Using Eye Tracking to Map Behaviors in an Online Course Prototype About Epilepsy

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Abstract. Human-computer interaction (HCI) design has its main focus on the needs of users, an approach known as user-centered design. Designing online courses is a field of human-computer research that integrates ubiquitous technology, cognition and design. The development of an online course is prototype-driven. Unfortunately, there is a lack of documented methods for assessing the design of a prototype course before it is presented to students. This paper should contribute to this need by proposing a method for evaluating online course designs based on eye tracking data, which can significantly help designers in analysing the public's behavior. Some of these measures include content fixation points, gaze position, duration and blink rate. Designers can also gather data about how stressed out or relaxed the test users are, how attentive they are and how they solve problems. Affectivity can also be measured and this can be used to create a more customized environment for content acquisition and learning. In this paper we set out to: (1) describe the general methodology of using eye tracking to design and evaluate an online course prototype (2) discuss interaction design challenges related to this methodology and its limitations. In order to guide our discussion we will refer to an actual ongoing online course project about epilepsy that will be used to train schoolteachers.

Keywords: Online course prototype · Eye-tracking · Learning

1 Introduction

Despite substantial innovations in antiepileptic drug therapy over the past 15 years, the proportion of patients with uncontrolled epilepsy has not changed, highlighting the need for new treatment strategies that should be associated with the dissemination of knowledge to improve the quality of life of the patient. Such strategies are associated with the preparation of professionals not only in health, but essentially linked to education, for a more efficient and early screening. Epilepsy affects over 50 million people worldwide, and, for a quarter of those affected, no combination of standard therapy—primarily medications and surgery—can control their seizures. The search for better drugs and surgical approaches, as well as preparation of professionals from multidisciplinary areas (especially teachers) for the overall gains of the person with epilepsy and more effective

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public policies, should be reconciled. Thus, it is essential to use large-scale dissemination technologies, considering the geographical demands of Brazil, in the training/qualification of education professionals.

Epilepsy is a cerebral disorder characterized by the long-term predisposition to epileptic seizures and by the neurobiological, social, cognitive and psychological consequences of this condition; being a quite serious neurological disease, it is more prevalent than other diseases of its class [1]. The Ministry of Health, through Datasus, has recorded 157,070 new cases of epilepsy per year [2]. In Brazil it is estimated that between 1 and 2% of the population (2,050,000 to 4,100,000 people) have epilepsy [3]. Despite being underreported and the fragility of these data- as they do not reflect epidemiological reality- local studies have given a prevalence rate of epilepsy of 1.19% in the population of São Paulo and ranging from 1.65% to 2.03% in Porto Alegre [3, 4]. In addition, it is estimated that between 20% and 30% of people with epilepsy will not be able to control epileptic seizures with drug therapy [2]. The diagnosis occurs predominantly among children, especially in their first year of life, adolescents and patients of 65 years or older [2]. During childhood and adolescence, these individuals demonstrate a physiological process of neurological maturation and development of psychosocial structuring, which normally presupposes a phase that involves some personal conflicts. In pre-adolescents with epilepsy, this phase may be increased by the personal confrontation of the disease associated with the prejudice and stigma that are generated in all social environments, school, friends, and even in the family nucleus.

Teachers, when they have the proper knowledge, play a key role in introducing clarification, promoting acceptance of diversity among people and creating tools to eliminate discrimination. This comprehension of the teacher about epilepsy can have an effective and transformative impact on the social achievements of the students and the school and, consequently, on the professional life and social.

Despite this important role of the educator, little research is done in this field around the world, especially with intervention programs. Studies in different countries, including Denmark, the United States, Spain, and Greece, report insufficient teacher training on epilepsy, often associated with inappropriate and potentially harmful concepts of conditions involving the person with epilepsy [3, 5–8].

In 2008, the Brazilian Association of Epilepsy (ABE) began an intervention program in elementary schools in the state of São Paulo called “Epilepsy in Schools: Teaching Teachers”, which was awarded by the International Bureau of Epilepsy (IBE). The content was delivered via face-to-face lessons and video conferencing in the “Knowledge Network” and evaluated through a questionnaire applied before (Phase 1) and after (Phase 2) the lecture “Epilepsy: Causes, Symptoms and Conduct” [9]. The evaluation consisted of 35 objective questions covering the following topics: Concepts and definitions of epilepsy (10); Treatment and adverse reactions of antiepileptic medications (10); Physical and occupational activities of the person with epilepsy (5); Stigmatizing popular knowledge (5); and Basic care during and after the crisis (5). A total of 1,153 educators, divided into two groups, participated in a face-to-face class (288 educators) taught in four Brazilian cities, as well as via videoconference (866 educators) transmitted to 74 cities in the state of São Paulo, including the capital. The results showed a use of up to 41% in the topic “Basic care during and after the crisis” and the greater ignorance

(74.6%) and worse utilization (0.1%) registered in the topic "Popular stigmatizing knowledge about epilepsy". The study concluded that joint efforts are needed to disseminate general knowledge about epilepsy and specific strategic planning on its stigmatizing conditions.

Making a course about Epilepsy available on the internet will probably engage a wider audience than if the material were taught exclusively in classrooms. In particular, this strategy may also allow schoolteachers from remote locations to become acquainted with current topics in Neuroscience that can help solve longstanding problems in children's education.

Translating the contents taught in a conventional classroom to an online environment requires attention to some fundamental differences between these two modalities. This includes handling instructional contents in interactive sessions promoting student engagement and increase their motivation along with the use of online features such as forums and chats that enable the dialogue between agents. Thus, the main challenge is to replicate actual social exchanges that are common in face-to- face implementations, since the observation of others and how they respond to one's own actions form the greater part of learning (enactive learning). The first step to decrease this distance is to develop a prototype and test it with the target public- in this case, teachers.

Furthermore, basic knowledge of neuroscience can stimulate a change of attitude towards special education students, fostering a positive approach when considering the behavior of such students as part of the normal spectrum of human differences, the so called neurodiversity [10].

In this context, the first step towards increasing teacher engagement and awareness would be made possible if there were a online course "Let's talk about Epilepsy" containing information about epilepsy and a guideline on how to proceed when dealing with specific situations. As Brazil is a continental country, access to the application should be facilitated by allowing teachers to download it on their cell and use it wherever and whenever they want.

However, this online approach has three major challenges. The first one is to ensure the adherence of these teachers along the course, bearing in mind that it is mostly composed of so-called digital immigrants, that is, people who are not so used to dealing with the language and the virtual tools used on the Internet [11]. The second one is the implementation of the course itself. The third challenge is the course structure and the definition of appropriate online activities to reduce transactional distance of the agentes [12] and allow their integrated action.

Considering these challenges, the purpose of this work is to present a methodology to evaluate an online course prototype. This methodology will evolve based on the use of eye tracking data collection during experimental trials. We will discuss the challenges and limitations of this methodology in a possible application on a e-learning about epilepsy aimed at schoolteachers.

2 Instructional Design

Currently, computing technologies and new transmaterials are incorporating more reciprocal architectures and human-based (digitally enhanced) environment interaction [12, 13]. Online education is the integration between technologies, including hypertext and interactive communication networks, for the development of educational content and learning support. Nowadays, students can access this interactive material everywhere, when they want. It is important to create materials that can teach students with the most efficiency. Research has proven that the results of learning a subject are increased when there is integration of text, images and diagrams [14, 15]. How can we design such efficient and integrated tools?

Some of the better-known (research based) approaches are user-centered/participatory, contextual designs and activity theory [13]. Most of these approaches are built on the assumption that a suitable design proposal is to be established through simulating a real interaction situation. The end result is to understand how the user responds to and interacts with the educational interface program.

The instructional designer is responsible for planning, preparing, producing every text, image and graphic, which are part of the course in a digital platform. The traditional instructional design model is called ADDIE. This acronym means: Analysis- identifying learning needs, setting instructional objectives, and surveying the constraints involved; Design and Development: planning instruction and the elaboration of instructional materials and products; Implementation: development of educational tools; and Evaluation: obtaining and reviewing feedback from the experience of users and technicians. Another approach is SAM (Successive Approximation Model), which was proposed by Michael Allen [16]. The main difference between these instructional design models is that the first is divided in five separate phases and the second is an iterative design incorporating a rapid prototyping, which means a continual basis feedback during implementation [16]. The various design versions of SAM, which are made of intermediary prototypes evaluated at the level of the user's experience, could be enhanced using eye tracker. It can provide insight into where students consume content based on the location on which they focus their eyes. To do this a camera is placed at the bottom of the computer screen to monitor eye movement. The information that is gathered through these eye-tracking devices shows us how interested the person is in the content and where they are placing their attention.

3 Eye Tracking

Eye tracker is a device to map and record eyes movement. It is performed by high resolution cameras that directly film the gaze and direction of eyes. This procedure is completely painless and does not include direct eye contact. There is no need for using glasses or any substance or medication during this recording procedure. Before starting to collect data, the system calibrates the viewers´eyes to ensure that the position of them is correctly mapped [17, 18] There are a various different types of eye tracking devices like head-mounted (used mainly in reading studies) and those that are integrated to

monitors or standalone units, used preferentially in market and usability researches. Independent of type, the measures collected by these devices include content fixation points, gaze position, duration and blink rate. This data could be correlated to users' behavior: their stress, fatigue and attention during the tests. Sometimes users don't read a text, they scan for a useful information. Eye tracking data shows the large numbers of fixations on many screen parts and wandering gaze. This information is important for marketing, for example, following consumers eyes during their navigation on e-commerce platform shows what they see, how long they spend paying attention in some specific product, what they did before they decided to order [19]. Thus eye tracking helps to identify usability problems.

Eye-tracking data has been used to identify how subjects figure out causal and reasoning problems in online courses [20]. According to these authors the eye movement variables is correlated with the cognitive processes involved in learning. [21] emphasize that visual attention is correlated with the activities proposed in a context of learning. Other researchers developed interface guidelines to e-learning that were based on eye tracking data collection [22].

On the other hand, some authors [23–25] discuss some limitations of eye tracking. They argue this device can´t track peripheral vision and sometimes the interaction between facilitator and participant interferes in the result. Thus the data could not reflect the cognition. Another difficulty is the device itself; most of them are expensive and require specialized professionals to administer it. Also the devices need to be calibrated to each participant and much time is spent on this. Finally, Nielsen and Pernice [17] and Gueise [19] point out that there is not a pattern in research using eye tracking because each study has its own protocol to evaluate a specific site. This implicates difficulties in comparing studies because it is not possible to generalize findings neither user behavior.

Considering these challenges, we will start the discussion about instructional design by concentrating more on usability than learning to improve instructional design method.

4 Prototype

Our approach to the prototype's design is a multidisciplinary one. A team composed of neuroscientists, graphic designers, instructional designers and programmers, along with school teachers will be involved in all the design process. This collective construction is divided in two parts: prototype development and prototype evaluation.

4.1 Prototype Development

Neurocientists have a series of meetings with designers to decide: the content, the format, the public and protocol. The prototype "Let's alk about Epilepsy" addresses how to deal with a student that is having a seizure. First, one interactive infographic about this topic will be created and presented to the schoolteachers who will then answer a small quiz about it. The infographic format is best suited for this content, because it can portray many iconic elements making it easier to show the steps that the teacher needs to follow

when a student has a seizure. The quiz is a multiple choice activity that will allow for scoring the schoolteachers responses.

According to Nielsen and Pernice [17] an adequate number of participants for eye tracking studies is 39. Following that guideline, this trial will include 40 teachers from 10 public schools in São Paulo (Brazil) that will be selected for participation.

We chose to use a lower priced eye tracking device that was created by Eye Tribe, a Danish start up. In December of 2016 the company was sold to Facebook. This portable device is installed on a computer. Like other eye trackers, it mainly measures:

- Gaze duration: the duration of gazes (fixations) on a certain area of interest.
- Number of fixations: the number of fixations on a certain area.
- Interval to first fixation: the amount of time until an area is first noticed.
- Density of fixations: the concentration of gazes in a particular area increases the density of fixations on that area

The analysis of these parameters will vary with context and care should be taken when trying to assess user intentions from eye movement patterns. For instance, high average gaze duration could be linked to very different causes, such as high level of engagement, high stress and even mind-wandering.

The programmers will work with the graphic designers to gather the Eye Tribe data and associate that with the images being displayed by the e-learning software.

The evaluation test will consist of the following steps inspired by recent studies [17, 19, 21, 22, 25]: pretest, data collection, data analysis.

4.2 Pretest

In this step, we will investigate the student's skills and experience in the following aspects: intimacy with equipment, experiences in training and calibration of eye tracker.

First of all, we explain to the participant what will happen in the trial. It is important to assure them that it is a safe, painless test. We could say, for example: "we will ask you to do two online activities that consist of one infographic and one quiz. During your navigation, this device (point to Eye Tribe) will record your eye movement. It is like a camera that films your eye. It is painless. You will help us to design better online courses". The designer needs to clarify them that there is no right and wrong in their actions and that a person will observe them during the test in order to note the sequence of activities that the participant will perform on each screen and that the participant should not worry about that.

The user signs an ethical agreement that assures him of the confidentiality of the study and of his rights. This agreement is also signed by the team who conducts the trial.

Before that, the user will answer a questionnaire on a computer. Our objective is to see his body position when he sits down to use the Web. In addition, we can inform him that he needs to focus only on the screen and he can't move his head a lot. This practice prepares him for the test. This is also an opportunity to ask him about his familiarity with the internet. These are the questions:

- Do you use your computer at work? Y/N
- Do you use the internet? Y/N
- Have you already done any e-Learning training? Y/N
- How was your experience? (*If you did an online course, please tell us about it)*

Finally, the Eye Tribe will be calibrated. This step is important to allow the data to be collected properly. The individuals who has ocular deficiencies can't participate in this study.

4.3 Data Collection

In the data collection step, eye tracking parameters will be collected. Another important data that can be collected in this step is "think-aloud" data. This consists of asking the participant to describe their interaction with what they see on the screen and could be used to better understand the relation between user intentions and eye tracking parameters.

4.4 Data Analysis

The objective of this step is to evaluate the efficiency of navigability and usability of the course. This should provide answers to questions such as:

- How intuitive is the navigation?
- More specifically, do participants know where to click?
- Are the instructions on how to explore the course satisfactory?

Gaze duration and time to first fixation could be used in determining if difficulty with some words or drawings in the infographic were the cause for problems in answering the quiz afterwards.

Additionally, there are software tools that help with statistical analysis of the eye tracking parameters and with the creation of visual representations of eye movements on top of the course images. Those can make it easier to identify improvements to the course material, i.e. low fixation densities could mean that information is more spread apart that what it should.

The results of the data analysis should then be used as seed for the next iteration within the context of the successive approximation model (SAM).

5 Conclusion

The increased use of technology applied to education requires more research about instructional design. Prototype-driven design and user-centric design are the basis of our methodology to the development of more effective courses in terms of usability.

Eye tracking is a tool that could help designers to evaluate the online course because mapping eye movements could give some clues about what needs to be changed in the course before it is launched. However there are some challenges to overcome, for

example, lack of qualified professionals to do this type of test as well as a few standard protocols to follow.

In the prototype suggested "Let's talk about epilepsy", we propose an initial protocol to designing and evaluating e-learning material that takes into account the familiarity of the public with digital interaction. Finally, this proposal helps to start the discussion on different approaches to instructional design.

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