Artigo Original

Eye tracking technique reveals strategies of multiple and nonlinear actions for virtual navigation of distance learning students on the LMS and on the internet

Técnica de rastreamento ocular revela estratégias de ações múltiplas e não lineares de navegação virtual de alunos de EaD no AVA e na internet

La técnica de seguimiento de ojos revela estrategias de acciones múltiples y no lineales para la navegación virtual de estudiantes de aprendizaje a distancia en cursos en línea y en internet

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Abstract

By offering multiple paths for access to a variety of content, hypermedia environments create new possibilities for online study and learning. However, little is known about virtual navigation trajectories and their relationships with learning in distance education. This research documented virtual navigation movements, through the use of the eye tracking technique, of undergraduate students as they studied in the learning management environment (LMS) and in the internet. It was reported that, when navigating in the LMS, students generally did not follow the linear sequence of the system and, specifically in the Lesson pages, they neglected some imagery and hyper textual elements because

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they considered them expendable to learning. The data analyzed gave rise to two categories of virtual navigation: simple, in which students focus on the LMS navigation; and complex, in which the students crossed several tracks and accessed websites, blogs, files on the network and expanded the content made available in the LMS. This has led, in some cases, to a loss of focus on the task and difficulties in understanding concepts. The autonomous action of the students is emphasized as they formulated and executed navigational strategies adequate to their study objectives, to the characteristics of the LMS and the study materials, aiming to carry out programmed activities to learn.

Keywords: Virtual navigation. Eye Tracking. Distance Education.

Resumo

Ao oferecer múltiplas trajetórias para acesso a variados conteúdos, os ambientes hipermidiáticos criam novas possibilidades para o estudo e para a aprendizagem on-line. No entanto, pouco se sabe sobre trajetórias de navegação virtual e suas relações com a aprendizagem na educação a distância (EaD). Esta pesquisa documentou movimentos de navegação virtual, através da utilização da técnica de rastreamento ocular, de alunos de graduação na modalidade EaD, no momento em que estudavam no ambiente virtual de aprendizagem (AVA) e na internet. Contatou-se que, ao navegar no AVA, em geral, os alunos não seguiram a sequência linear do ambiente e, especificamente nas páginas das Aulas, desprezaram alguns elementos imagéticos e hipertextuais por 2 considerá-los dispensáveis à aprendizagem. Os dados analisados originaram duas categorias de navegação virtual: simples, em que os alunos se concentraram na navegação no AVA; e, complexas, na qual os alunos percorreram trilhas diversas e acessaram web sites, blogs, arquivos na rede e ampliaram os conteúdos disponibilizados no AVA. Isso gerou, em alguns casos, perda de foco na tarefa e dificuldades na compreensão de conceitos. Ressalta-se a ação autônoma do aluno de EaD ao formular e executar estratégias de navegação adequadas a seus objetivos de estudo, às características do AVA e aos materiais de estudo, visando realizar atividades programadas e de aprendizagem.

Palavras-chave: Navegação virtual. Rastreamento Ocular. Educação a Distância.

Resumen

Al ofrecer múltiples trayectorias para acceder a variados contenidos, los ambientes hipermidiáticos crean nuevas posibilidades para el estudio y el aprendizaje en línea. Sin embargo, poco se sabe sobre trayectorias de navegación virtual y sus relaciones con el aprendizaje en la educación a distancia. Esta investigación documentó movimientos de navegación virtual, a través de la utilización de la técnica de rastreo ocular, de alumnos de graduación en la modalidad a distancia, en el momento en que estudia en cursos en línea e Internet. En la mayoría de los casos, los alumnos no siguieron la secuencia lineal del ambiente y, específicamente en las páginas de las Clases, despreciaron algunos elementos imagéticos e hipertextuales por considerarlos dispensables al aprendizaje. Los datos analizados originaron dos categorías de navegación virtual: simples, en que los alumnos se concentran en la navegación en cursos en línea; y complejas, en la cual los alumnos recorrieron sendas diversas y accedieron a sitios web, blogs, archivos en la red y ampliar los contenidos disponibles en cursos en línea. Esto generó, en algunos casos, pérdida de foco en la tarea y dificultades en la comprensión de conceptos. Se resalta la acción autónoma del alumno al formular y ejecutar estrategias de navegación adecuadas a sus objetivos de estudio, a las características de cursos en línea ya los materiales de estudio, buscando realizar actividades programadas y aprender.

Palabras clave: Navegación virtual. Rastreo Ocular. Educación a distancia.

1. Introduction

The development of pedagogical projects and the use of digital technological supports aligned with new education paradigms, in particular the development of content and practices that use hypertext resources (GOMES, 2018; LANDOW, 1994) and multimodality (de FAIRCLOUGH, 2000; KRESS, 2003), are becoming more popular. The most visible face of these formulations is in the design and format of

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hypertextual online artifacts (adding the use of images, video, audio and links) available on digital networks such as the internet.

When addressing the specificity of the contents found on the internet, Manovich (2001) classifies them as a database, being a "structured set of data organized for quick search" (p. 218) that allows "to view, browse, search and store information "(P. 219) and which stores texts, images, graphics, links and multimedia objects (sound and video) allowing "changes, updates, interactions" (p.221).

According to the author, it is a collection of items and not an already established narrative. Hence, the possibility for each user / reader to build their own navigation, since access to this collection of items can occur in a random, unstable manner, including in the Virtual Learning Environments (VLE), which have different areas and sections. Padovani and Moura explain that

> hypermedia navigation is unique, given the enormous flexibility of access that such an information system provides. This system allows, but also requires, the user to choose at every moment how and with what information available in the environment they want to interact (PADOVANI and MOURA, 2008, p.9).

Agner and Moraes (2017) consider that looking for information on websites is a frustrating experience for the user, which can lead to the task being abandoned due to factors inherent in hypermedia. Brazilian and foreign researchers have developed several studies seeking to understand the new elements and the difficulties associated with digital reading (COSCARELLI; RIBEIRO, 2019). These characteristics of hypermedia environments lead to the question about how the distance learning student navigates in both structures - the internet and the AVA - in their study moments. It becomes clear the need to know the virtual navigation of the EaD student and analyze their choices, the navigation paths followed and the information and content accessed during the study moments.

> The present study generated knowledge about the types of navigation and interaction of students in distance

learning, in the context of learning, using the methodology of documentation of eye tracking. The students' navigation, reading and interaction actions were documented in the AVA used by them and also on the internet during activities of the subjects taken. Interviews with participants were conducted after each navigation and study activity, in order to understand the documented actions. The collected data were analyzed to identify the students' virtual navigation actions.

2. Internet and virtual navigation

The internet consists of a chaotic set of networks, nodes, links containing all types and forms of information that can be accessed in a vast combination of paths outlined by users.

According to Lemke:

> there are many possible trajectories, or crossings, through the hypertext web. Meaning in a large scale time and text, compared to the typical scale of linked units (for example, a number or a page) it becomes a user/reader creation that is much less predictable for the creator than in the case of a printed book whose narrative or argument has a single conventional sequence (LEMKE, 2002, p. 300).

Braga also explains that "hypertext is completely different from printing, since it only offers the reader bits and pieces of information, allowing potential loop paths without a narrative or argumentative axis that reported all of them in a sequence" (2005, p 147). This means that the user "navigates through network nodes in a totally unpredictable way, often even for himself" (LEÃO, 2001, p. 57). Despite this chaotic nature, the authors point to the fact that the navigation process can be influenced by hypermedia, as highlighted by Teixeira:

> when we surf the internet, we are continually making choices. We chose one link over another, not only based

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on our goal of getting to a point behind it, but also based on the way the link was displayed in the interface by the designer. In an environment of information abundance, we suffer from a lack of attention. An interface design that captures the user's attention is critical to their success (TEIXEIRA, 2005, p.1).

Therefore, virtual navigation implies the movement of users through the built space of nodes and other types of connections, such as links (ULBRICHT apud PADOVANI, MOURA, 2008). This is necessary to search for information and build knowledge, not being restricted to a mere mechanical action. Santaella (2004) states that current browser actions incorporate the following characteristics: (TEIXEIRA, 2005, p.1).

- contemplation: the behavior is related to a silent and linear action, in which he can access and read books, paintings and maps;

- movement: the behavior is related to the fragmentation associated with the media contexts, reading is fast and the language is ephemeral and hybrid in nature;

- involvement: the behavior is related to living in a state of alertness, being connected through cyberspace nodes.

Still according to the author (SANTAELLA, 2004), navigation is based on a path that is built by the interaction between the user and the materials in cyberspace, including the nodes of words, images, people and others. This constitutes a navigation process that is exploratory and co-creative.

Padovani and Moura (2008), based on previous studies, systematized the following categories of virtual navigation performed by the user: browsing, scanning, skimming, exploring, searching and wandering. These categories describe hypermedia navigation movements, which are actually navigation strategies used by the Internet user to access a link, return to the previous page, perform a search with a specific objective, or even browse at random, without a clear objective . The following movements comprise:

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- browsing - visiting a set of interrelated nodes through the activation of links;

- scanning - covering a large area with no depth in order to locate something;

- searching - focused search for a pre-established target node;

- exploring - searching for information on the network or system;

- skimming - covering a large area in order to map it quickly and superficially

- wandering - random, unstructured navigation with no pre--defined objective.

According to Gall and Hannafin (1994), navigation can become problematic in hypertextual systems: with the increase in the number of options, the possibility of confusion and disorientation also increases (LOCATIS, LETOUMEAU and BANVARD, 1989).

Conklin described the orientation as "the lack of awareness about its current location in relation to the rest of the network or as the inability to find a point in the network even though it exists. Others characterized this phenomenon as being 'lost in cyberspace'"(CONKLIN, 1987, p. 21, our translation).

In the context of the learning processes experienced by distance education students, additional challenges in navigation include the large amount of information available on similar topics and accessible through multiple channels; a definition of the pace and style of navigation throughout the learning process; the creation of a personal position in relation to knowledge; the construction of knowledge based on personal needs and goals; and the critical construction of knowledge based on several ideas and points of view available in cyberspace.

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3. Research and data collection methods

The eye tracking technique was created over a century ago, but it was only in the 1970s that automated processes were developed, which allowed the documentation and processing of eye saccades, that is, an eye movement from one point to another. This inaugurated the so-called third era of investigation, the movement of the eyes (RAYNER, 1988), and generated a nomenclature of actions documented by the referred technique that became universal and endures.

The saccade is defined by a rapid movement of the eyes, usually lasting around 8 and 12 characters, which configures jumps of small distances, but with great speed. Fixation refers to a brief interval of time, lasting about 250 milliseconds, where the eye is paused at a certain location, which corresponds to an action of the brain, which processes visual information. Regression is a movement of returning the eyes to an already observed point and may indicate lack of understanding, confusion, disturbance (BEYMER, ORTON, RUSSELL, 2007). The use of the eye tracking technique has received great attention in the area of usability studies and human-computer interaction.

Today, eye trackers have high temporal resolution and allow, through software analysis, the fractionation of tracking times into various components. Another highlight is the fact that participants can act more easily during collections, an important fact in the acquisition and interpretation of data on various tasks, which require long periods of machine time. The technique is, therefore, very effective for the investigation of virtual navigation, allowing the accurate recording of the points on the computer screen actually viewed by the student when navigating, a key element for the documentation and understanding of the behavior of distance education students[2]. A recent study in the area used the tracking technique and allowed to analyze how distance education students view the teacher's image in institutional videos. It was possible to conclude that this students' visual attention was an indicator

[2] For a more detailed approach to the technique and its application in studies in the field of education, see: JUNQUEIRA, Eduardo S.; TEIXEIRA, Elisangela .; SILVA, Zilmara. A trajetória ocular durante a aprendizagem on-line: o uso do eye tracking para investigar percursos de navegação virtual na Educação a Distância. In: Educação a Distância. Interação entre sujeitos, plataformas e recursos.1 ed. Cuiabá: EdUFMT, 2016, p. 211-234

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of satisfaction when watching the video and that fixing their eyes on the teacher's image was positively related to reducing cognitive overload for thematic topics considered difficult and to increasing satisfaction in studying such topics, among others (WANG, ANTONENKO, DAWSON, 2020).

The present study focused on the analysis of the students' virtual navigation sequences from the discussion forum and outside the LMS. The tracking equipment documented the student's eye movements on the computer screen, as well as the jumps, fixations and regressions of the eyes on parts of the screen. It was possible to track each movement made by the student, each look, each click of the mouse, allowing a precise analysis of navigation movements, covering the complexity of the actions undertaken by the study participants.

3.1. Participants and data collection procedures

Nine distance education students from the Mathematics and Modern Languages/Portuguese courses took part in the study at a pole of the Universidade Aberta do Brasil in partnership with the Universidade Federal do Ceará. Data collection lasted for two academic semesters.

In the laboratory, students were invited to browse as if they were studying, with the students only being asked to start their navigation from the discussion forum of one of the subjects studied in the LMS, at the time of collection. Students could also use any other means of study, such as notebooks, books and other research materials. The students spent at least 10 minutes browsing, in the way that was most appropriate for them, as if they were at home studying for different subjects. At least four navigation documentation shifts of 10 minutes each were carried out. In the first two shifts, the student remained alone in the laboratory while the equipment documented navigation. In the other two shifts, the researcher monitored, in person, the navigation actions and took notes. After the four shifts were completed, the researcher interviewed the student, trying to understand the navigation actions carried out in the four shifts. The transcription of the interviews recorded in audio was carried out, in which the students explained their movements in
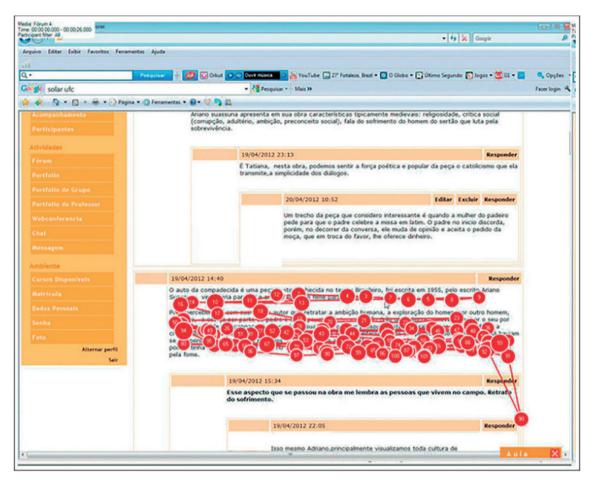
detail. The testimonies were considered and analyzed, which added precision to the analysis of the navigation trajectories.

No research conducted with individuals is exempt from the researcher's influence, however, although, at times, the researcher was present in the laboratory, it is believed that the students were comfortable, even browsing social networks.

4. Results

The results of the analysis of the virtual navigation documentation, generated by the eye tracker, indicated particularities in the students' path and navigation modes in the context of learning activities: student navigation encompassed genuine actions in the LMS and multiple actions outside the environment, the result of strategic and conscious choices made by students throughout process, aiming to achieve their goals when studying.

At each new study session, the majority of students began to browse the LMS discussion forum, as requested by the researcher. When browsing the forums, the students, in general, were mainly interested in their colleagues' posts (see Figure 1), also sometimes including content published by the tutor. Then, they went to consult messages in their inboxes, in addition to carrying out other browsing movements, such as internet searches and extra materials. In general, only after carrying out these actions, they navigated through classes (the disciplinary content produced by the teacher and published in HTML format on the LMS). This movement was documented even when the initial action in the forum had not been requested by the researcher, demonstrating the centrality of the discussion forum in the navigation actions of students in the LMS when studying.

Figure 1: Image of eye fixations on the content posted by students in the LMS forum, revealing the attention of the participants dedicated to these contents.

Thus, a recurring navigation action by the students participating in this study included the following sequence: access to the LMS to start or continue some activity of the course subjects; and navigation through the discussion forum or sections of the activities of the disciplines. After accessing the forum and checking the posts of colleagues, the student, if needed, accessed the corresponding class and, after accessing the material, navigated outside the LMS and performed searches on the internet. In several cases, navigation outside the AVA was performed to access files received from colleagues or previously stored on the network or on physical devices. During data collection in the laboratory, some students interrupted their computer browsing activity to consult printed study materials such as books, handouts and notebooks containing handwritten notes (see Figure 2).
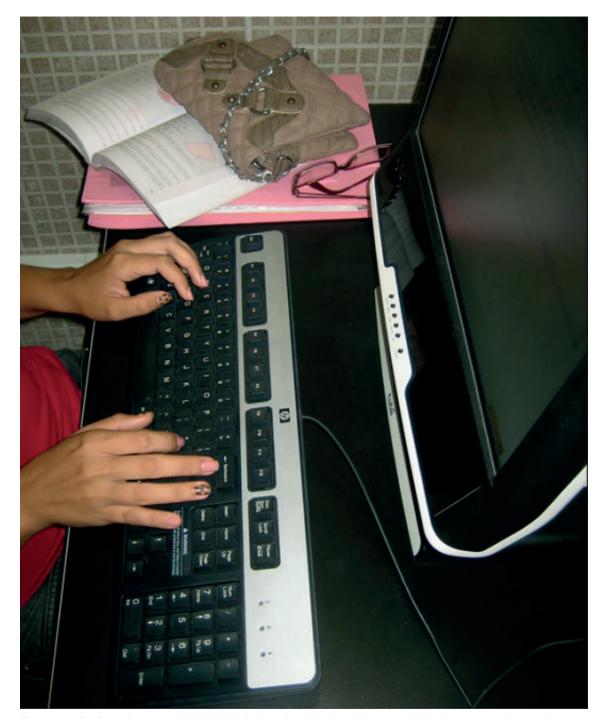
Figure 2. Students consulted books and other printed materials when browsing to perform course activities.
Source: the author.

Thus, access to classes, that is, to the formal content made available by the teacher, was intermittent and, generally, dependent on the learning activity to be carried out by the student and the debates in process in the forum. In most of the documented actions, the navigation in the

classes was directed to specific parts of the materials, those that were of interest to the student at that moment for the accomplishment of an activity of the subject (a publication in the forum, a written work etc.). In this way, navigation was personalized and non-linear, that is, it did not follow the sequence of the LMS or the classes (of the contents prepared by the teacher), flexing the traditional teaching and institutional centrality in the formal teaching processes.

Still on the navigation of students in the forum, it included actions in response to comments from colleagues and the exchange of online materials. The interaction between the students proved to be very important in their learning process, because, in general, the navigation performed by the students outside the LMS happened after accessing the comments of their classmates in the forum. Students responded to a comment or went on to research in class or even outside the LMS, as mentioned, in order to answer questions about some content, term or conceptual expression, or problems mentioned by colleagues. In solving these doubts, they published a comment on the forum. In this way, it was noticed that the comments of more experienced or more frequent students acted as triggers for new navigation actions of the other students of the class, inside and outside the LMS, in the case of the activities of the discussion forum.

The documentation and analysis of navigation actions with eye tracking allowed to identify and group the most recurrent navigation movements among students in two categories. The first category refers to a less complex type of navigation, where students were restricted to browsing the LMS, accessing published content and posting comments on the forum, which sometimes included a longer navigation through the contents of the classes. The second category refers to a more complex navigation, where the students, in addition to accessing the comments published in the forums and the study materials of the classes, also explored environments outside the AVA, seeking additional information on blogs, various websites and text files, which was often contained in files attached to e-mail messages shared by fellow students. These more complex navigation actions also included, in the case of some students, the access to web links inserted in the classes themselves and which

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extended the navigation to spaces located outside the LMS at the teacher's indication. All of these movements constituted a rupture in linear navigation in the LMS.

Through the analysis of the participants' responses to the interviews carried out, it was found that the students left the LMS when they considered that the content of the classes was not sufficient to understand concepts and solve problems presented in the course taken. Some testimonies indicated the importance of this type of navigation outside the LMS for some students. They stated that this navigation movement helped them a lot in understanding the content of the classes. But leaving LMS also created difficulties for some students, who mentioned problems such as loss of concentration and focus on the activity in progress when accessing many links on the internet. It is understood, therefore, that, although navigation outside the LMS has been positive for many students in different situations, content that better meets the student's study needs within the LMS could reduce some disruptions to the student's learning process.

4.1. Navigation Strategies

Using the theoretical categories of Padovani and Moura (2008) as reference, several navigation strategies of the students when they studied were identified. They are called that way because they configure their own modes performed by students when navigating, in order to supply difficulties in conceptual understanding and problem solving, gaining time, carrying out activities, reaching goals. The browsing strategy, for example, was performed when the student accessed a link from the class in the LMS or outside it. This was identified, for example, when the student accessed the LMS and, before engaging in any specific activity, he checked the news that emerged since the last access. To do this, they quickly navigated through the different sections of the environment, checking the message inbox, new forum posts and notes sent by the tutor. The searching strategy occurred, frequently, when the student knew of the need to obtain more information and, therefore, left the LMS and accessed the internet to search for it. This movement, in general, was triggered by a doubt that, in turn, arose when browsing the forum or the contents of the class. The student then searched for it and accessed

related content on the internet to learn more about a curricular topic, a concept etc. (see figure 3). The scanning action also occurred, frequently, when the students scanned a page or a file they found, examining its adequacy to the needs of the moment of study (see figure 4). Thus, instead of engaging in a detailed exploration of the material, they initially limited themselves to knowing the main elements of the content displayed on the screen. Thus, they avoided wasting time and went ahead with the research activity to solve the problems encountered while studying.

Figure 3. Eye visualization through the heat map effect shows that, after performing the search, the student accesses content on the internet related to the topic of study.

Figure 4. Tracking the sequence of ocular fixations shows that, when navigating outside the LMS to deepen information on studied themes, the students scanned the textual information, disregarding images unrelated to the themes of interest, just as it occurred in the LMS.

When they identified that the material was of interest to the task to be performed, the students then initiated a skimming action, that is, a more detailed navigation to know the study material or comments in the forums. Scanning was also carried out very frequently in the LMS forums, to identify new comments available, tutoring interventions, etc. Rarely, linear navigation, from top to bottom, from beginning to end, for example, occurred in forums. The students determined the navigation path, regardless of the structure and flow of actions programmed in the LMS, seeking to find what was of interest at the time.

The wandering strategy was identified less frequently on the internet and occurred when the student surfed in a very random manner, accessing various web links and briefly viewing parts of the texts available on

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the screen. This occurred, generally, when the student was articulating the next navigation action, when preparing a response to a scheduled activity of the discipline, or before the writing of the forum's comment in the LMS. Therefore, it was not configured as a main navigation action when studying.

An occurrence of particular interest in the navigation of the students, in the contents of the classes, was revealed in a very specific way by the mapping of the eye movements of the students of the Modern Languages and Mathematics courses. When browsing, students of Modern Languages ignored several images inserted in the classes. Their eyes never fixed on these images during navigation, the written text being the target of their attention and focus (see Figure 5). The same occurred for content accessed by them on the internet (see Figure 4). In the interviews, it was found that this fact was generated by the students' understanding that they were accessory images, merely illustrative, and that they did not contribute to the understanding of the studied contents. In the case of mathematics students, the opposite occurred. The images contained in the classes were visualized - the eyes were fixed on them on the computer screen, as indicated by the eye mapping (see Figure 6). And, conversely to the students of Modern Languages, the students of Mathematics stated that they viewed such images because they were fundamental to the understanding of the studied contents. This behavior is similar to actions documented in similar studies and is explained by Stemler when he stated that

> students who do not understand information through texts will often understand it if it is presented or aggregated in visual formats (MERRILL, 1983). Difficult topics often become easier to understand when added to graphic elements (GROPPER, 1983 apud STEMLER, 1997, p. 9, our translation).
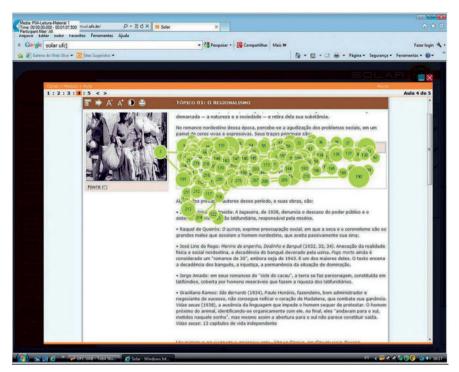
Figure 5 - Tracking the sequence of eye fixations reveals that the image was not viewed by students of Modern Languages during navigation in class.
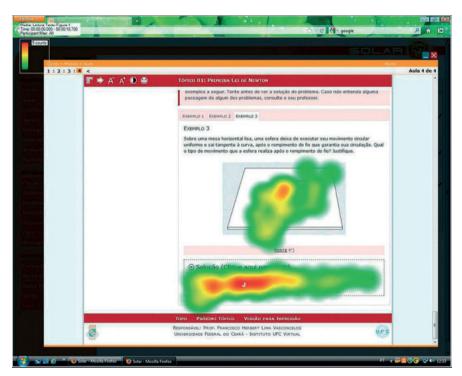

Figure 6. Mapping using the heat map reveals that students observed figures directly related to the understanding of the topic studied in the LMS.

In the case of Modern Language students, it is important to note that the images did not disturb the students' navigation and study process either, as they were ignored, that is, they were not visualized.

Regarding the navigation strategies proposed by Padovani and Moura (2008), the results of the study indicate their relevance, also, in the context of students in the distance education modality. The classification of the authors offered a conceptual basis that guided the analysis of the data obtained, which led to the proof that generic navigation movements for digital network environments are relevant to distance education students and that they make up a larger and more complex navigation system, in which students use the various tactics aimed at reaching an objective: performing tasks and learning.

With regard to the didactic design of courses, planning of student activities in the LMS and development of the content of classes for distance education, it is important to highlight the fact that navigation, in most cases and for most students, did not occur in a linear and sequential form, as how the structure of the LMS and the classes would suggest. On the contrary, students built their own navigation paths, in LMS and outside the environment, according to their interests (developing and concluding activities) and needs (understanding concepts, resolving doubts, collaborating with colleagues, etc.).

The students' proactiveness in the actions documented and analyzed in this study was clearly and positively outlined, as the students ignored content posted by the teacher (images, web links) when they thought they were unnecessary for their learning. The opposite also occurred: they performed access outside the LMS when they believed that the new materials would be useful for learning, even though they could require more time and energy to complete a task. The navigation actions indicated a pragmatic, independent and conscious attitude of these distance education students when studying.

This type of browsing behavior of students is correlated with research in the area of online reading developed by some researchers. McNabb reports that

> in online reading, the reader's choices and purpose, not the author's, determine the reading sequence. Conventional reading strategies that are effective for reading a block of text - or what Landow (1992) calls lexia - do not necessarily apply for reading hypertexts. Hypertext readers must continually make decisions about which link to click on and why they should do so and they are forced to make associations between lexias and create their own narratives in the process. (MCNABB, 2006, p. 76, our translation)

Studies carried out for more than two decades have already indicated the benefits of autonomous strategies and the proactivity of students' virtual navigation. Jonassen and Grabinger, also dealing with hypertext content, affirm that "meaningful learning through hypertext will only occur if it allows the active construction of knowledge" (JONASSEN AND GRABINGER, 1993, p. 15, our translation). These are actions already described by researchers about the use of hypertexts, as reported by Gall and Hannafin:

> the learner's control when navigating the hypertexts depends, fundamentally, on the nature of the decisions to be made. According to Chung and Reigeluth (1992), the learner's control decisions can be directed to the content of the lessons, sequences, rhythm, presentation of the contents, strategies, processing and advice […] In general, hypertexts support four control functions of the student: searching, browsing, collecting and connecting. (GALL and HANNAFIN, 1994, p. 218)

5. Final considerations

The pioneering use of the eye tracking technique to document and map the study actions of distance education students allowed to advance the knowledge about the behavior of learners when browsing through LMS and on the internet. The non-linear and unpredictable paths of students in their study moments were revealed through the mentioned technique,

which, in general, resulted in benefits for their learning, as they were configured as strategies to seek necessary information and add knowledge to the activities developed by them, over the courses taken. Exercising a proactive and pragmatic attitude, they chose what to access and what to ignore - particularly in the forums, in classes and on the internet - and did so in an effort to stay focused on the task and save time dedicated to study, since they have many other activities at work and with their families.

It was concluded, from the analysis of navigations and testimonies of students, that the LMS does not cover and does not host the various learning actions of the distance learning student. Many students participating in this study used additional materials - in digital and printed formats, which were often shared and indicated by their classmates. Taking advantage of the flexible and multiple nature of hypermedia environments and content, students used extra links and sources of research as an important alternative for their studies. This helped them learn. However, it is recommended that this use occurs in moderation, as the excess of links and content can cause disorientation and loss of focus on the concepts studied.

It was also found that the discussion forum played an important role in all the navigations analyzed, functioning as the main entry point in the LMS, as a space for exchanges and interaction between students, and as a motivating element for research and in-depth study of topics of the courses, regardless of the formal structure of the LMS and the curricular content made available in classes.

Acknowledgments

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