traces. Based on the design process in ergonomics and the trace theory, the idea of our approach is to use the concept of modelled traces to generate knowledge about the activities of different actors in order to improve the process of designing. This approach is presented in the next section.

3 DESIGN APPROACH BASED ON TRACES

In this section, we present our evolutionary design approach based on both quantitative and qualitative traces. The quantitative traces represent the user activity by low-level of observed elements which they must be transformed in order to extract high-level knowledge. The observed elements of a quantitative trace can be for example: *the learner has opened such a file at t_2, has clicked on such link at t_3, etc.* The qualitative traces can give the point of view of a user on his own activities. The collection of such traces is usually based on questionnaires. The nature of the questionnaires depends on the application domain and the objectives of the analysis. Section 4 presents an example of a questionnaire intended for tutors of VCIel training. In this section, we present our methodology for collecting and using the quantitative traces.

3.1 The Quantitative Traces

We focus on a dynamic approach to study changes in the activities of different actors in the device to include in a process of evolutionary design. We rely on the use of interaction traces as sources of knowledge that actors can operate in different ways to improve the quality of the device. Our approach considers the following three phases: collection, transformation and visualization.

3.1.1 Collection Phase

All interactions between the user and the tools of the platform are stored in a first record. It is a *raw trace* representing all user actions in observed elements. The collection phase ensures the observation of the use of platform tools from sources tracing. It elaborates, in an automatic or semi-automatic way, information generated by the interaction between users and the tool into a raw trace. We call a source tracing any structured information flow from which it is possible to establish a process for traces collection.

The raw trace is not always directly usable, and one or more transformation(s) are needed to reach a trace with a coherent level of activity (*i.e.* significant in the context for the user).

3.1.2 Transformation Phase

The raw trace contains basic information that is necessary to analyze and extract information from the highest level. The extraction is complex for several reasons:

- The raw trace contains a wealth of data produced by events generated by user actions;
- Analysis of the raw trace must often be supplemented by information from other sources (surveys, tutor annotations, etc.) to be relevant;
- Analysis of the raw trace requires expertise that the actors do not know necessarily.

All these difficulties led to a formalization (Settouti, Prié, Marty & Mille 2009) that facilitates the treatment and processing of the raw trace to achieve most relevant traces. A traces transformation is a process that can transform one or more trace to another trace high level. A transformation model is a set of rules expressing selection conditions or rewrite patterns. They include, for example, production of indicators and patterns of use and design. (Settouti Prié, Marty & Mille 2009) gives more details on the transformations model.

3.1.3 Visualisation Phase

Broadly speaking, the visualization of traces is considered the best way to provide feedback to re-engineering environments (Cram, Jouvin & Mille, 2007). We apply this principle for a scalable through a distance learning.

For the *designer,* the trace visualization allows to detect the emergence of new uses made by the tutor and learner and to assess the suitability of a resource in a learning situation, *e.g.* the number of aid applications and assistance. For the *tutor*, the trace visualization allows monitoring of the learner, *e.g.* the number and duration of consultations of the course. It also allows the assessment of the level of collaboration among learners, *e.g.* the number of messages posted on a forum.

The information contained in the trace of interaction is part of the use of the learner. By visualising its own traces, the *learner* should be better able to take its environment and therefore adapt their work as demonstrated by the reflexive learning works (Soller, Martinez & Jermann, 2005) (Schön, 1983). Indeed, the display traces will allow learners to wonder about the experiences they lead, the results they produce, and the knowledge they conclude. Thus, by visualisation of traces, the learner can ensure the relevance of his/her approach or to readjust his/her actions (Cram, Jouvin & Mille, 2007).

4 USING TRACES TO MODIFY DESIGN CHOICES

Recall that our goal is to show that the activities of actor change and allow the specification of new design choices that may improve the quality of the training device. The design process is dynamic: the evolving needs of actors to put in place new tools for supporting their activities, and these new tools lead to the elaboration of new requirements.

The analysis focuses on the evolution of the use of platform tools SPIRAL (Renaut et al., 2006) by each actor over the past four years (4 classes) of VCIel training. For each actor, we specify the task that he/she must accomplish (prescription), the tools at his/her disposal; and the way he/she actually uses them. This analysis would show that these practices are changing the requirement of the beginning task, which re-starts the design process. Data were collected from:

- Direct observation on the use of the platform by students (quantitative traces);
- Indirect observation based on questionnaires to authors and tutors (qualitative traces). The questionnaire below is an example of a questionnaire that has been destined to tutors of VCIel training.

- Are you the author of the course for which you are a tutor?
- In what year did you begin to tutor VCIel?
- Have you participated in the design of the campus (before 2006)?
- This year or the past years, have you modify the chat sessions?
- This year or the past years, have you modify the answers to students' messages?
- This year or the past years, have you change the use of the platform SPIRAL?
- This year or the past years, have you modify the training schedule?
- Do you use the platform tool to monitor students?
- Do you have contacts with other tutors?
- Do you use the module "The tutors' space"?
- Do you have changed your practice of tutoring over the years: pedagogic way
- Do you have changed your practice of tutoring over the years: use the platform?
- How do you drive the weekly chat sessions?
- If you're not the author of the course, did you have contact with him?

4.1 Designers

The designer must ensure the coherence of the pedagogical and technical device. His/her responsibility is to develop a learning strategy taking account of evolutionary changes in the use of tools on the platform.

Thus, the role of the designer is not limited to prescribing scenarios; he/she also anticipates the changing needs by monitoring and analysis purposes. For this, the designer is responsible for:

- Identifying relevant observables. These are elements that will be traced during the interaction.
- Building indicators of use to change the device.

Working groups have made documents during the early phase of design. They allow one to specify the activities of actors: authors, tutors and learners. They are regarded as contractual, and describe the required task of each. The analysis of the device use may allow one to adapt better these documents to the context. This analysis is conducted through surveys of various stakeholders and at meetings.

4.2 Authors

The author is responsible for designing and preparing the course materials until they are posted online. His/her role can be summarized as:

- Designing of content/structure of supports;
- Screenwriting teaching activities;
- Updating content.

Thus, the evolution of each medium requires a consideration of the use made by the tutor of the content and required scenario. Design tools and multimedia support scripts are available to authors on the platform. Trace of activities conducted with these tools is not registered. Therefore, it does not allow a reflexive analysis by the author. However, it is possible to extract traces of usage of the content of tutors to perform a gap analysis between the made scenario and the prescribed scenario.

We note that at the start of training, the majority of authors also play the role of tutor. The author has a return on the work he/she has advocated and can adapt to the context. However, since the third class, and for some courses, some authors are no more tutors on the course they have designed. Therefore, there is a new role that will lead to a reflexion on a tool providing communication between authors and tutors, to integrate a user-centered design in the same design and content of their scenario.

4.3 Tutors

The tutor is responsible for the supervision and monitoring of learners in different learning activities until the final test. For this, he/she is supposed to follow the teaching scenario advocated by the author of course, document and manage learners, assist them in their understanding of the course and provide an hour of chat per week for 10 weeks to the whole group.

Tutors have tools for synchronous and asynchronous communication, an area of exchange of documents and administration tools to manage rights, view profiles and traces of learners.

Since the beginning of training, tutors platform connections have decrease over the years. Hence, the behaviour of tutors has changed. Several factors justify this result:

- Appropriateness of tools of the platform over time;
- Design of course when the training starts;
- Decrease of the number of tutors and students (21 in 2006, 17 in 2007, 12 in 2007-2008 and 18 in 2008-2009 and for the current year).

In parallel, evidence suggests that some tutors modified the initial pedagogical choices. One of them, a tutor of the course on a tool for developing animations, asked to cancel the chat sessions to communicate with students via email on individual productions. It is therefore very difficult to know, through the export of data to the platform, if tutors use the tools differently, if this difference is related to a pedagogical or technical choice, if there are patterns of use. Trace of connections is quantitative and global. A formalization of individual traces from pre-defined categories would be necessary to implement on the platform.

Thus, the analysis of tutors trace connections allows us to assume appropriateness of the device, pedagogical and technical, on their part. However, this type of trace does not inform on the process that has allowed this appropriation process. To do this, more qualitative and individual traces would be required, through an export platform or through interviews conducted to determine better what has changed in how they work. The results could provide elements for designers to improve the contractual documents for tutors, setting out their tasks, and offer new or different settings on the platform.

4.4 Learners

During the training, learners use the tools at their disposal on the platform to assimilate the content. As authors and tutors, they sign a contractual document that describes the activities, whether pedagogical or technical, that may result in the training. They must respect the planning for chat sessions. In case of difficulty, they can contact the tutor by email. They participate in collaborative meetings held by the tutor.

Figure 1 presents the development of learners' connections to the platform, the number of mails sent and forums consultation. In contrast to the tutors, there is an increase in connections over the years, suggesting that learners operate more tools from the platform (forum, chat, exchange area, documents...). The results also show that the evolution of the use of each tool is different at any given time. While connections to the platform are important at the beginning of the semester, and then decrease with time, the number of mails is relatively stable during the first months, while access to the forum is important in the middle of the semester.

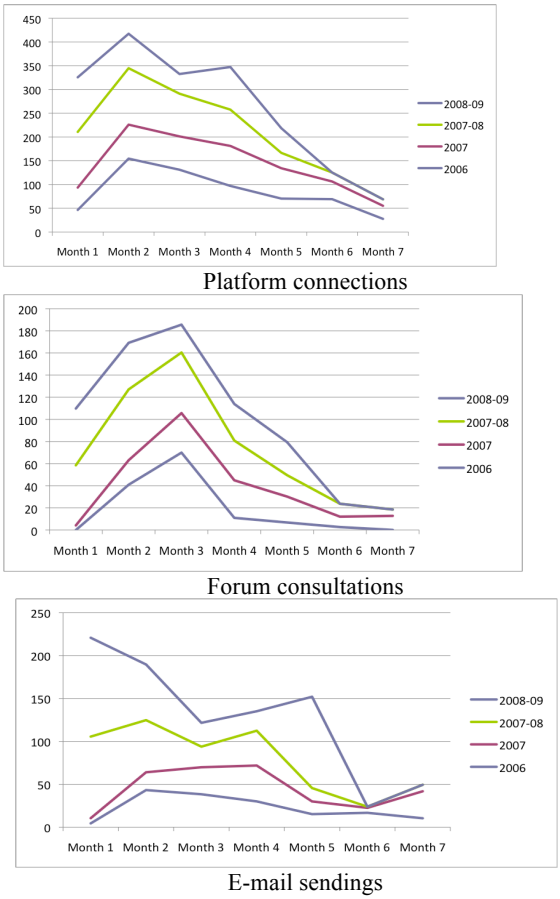

Figure 1: Use evolution of the tools of the platform by learners.

The designer may use these results to rewrite the learner and tutor contractual documents and think to the organization of the platform. For example, to increase the number of learners attending the chat sessions, the strategy was to schedule these sessions in two days of the week and not spread throughout the week for working students. The important use of the forum in the middle of the semester coincides with the start of the course "Realization" that requires teamwork, which suggests that learners promote the forum as a means of communication.

Currently, all messages from all the teams are stored in the same space, this is one problem. To facilitate access to data, it would be best for each team to create a space for exchange dedicated to it.

5 DISCUSSION AND CONCLUSION

This article presents a design approach based on traces of interaction. The aim is to evolve the design process by observing and analyzing activities of different actors. The advantage of this approach is that it takes into account the use to re-examine the design. Indeed, the trace to assist in understanding the activity of each actor and identify new needs. This is particularly interesting for the design of complex projects such as VCIel. However, the trace does not always identify the problem specifically for use because it is often of a quantitative nature. Indeed, most of our interpretations, even if they come from questions about quantitative data, are derived from qualitative data. The quantitative aspect, as suggested by data from the platform, is therefore not enough to interpret the reasons for the observed behaviour. We propose therefore to bind traces of a different nature, which would deepen the analysis but also to identify specific profiles of use.

In addition to improve the overall design process, the traces can be considered as sources of knowledge on learning of the learners as individuals (reflexivity) or as a group (collaboration, sharing, coordination, etc). In this sense, the analysis of the trace can improve the pedagogical scenario and adapt to the situation. Eventually, the trail could also be used for the sharing of experience between actors and indirectly allow a return on the design.

The theory has enabled us to glimpse the complexity of the design process in various ways: poor definition of the problem, collaboration between members of the team of designers, the importance of integrating the end-user at various levels of the process. VCIel experienced this complexity, and this shows how the creation of online training courses can be considered as the design of products studied in ergonomics: industrial products... With regard to the poor definition of the problem, VCIel is actually poorly defined in the sense that it is innovative with actors-designers beginners to this type of work. The user-centered design proposed by (Norman, 1999) seems to be entirely appropriate to address these difficulties. Indeed, during the process, it was found that if the user has been interviewed, tested, and he/she is integrated in the development of tools, it will allow a certain quality tools at the end of the cycle.

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