DEVELOPMENT OF DIGITAL EDUCATIONAL TECHNOLOGY ABOUT MINIMALLY INVASIVE INTRACRANIAL PRESSURE MONITORING[1]

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ABSTRACT

Objective: to develop a digital educational technology on a new intracranial pressure monitoring method for nurses, physicians and physiotherapists.

Method: descriptive study with an applied methodological technological production design. To construct the digital educational technology, Computer Supported Learning Activity Planning was adopted.

Results: the product was evaluated by usability experts, using Nielsen's ten heuristics. The usability problems identified through the violated heuristics were taken into account to construct the final version of the digital educational technology, which consists of 36 screens and is spoken in Portuguese.

Conclusion: Computer Supported Learning Activity Planning showed to be appropriate to achieve the proposed objective and can be used to develop digital technological resources.

DESCRIPTORS: Educational technology. Health technology. Distance education. Nursing. Intracranial pressure.

DESENVOLVIMENTO DE TECNOLOGIA DIGITAL EDUCACIONAL SOBRE MONITORAÇÃO DA PRESSÃO INTRACRANIANA MINIMAMENTE INVASIVA

RESUMO

Objetivo: desenvolver uma tecnologia digital educacional sobre um método novo para monitorar a pressão intracraniana para enfermeiros, médicos e fisioterapeutas.

Método: estudo descritivo, do tipo pesquisa metodológica aplicada de produção tecnológica. Para a construção da tecnologia digital educacional, adotou-se o Planejamento de Atividades de Aprendizado Apoiadas por Computador.

Resultados: o produto foi avaliado por especialistas em usabilidade, utilizando as dez heurísticas de Nielsen. Os problemas de usabilidade identificados por meio das heurísticas violadas foram considerados para a construção da versão final da tecnologia digital educacional e é composta por 36 telas e locução na língua português.

Conclusão: o Planejamento de Atividades de Aprendizado Apoiadas por Computador mostrou-se adequado para o alcance do objetivo proposto podendo ser utilizado para o desenvolvimento de recursos tecnológicos digitais.

DESCRITORES: Tecnologia educacional. Tecnologia em saúde. Educação a distância. Enfermagem. Pressão intracraniana.

DESARROLLO DE TECNOLOGÍA DIGITAL EDUCACIONAL SOBRE EL MONITOREO DE LA PRESIÓN INTRACRANEAL MINIMAMENTE INVASIVA

RESUMEN

Objetivo: desarrollar una tecnología digital educativa sobre un método nuevo para monitorear la presión intracraneal para enfermeros, médicos y fisioterapeutas.

Método: se trata de un estudio descriptivo, del tipo investigación metodológica aplicada de producción tecnológica. Para la construcción de la tecnología digital educativa se adoptó la Planificación de Actividades de Aprendizaje Apoyadas por Computadora.

Resultados: el producto fue evaluado por especialistas en utilidad utilizando las diez heurísticas de Nielsen. Los problemas de usabilidad identificados por medio de las heurísticas violadas fueron considerados para la construcción de la versión final de la tecnología digital educativa compuesta por 36 pantallas con locución en la lengua portuguesa y está en fase de implementación en la dirección electrónica www.difusaopicmi.com.br.

Conclusión: la planificación de actividades de aprendizaje apoyadas por ordenador se mostró adecuada para el alcance del objetivo propuesto, pudiendo ser utilizado para el desarrollo de recursos tecnológicos digitales.

DESCRIPTORES: Tecnología Educativa. Tecnología en Salud. Educación a distancia. Enfermería. Presión intracraneal.

INTRODUCTION

Intracranial pressure (ICP) results from the pressure applied by the components blood, cerebrospinal fluid, and brain tissue, found inside the cranial cavity. Changes in ICP depend on a number of factors, such as: intracranial volume expansion, component volume distribution, edema, component elasticity, and the presence of lesions.[1] ICP monitoring is essential for the evaluation and treatment of neurological diseases.[2]

The ICP monitoring techniques evolved from invasive to noninvasive, both with their limitations and advantages. The invasive method is characterized as a procedure in which a catheter is inserted in the intraventricular, subarachnoid or intraparenchymal region, which may expose the patient to risks of precipitation of intracranial hematoma, aggravated cerebral edema, damage to the parenchyma, intracerebral hemorrhage and infection.[3]

In addition to the risk factors, there are some limitations of the long-term invasive methods, including the risk of infection, bleeding, pain, discomfort, among others. The idea of noninvasive monitoring of ICP is attractive, as it eliminates most of the problems associated with invasive monitoring.[1] Thus, a new ICP monitoring method has been discovered and developed in Brazil that is minimally invasive. An extensometer with a strain gauge sensor is attached to the skull and is capable of capturing the bone deformations resulting from the variation of intracranial pressure.[3]

It is noticed that, in view of the vast demand for information and technological resources available in health, there is a need for increasingly qualified and knowledgeable professionals who can guarantee patient safety and make better decisions.[4]

Thus, the continuous search for knowledge and professional recycling is necessary and, for this, digital educational technology (DET) can be a facilitating resource for health professionals, as it permits flexibility of learning time and pace.[5-6]

The DET refers to the resource available via computer, which serves as a support for the learning process. Examples are simulation,[7] educational software,[8] virtual class,[9] videos, virtual learning environments,[8,10] among others. Health professionals, such as nursing professionals for example, have adapted to this new teaching method, including both its development,[7,10-14] and its use as a resource facilitator in the teaching-learning process, especially in teaching and research centers.[6,8,15-16] For DET to be an efficient resource in this teaching-learning process, however, the development needs to take place with methodological rigor.

Thus, the objective of this study was to develop a DET on a new method for monitoring minimally invasive intracranial pressure.

METHOD

A descriptive study was undertaken, that is, an applied methodological technological production research in order to develop a DET to disseminate a new product. The methodological research aims to develop or improve a new intervention using existing knowledge, to develop or improve an instrument, a device or a measuring method.[17]

The execution of this research met the standards for ethical and scientific rigor,[18] receiving a favorable opinion from the Ethics Committee for Research involving Human Beings of the *Centro Universitário Paulista* (UNICEP) in São Carlos, process 027/2011. The product development started

immediately for approval by the Ethics Committee and finalized in 2013.

The method used for the development of the DET was the Computer-supported Learning Activity Planning (PACO),[19] which aims to guide teachers in the planning of activities supported by computer, respecting the characteristics of the target audience and pedagogical aspects. PACO consists of seven stages:[19]

Step 1: Overall goal, target audience and theme

In this stage, one must know the characteristics of the target audience and their expectations regarding the product that will be developed. In general, when the development of the theme and the overall goal coincide with the expectations of the target audience, the results of the teaching-learning process are better. For the development of the DET, the following steps were defined:

Overall objective: to develop a digital educational technology on the new intracranial pressure monitoring method for health professionals.

Target audience: nurses, physiotherapists and physicians.

Topic: Intracranial pressure (ICP) monitoring: innovation using the minimally invasive method.

Step 2: Organization of the theme

After choosing the overall goal, it is important to prepare the course menu. If the apprentices have not had any contact with distance learning, the course content needs to include activities to adapt to this method. It is up to the instructor to designate the topics to be addressed, in what order and the degree of refinement. The theme was organized as follows: a menu was developed with content based on the new method;[3] a script was created for each screen of the DET prototype in a logical sequence of learning.

Step 3: Pedagogical framework

The elaboration, editing of the instructional content and the choice of computer resources should be based on the pedagogical framework chosen. For this phase, Ausubel's meaningful learning was used.[20] In meaningful learning, the individual learns new information from previous knowledge, that is, new knowledge becomes significant when it is linked to prior knowledge. For new knowledge,

however, background concepts need to be introduced through devices with little information until the individual is able to link knowledge to the other; this process is called subsumption.[20]

Step 4: Design of instructional actions

To design the instructional actions, the pedagogical framework chosen was taken into account. In principle, activities should be proposed so that students can connect existing concepts with new concepts to build a new knowledge structure. In this stage, initially, the DET was elaborated with subjects previously known by the target public, being: anatomy and physiology of the nervous system, pathophysiology with change of the ICP, methods currently used to evaluate the ICP. Subsequently, knowledge about the new ICP monitoring method was introduced, facilitating meaningful learning.

Step 5: Digital tools to support the implementation of activities

At this stage, the profile of the students, the activity to be developed, the immediate feedback, the pedagogical objective, the availability of the internet, as well as questions about technology and time to carry out the activities should be considered. The chosen tools were: static and animated images; 3D videos produced by a graphic designer under the supervision of the author; locution in Portuguese of the script narrated by a speaker in a studio under the supervision of the author.

Step 6: Building the digital resource

In this step, the digital resource is built and, to reach the proposed goal, hypertexts, images, videos, sound, animations, virtual environment and other resources can be used.

For the construction of the DET, some meetings with the project team were necessary to develop the new method to monitor the intracranial pressure, belonging to the research group Neuroscience, Physiology, ICP and Applications, in order to understand and clarify the new technology and its use by the health professionals. Subsequently, the author developed a prototype using the software Microsoft Office Power Point 2007®. The content was developed in 36 screens with the following structure: welcome with registration, objective, menu, contents and support text.

After assessing the prototype, as described in the next stage, an informatics professional devel-

oped the final version of the DET in Adobe Flash Player 10® under the supervision of the author.

Step 7: Assessment

After developing a DET, it is important to assess it in terms of technological and pedagogical aspects.

In this study, informatics experts carried out this assessment, focusing on man-computer interaction in the prototyping phase. The usability method was chosen, using Nielsen's heuristics,[21] consisting of ten criteria: visibility of system status; match between system and the real world; user control and freedom; consistency and standards; error prevention; recognition rather than recall; flexibility and efficiency of use; esthetic and minimalist design; help users recognize, diagnose and recover from errors; help and documentation.

Initially, the prototype was presented to the experts, who then went through the interface looking for usability problems based on the heuristics. Next, the identified problems were classified by severity on a scale from 0 to 4, in which 0=not considered entirely as a usability problem; 1=esthetic problem: does not need fixing unless there is time available; 2=small usability problem: low priority for fixing; 3=big usability problem: high priority for fixing; 4=usability catastrophe; has to be fixed before disseminating the product.[21]

The assessment was done by means of a tool containing: violated heuristic, usability problem, prototype screen, severity and solutions for the identified problems.

RESULTS

Usability problems were identified during the assessment and the evaluators suggested changes. In Table 1, the eight violated heuristics and some usability problems are displayed, together with their degrees of severity and suggestions.

Table 1 – Violated heuristics, usability problems, severities and suggestions. São Carlos-SP, Brazil, 2017

Violated heuristic	Usability problem	Severity	Suggestions
User control and freedom	The user cannot skip the video if he does not want to watch, no button is available	3	Add an icon "next" in the lower bar
Visibility of system status	The user does not know exactly where he is, as the screen/page is not indicated	2	Include name of DET and subtitle in the upper bar and screen/page number in the lower bar
Match between system interface and real world	The analogy between the bladder and the skull should be explained to justify it	2	Add the explanation
Consistency and standards	Some figures are clickable while others are not	3	Remove clickable figures
Help and documentation	No help icon	3	Add "help" button
Esthetic and minimalist design	Long paragraphs	1	Reduce paragraphs and add a search icon plus information on the topic, such as the symbol of a lamp for example
Error prevention	Clicking on the registration figure does not lead to the completion of the registration	3	Remove the clickable figure and add the information "Complete registration" in the form of a blue link

All suggestions were considered for the final development of the DET called Intracranial Pressure (ICP) Monitoring: innovation using the minimally invasive method.

The DET consists of 36 screens in Portuguese language and, for access, an individual login and password need to be used with a computer connected to the internet. Its presentation follows a logical sequence with standard colors, fonts and font size on all screens for easy user navigation.

The first four screens, shortly after the registration, contain general information about the DET, being: welcome, objective (Figure 1), demonstration of symbols that will appear during the DET and its use and, finally, the menu screen with the option in a link (Figure 2), so that the users can go to the topic they consider necessary, without having to go through the entire DET.
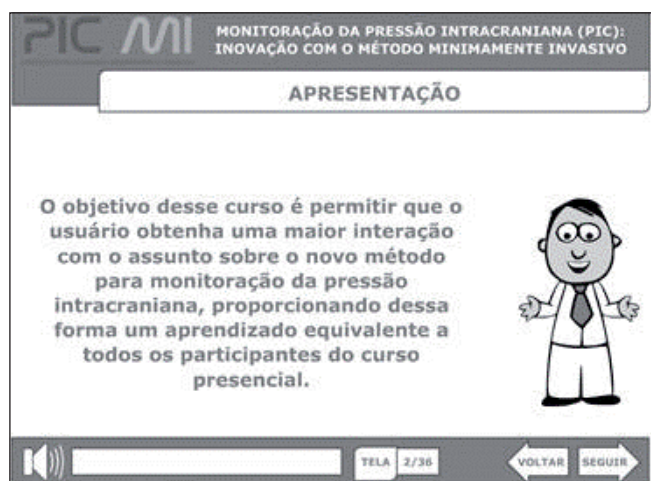
Figure 1 - **Screen presenting objective of the course Intracranial pressure (ICP) monitoring: innovation using the minimally invasive method. São Carlos-SP, Brazil, 2013**

To facilitate the navigation through the DET, all screens display the course name and the title the user is going through. In addition, the screens include a figure discussing the content on screen. The sound can be switched off by clicking the speaker icon displayed on the left in the lower bar (Figure 2).
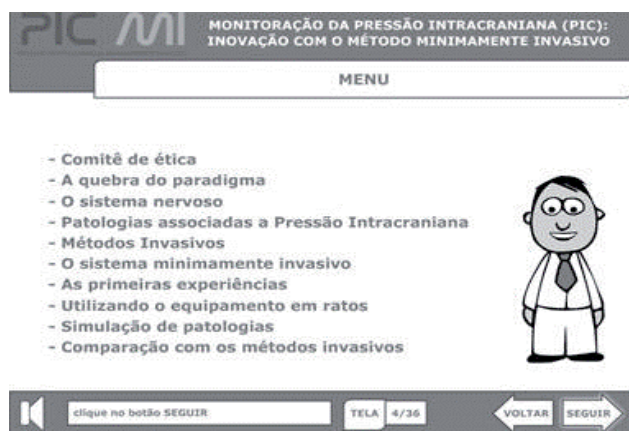

Figure 2 - **Screen showing menu of the course Intracranial pressure (ICP) monitoring innovation using the minimally invasive method and sound icon. São Carlos-SP, Brazil, 2013**

The lower bar contains the information about the screen the user is watching, with the option to proceed to the next screen or return. In the upper left corner, the user has the option to print the text. In some screens, 3D videos on the minimally invasive method were inserted (Figure 3).
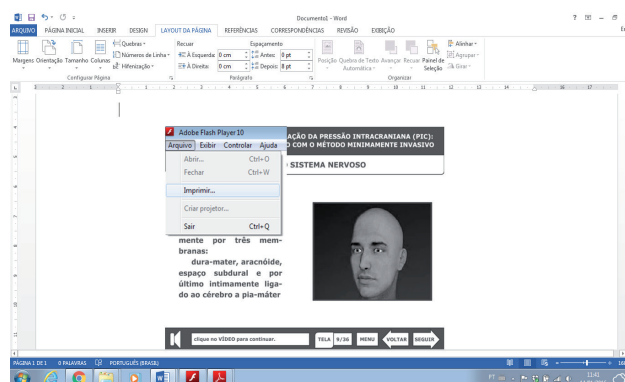

Figure 3 - **Screen with 3D video, option to print and return or next buttons. São Carlos-SP, Brazil, 2013**

Some screens display the symbol of a lamp that aims to help the user to better understand and / or go deeper into the subject in question. When clicking on the lamp, a book is shown with more detailed content. The first page of the book explains how to go through it. Clicking on it will turn the pages and, when clicking outside the book, the user returns to the course (Figure 4).
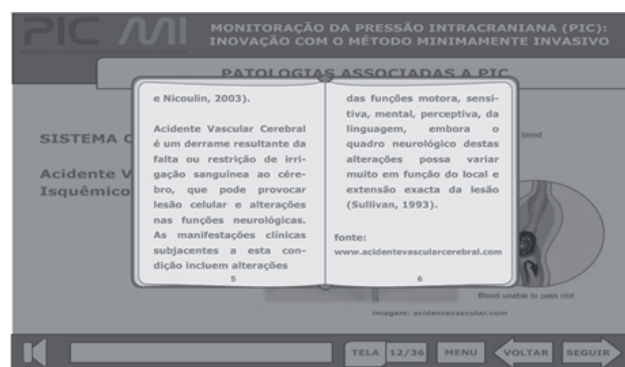

Figure 4 - **Screen with the book after clicking the lamp. São Carlos-SP, Brazil, 2013**

DISCUSSION

Information and communication technologies have been used for teaching, research[6-8] and education in health services to improve care.[5,11] In health institutions, professionals have faced great challenges as a result of the technological advances, modern and sophisticated equipment they are exposed to.[22] Thus, training is necessary to use this equipment, so that they are used properly, aiming at patient safety.[22-23]

In view of a new product to monitor ICP, the DET Monitoring intracranial pressure (ICP): inno-

vation using the minimally invasive method was developed to train health professionals who will have contact with the new equipment.

DETs have been used for nursing education and for training the health team, as it provides for the active and participatory construction of knowledge,[5,12] possibilities to update the work environment with flexibility to consider the time and learning pace of each.[4,6]

When developing a DET, it is important to use methodological rigor in the construction of the product, so that the learning objective is reached. In addition, the appropriate pedagogical framework for the target audience needs to be chosen, so that the quality of the products developed can be guaranteed as demonstrated in studies.[7-8,13]

The pedagogical framework used for the construction of educational material was based on the meaningful learning,[20] as it introduces and re-elaborates a new concept based on previous knowledge, making sense and changing professional practice.[24] Some authors have used this reference to develop DET aimed at adult audiences.[8,25-27]

After the development of DETs, it is important that the products by evaluated by experts or users, as there are several evaluation methods, including the usability.[6-7,28] The term usability refers to the quality of a product, that is, which satisfies and meets the needs of the user.[29] Thus, in this study, the DET was evaluated according to the usability using Nielsen's ten heuristics[21] in the prototyping phase. Thus, with a minimum investment, the problems met could be corrected in the development of the final project.

All of the evaluators' suggestions were considered in the final version of the DET, among which we can mention the interface, developed in a way that allows the users to navigate freely, making them active in their learning process and considering their background experiences as described by authors.[8] Thus, at the start of the DET, the menu option contains the titles of each screen. The users can navigate and are free to create their own learning route and pace.

In addition, technology for educational purposes can lead health professionals to meaningful learning as a result of the reflection and criticism,[8] as it permits the construction of knowledge as needed. To achieve this goal, a symbol of a lamp was developed in some screens. Upon clicking, more information related to the subject on the screen is displayed.

The DET layout follows a presentation pattern related to color, letter size and font. The icons are intuitive and marked. The content was also distributed, avoiding excess information on the screens, corroborating other findings.[11]

One limitation for this study was that end users did not evaluate the appearance, content and learning of the DET. Therefore, in the future, we intend to evaluate the interface and content of the digital educational technology, as well as evaluate the learning using the TED in comparison to the traditional teaching method.

CONCLUSION

In this article, the development and assessment of a digital educational technology using the PACO method was presented, which showed to be adequate to achieve the proposed objective. Each step of PACO was fundamental to achieve a user-centered product in accordance with the experts' assessment and suggestion.

The usability assessment demonstrated its efficiency to construct the final version of the DET and is fundamental to fully use all of its functions and achieve the educational objectives. The construction of the DET contributes to the dissemination and knowledge of a new technology to monitor the ICP among health professionals.

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