World Conference on Research in EDUCATION
29-31 August, 2019 Berlin, Germany

Designing Animated Pictorial Instructions: A Methodology Proposed for the Open University of the Unified Health System in Brazil (UNA-SUS/UFMA)

Carla Galvão Spinillo[1], Ana Emília Figueiredo de Oliveira[2], Katherine Marjorie[3], Camila Lima[4], Larissa Ugaya Mazza[5], Luana Oliveira[6], Ivana Figueiredo de Oliveira Aquino[7]

[1,5,6]The Federal University of Paraná, Brazil

[2,3,4,7] UNA-SUS/UFMA- The Federal University of Maranhão, Brazil

Abstract

Animated pictorial instructions are effective resources for learning medical content (e.g., surgical procedures). Considering this, the Open University of the Unified Health System of the Federal University of Maranhão (UNA-SUS/UFMA) in Brazil employs animation in their distance learning courses. From 2009 to the present the UNA-SUS/UFMA has offered 48 e-courses to health professionals, reaching around 470,000 enrolments. The development of animated instructions at UNA-SUS/UFMA considers medical and pedagogical knowledge only, lacking information design expertise to reach communication effectiveness. Thus, a design methodology was proposed based on: (a) the results of an analytical study of 100 medical animations; (b) the outcomes of a context analysis of the UNA-SUS/UFMA design process through interviews with the heads of the educational production departments; and (c) the results of an online questionnaire with 1,735 health professionals. The methodology consists of three phases: (1) Structuring: identification and arrangement of different contents (introductory content, inventory information, steps, warnings), resulting in an animation script; (2) Representation: definition of the animation graphic appearance and technological resources (e.g., pictorial style, camera framing, interaction cues), resulting in a visual storyboard or mock-up/prototype that can be tested with users (e.g., comprehension, usability tests); and (3) Finalization: programming and production of the animation. For each phase, instruments/protocols were developed to aid decision-making (form, guidelines and checklist). To evaluate the methodology, a focus group was conducted with the animation stakeholders/developers of the UNA-SUS/UFMA. The results were positive, but suggestions were made to improve the decision-making instruments, which were considered in the methodology final design.

Keywords: animation; decision-making; guidelines; medicine; procedures

1. Introduction

Animation with instructional purposes has been widely used to show what cannot be seen with a naked eye (e.g., blood circulation, movement of air mass) and/or to represent complex concepts and processes (e.g., medical surgeries). As a learning resource, animation is considered to facilitate comprehension, to reduce the cognitive load and to promote motivation in learning (Bétrancourt, & Tversky, 2000; Höffler & Leutner, 2007; Schnotz & Lowe, 2008; Ainsworth, 2008). In this regard, Plaisant and Shneiderman (2005) propose recommendations for the development of effective animations:

- Contents of the animation should be grouped into short and independent segments to allow users to review them whenever they wish; and titles/heading should be employed to identify the segmented contents;
- Content should be presented in a simple, clear, precise and assertive way, in a user-friendly language;
- Images should be represented accurately in the animation to promote recognition of the actual elements of the task;
- Emphatic elements (graphic/visual, verbal/narration) should be employed to draw the user's attention to relevant details or aspects of the step/task.
- Interactive features (e.g., pause, accelerate, rewind, select) should be employed to enable users to control the animation

Animation with the purpose of communicating procedures, that is, steps of a task, are referred to as Animated Procedural Pictorial Sequences -APPSs (Spinillo et al. 2010, 2011). They employ images as the main means of conveying a procedure. Texts function as support to the images in the animation. According to Spinillo (2017) this kind of animation presents procedural (steps) and non-procedural contents. This latter regards information other than the steps to be performed. The non-procedural contents can be introductory information (e.g., titles), warnings and/or complementary information (e.g., tips about the task). Among the non-procedural contents, warning is of prime importance to inform users about risks to their safety and/or damage to equipment/tool that may jeopardize the task (Wogalter, 2006). In Animated Procedural Pictorial Sequences warnings can be represented by texts, images, audio and alert sounds (Spinillo et al, 2010). These are intended to draw attention to the risk, since attention is a key-element to warning information (Wogalter, 2006). It is worth highlighting that the use of warnings is particularly relevant to animations about medical procedures as their omission may lead to cause harm to or even the death of patients.

Other non-procedural contents relevant to animation in the medical field are inventorial and contextual contents (Bieger & Glock, 1985/1986). The inventorial content refers to the presentation of the components to be manipulated/used during the task, functioning as a ‘visual inventory’ of the task (e.g., syringe and insulin bottle). Contextual content, however, regards the output of the task, providing the 'visual context' of the task. It is worth emphasizing that the use of images representing the contextual content is important for tasks that have an expected result (e.g., plastic surgery). Contextual content is considered to reduced

assembly times and errors (Bieger & Glock, 1985/1986) and to facilitate mental representation of tasks during the cognitive process (Ganier, 2010).

Despite the importance of visually depicting content in animations, most studies have not focused on aspects of the graphic representation (e.g., Mayer & Moreno, 2002; Mayer, 2005; Höffler & Leutner, 2007; Ainsworth, 2008; Tversky & Morrison, 2002). The graphic representation of contents in procedural animation in the medical field may facilitate or even determine learning, understanding and apprehension of information. For instance, an animation on how to make a surgeon's knot may need to emphasize the position of the surgeon's hands to properly show an action.

1.1 Distance learning in health education in Brazil

In the scope of health education in Brazil, the use of technological resources for the continuous training of professionals has been the focus of government programs, such as the Permanent Health Education Program. This Program focuses on distance learning courses aimed at the qualification of health professional nationwide. This is of prime importance to medical doctors acting in remote regions of Brazil where the access to educational institutions is difficult. With this concern, the Ministry of Health created in 2008 the Open University of The Unified Health System (UNA-SUS) to offer professional training courses in distance learning. The UNA-SUS is a partnership network of 36 Brazilian public universities and from 2008 to April 2018 they had 1,753,816 professionals enrolled in distance learning courses.

One of the pioneers of the UNA-SUS is the Federal University of Maranhão (UNA-SUS/UFMA) which joined the network in 2009. From 2009 to the present, the UNA-SUS/UFMA has offered 48 e-courses to health professionals, reaching around 470,000 enrolments, and thus, becoming one of the most active partners of the network. The courses offered by UNA-SUS/UFMA employ technological and media resources to promote content learning and to motivate their health professional students. Animation is one of the resources employed to simulate clinical cases and to visualize medical procedures. The procedural animations have been developed in UNA-SUS/UFMA by taking into account medical and pedagogical approaches. However, in the context of distance learning, procedural animations in health should be designed to reach both educational-medical and communicational goals. Thus, it is necessary that their design process embraces not only pedagogical-medical but also information design aspects (Spinillo et al 2010, 2011).

By considering this and with the premise that animations facilitate the visualization of medical procedures, a research-based methodology was proposed for the UNA-SUS/UFMA to design animated pictorial sequences, which is presented next.

2. Developing the Methodology for designing animated pictorial instructions

The Methodology for designing animated medical procedures for the UNA-SUS/UFMA was developed based upon the outputs of an analytical study of the graphic representation of procedural animations, and a context analysis with the stakeholders of the UNA-SUS/UFMA.

2.1 The Analytical study of the graphic representation of medical procedure animations

This study aimed to identify how the medical procedures were graphically represented in a sample of animations available in the internet in the websites YouTube and Vimeo. The sample was selected by meeting the criteria: (a) to represent a medical procedure, (b) to be in English and/or Portuguese languages and (c) to be open source.

To analyse the sample, a descriptive protocol was adapted from the one proposed by Spinillo (2016) to describe Animated Procedural Pictorial Sequences for medicine usage. The protocol to analyse the animations accounted for the following aspects: non-procedural content (e.g., warnings, inventorial information); representation of the agent (medical doctor/surgeon) in the animation; pictorial style and resources employed to promote visualization of the procedures (e.g., symbolic and emphatic elements, depiction views, completeness of the image).

The results of the study were analysed qualitatively but considering the incidence of the variables in the sample in order to identify commonalities that indicate possible trends in the animations' representations.

2.2 The Context analysis with the stakeholders of the UNA-SUS/UFMA

The context analysis regarding the development and use of instructional animations was carried out with: (a) three coordinators of developing teams of educational resources/ animations of the UNA-SUS/UFMA through interviews; and (b) health professional students enrolled in distance learning courses offered by the institution through an online survey.

The interviews with the coordinators of developing teams was semi-structured with open-ended questions about the production and use of procedural animations and their interest in using a methodology for designing this type of educational resource. The responses were recorded in audio, then transcribed in writing and analysed qualitatively.

The survey was conducted via an online questionnaire developed in Google Forms and made available to the health professional students enrolled in the UNA-SUS/UFMA courses. They were asked to voluntarily participate in the survey. The questionnaire consisted of closed-ended multiple-choice questions, agreement scales, semantic differential scales and open-ended questions. The results were analysed quantitatively and qualitatively.

The context analysis allowed to understand the design process of procedural animations in UNA-SUS/UFMA, the problems/difficulties faced by the developers in this process, their demands to design procedural animations, as well as the views of the health professional students about the use of animations to communicate medical procedures.

3. Results and discussion

3.1 Synthesis of the results of the analytical study

A sample of 100 procedural animations was gathered for the study which were categorized as invasive procedures (n=50 animations) and non-invasive procedures (n=50 animations). The former animations were related to surgical procedures that require large incisions or sutures in the patient (e.g., tracheostomies). The non-invasive ones, in turn, regard medical procedures that required minor cuts or perforations, or even represent physical exams (e.g., gynaecological exams).

In general, the sample of animations presented similar graphic representations for both invasive and non-invasive medical procedures. Most of them either did not visually presented warnings about the steps of procedures (n=87 animations) nor the agent (the medical doctor/surgeon) performing the steps (n=76 animations). Emphatic resources were rarely used in the animations to call users' attention to moments and/or to components of the tasks. The procedures were animated as continuous narratives, that is, without segmenting the content (e.g., introductory information prior the procedure). This does not meet the recommendations from the literature on animation for content learning (Plaisant & Shneiderman, 2005).

It is worth noting that almost all animations of the sample (n=94) did not present inventorial information, that is, the equipment/instruments or material necessary to perform the medical procedures (e.g., scalpel, foci). These should be showed prior the animation. The omission of inventory information may impair the planning of the task by users, as they will only know what is needed to perform the medical procedure when the animation is taking place. This may also negatively affect user's understanding of the contents, and it is in disagreement with the literature (Mayer, 2005; Ganier, 2010). Nevertheless, the animations for advertising medical products (n=6) had inventory information. These animations began with images of the product, its components and the explanation of the medical problem related to the procedure. These results seem to indicate that there is a lack of concern in communicating inventory information to users when the animations have not a commercial purpose in the medical field.

As for the pictorial representation, most animations (n=93) employed three dimensional images. This may be due such images make it possible to visualize the referent (object and/or patient) in various angles and confer a greater degree of realism to the depictions (Vernon & Peckham, 2003). In this sense, sectional views and transparency of the human body were also employed in the animations. They were intended to show actions/movements and/or internal parts of the body which would not be visible otherwise, that is, with a naked eye. It is worth mentioning that such pictorial conventions are also employed in scientific illustrations of the human body anatomy (Trotta & Spinillo, 2018), therefore, medical doctors should be acquainted with them.

Based upon the results of the analytical study and aligned with the literature (e.g., Weiss et al., 2002; Plaisant & Shneiderman, 2005), requisites were proposed for the Methodology to design animations on medical procedures, as for instance, to present non-procedural content

(e.g., inventory information, warnings) and to segment the content in a coherent manner to ease information processing.

3.2 Synthesis of the results of the interviews

The interviews were conducted with the coordinators of the Instructional Design, the Information Technology and the Communication units of UNA-SUS/UFMA. According to them, the production of a procedural animation is mainly carried out by instructional designers. They are responsible for developing the pedagogical and medical content, for drafting the animation (storyboard) and for its final approval. The Information technology team is in charge of the technological resources of the animation, and the Communication team for launching the animation, making it available to the health professional students.

The interviewees agreed that the production of procedural animations in UNA-SUS/UFMA is timid. This may be due to overwork in the production process and a lack of expert support in the decision-making process. Another aspect raised by the coordinators was the need of recommendations to guide the production process of procedural animations.

According to the instructional design coordinator, the lack of expert knowledge about procedural animations weakens and even hampers the decision-making process. Thus, their decision about the procedural content, pictorial style of the animation, scene cuts, camera positioning are made tacitly, in an intuitive manner. This is because the professional background of instructional designers is in the education and/or psychology fields, therefore not embracing information design aspects of procedural animations. Moreover, the coordinator of the IT highlighted the lack of tools to support the decisions made by the instructional designers about the technological aspects of the animations. Such tools would facilitate the work of the IT team, preventing turning backwards in the production process.

In addition, the coordinators' responses indicated information gaps in the animation production process that affect the smoothness of the process. This leads not only to doubts in the animation development but also unnecessary iteractions (returns) during the design process. This may have as a consequence a lack of efficiency in the design process of procedural medical animations in UNA-SUS/UFMA.

Finally, the coordinators showed great interest in methodological tools and design guidelines to support decision-making in the production of medical procedural animations in UNA-SUS/UFMA.

3.3 Synthesis of the results of the survey

In order to verify the students' demand and opinions regarding the use of procedural animations, the online questionnaire was made available to them through a link in the UNA-SUS/UFMA courses' announcement in the social media. A total of 1,825 students accessed the link and 1,778 of them agreed to participate in the survey.

The majority of the respondents was women (80.35%), varying in age groups with the highest incidence in 26 to 35 years old (35%) followed by 36 to 45 years old (26.5%). No trend was found in their education degree and professional profile. However, the highest

incidence of responses was in postgraduate degree (44.9%) and professional experience in the fields related to psychology (35%) and nursing (29.3%).

In general, the results show that the respondents are very interested in medical procedural animations, whether presented as a resource within e-books or as part of the distance learning courses of UNA-SUS/UFMA (65.9%). The majority considers that procedural animations motivate (60.7%) and facilitate (61.5%) learning of content in the health field.

Regarding graphic representation, most of the respondents believe that: (a) the agent (physician/health professional) should be shown performing the steps (85.4%); (b) the steps should be represented through images with audio narration and written text (81.3%); and (c) the images should be simple, showing details when necessary only (50.7%). The respondents also consider that warnings should be shown in the animation through written text, audio and image (44.1%), followed by those who consider that warnings should be shown in written and audio only (23%).

The results of the survey are in agreement with the literature regarding the perception of the value of animations for motivation and the learning of contents (e.g., Mayer & Moreno, 2002; Höffler & Leutner, 2007; Ainsworth, 2008; Tversky & Morrisson, 2002). About the graphic representation of procedural animations, the participants' views on simplicity of representation and on the use of details only when pertinent are aligned with the findings of previous studies (e.g., Spinillo et al, 2010, 2011).

In sum, the results of the survey with the health professional students of UNA-SUS/UFMA showed they all agree that the representation of medical procedures through animations aid learning and should be clear and simple so as to properly communicate information to perform tasks.

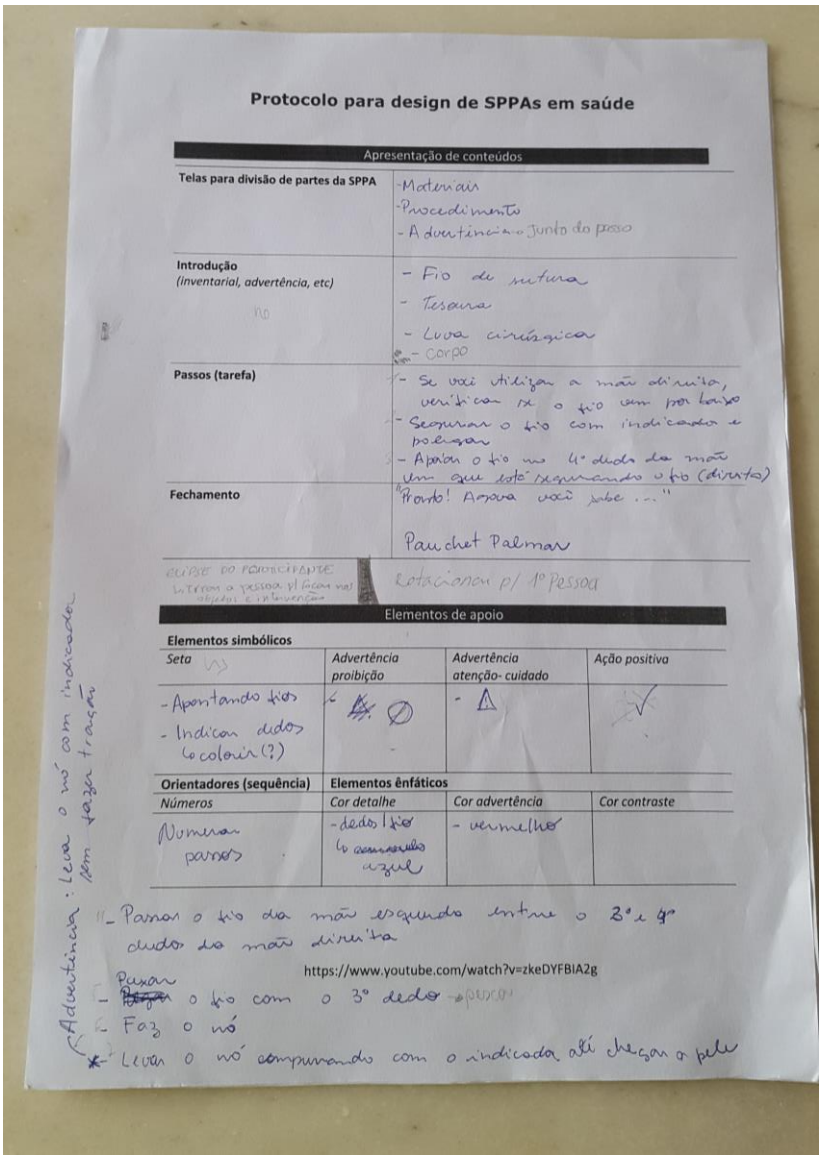
Like in the analytical study reported herein, the outputs of the interviews and the survey led to propose other requisites for the Methodology to design animations on medical procedures. This Methodology is briefly explained next.

4. The Methodology for designing procedural animations

The Methodology proposed to UNA-SUS/UFMA is composed by three consecutives phases and for each phase instruments were developed to aid decision-making in the design of procedural animation, as follows.

(1) **Structuring phase:** this regards the identification and arrangement of different contents to be animated: introductory information (e.g., titles), inventory information, steps, warnings, and other non-procedural contents (e.g., waste disposal). For that, a *Structuring Form* (Figure 1) is provided to be filled in by the content developers and graphic designers with information from a row material (e.g., a text about the topic to me animated). Based upon the *Structuring Form*, the animation written script is produced to guide the following phase, with the approval of the Instructional Design coordinator.

Figure X: Example of the Structuring form filled in



Protocolo para design de SPPAs em saúde

Apresentação de conteúdos	
Telas para divisão de partes da SPPA	- Materiais - Procedimento - Advertência junto do passo
Introdução (inventarial, advertência, etc)	- Fio de sutura - Tesoura - Luva cirúrgica - Corpo
Passos (tarefa)	- Se vai utilizar a mão direita, verificar se o fio vem por baixo - Segurar o fio com indicador e polegar - Apoiar o fio no 4º dedo da mão em que está segurando o fio (direita)
Fechamento	"Pronto! Agora você sabe..." Pauchet Palmar
EQUIPE DO PROTOCOLANTE: Interrompa a pessoa p/ fazer nas objetos e intervenções	Rotacionar p/ 1º Pessoa

Elementos de apoio			
Elementos simbólicos			
Seta	*Advertência proibição*	*Advertência atenção- cuidado*	*Ação positiva*
- Apontando fios - Indicar dedos (colorir (?))		-	
Orientadores (sequência)	**Elementos ênfáticos**		
Números	*Cor detalhe*	*Cor advertência*	*Cor contraste*
Numerar passos	- dedos / fio (e acompanhado azul)	- vermelho	

Advertência: levar o nó com indicador sem fazer tração

1 - Passar o fio da mão esquerda entre o 3º e 4º dedo da mão direita

https://www.youtube.com/watch?v=zkeDYFBIA2g

- Passar o fio com o 3º dedo
- Faz o nó
- Levar o nó acompanhado com o indicador até chegar a pele

Source: The authors

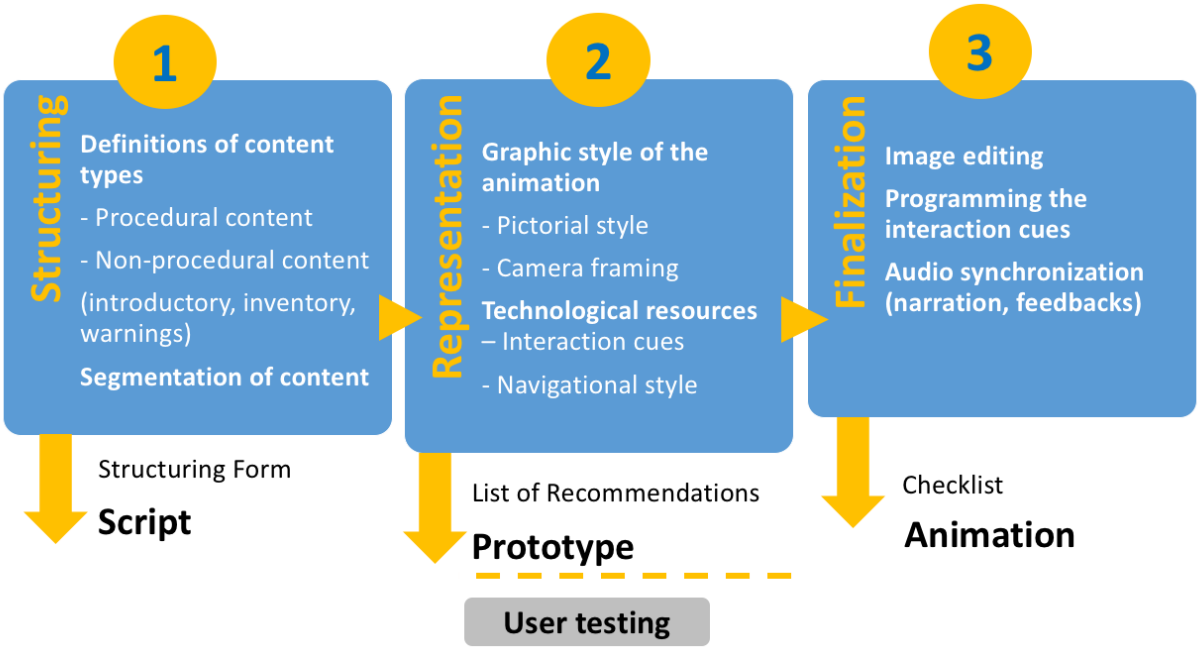
(2) **Representation phase:** this regards the detailed definition of the graphic appearance and technological resources of the animation (e.g., pictorial style, camera framing, interaction functions), considering its educational purpose. For this, various visual references may be used by the developers, such as videos and printed illustrations to aid the final production. To support the decision making in the Representation phase, a *List of Recommendations* for content representation through animation is provided which is founded in the literature. The output of this phase is a digital storyboard or functional mock-up/prototype of the animation which can be tested with users (e.g., comprehension and usability tests, UX tests). Then, the animation prototype goes to

the final phase of the Methodology, with the approval of the Instructional Design and TI coordinators.

(3) **Finalization phase:** this regards the programming and production of the animation to be released, such as image editing, programming of the interaction cues and audio synchronization (narration, feedbacks). To verify the compliance of the animation produced with the design recommendations of the previous phase, a *Design Checklist* is provided to the developers. The output of this phase is the final version of the animation to be released to the students with the approval of the Instructional Design, TI and Communication coordinators.

It is worth noting that iterations may occurs in the development process, if it is necessary to review a decision made and/or the output of a phase is not approved by the coordinator(s). Figure 2 shows a visual synthesis of the Methodology for designing animated medical procedures for UNA-SUS/UFMA.

Figure 2: Visual synthesis of the Methodology for designing animation of medical procedures for the UNASUS/UFMA.



Source: The authors

4.1 Evaluation of the proposed Methodology

A focus group was carried out to evaluate the Methodology for designing animated medical procedures for UNA-SUS/UFMA. It aimed to use the Methodology for decision-making in the development of an animation of a given content. For that, the instructional medical video about a surgeon-knot (*The Pauchet Palmar knot* of 1minute and 30 seconds) was used as the row material for design the animation (Figure 3). A total of nine developers of

educational materials of the Instructional Design, Information Technology and Communication units participated in the focus group.

Figure 3: Screenshot of the The Pauchet Palmar knot video used as the row material for design the animation in the focus group

Source: The authors

Initially, the proposed Methodology and its theoretical bases were presented to the participants, followed by the exhibition of the surgeon-knot video. Afterwards, the *Structuring Form* and the *List of Recommendation*s were given to the participants who were asked to gather in mixed groups to fill in the form collectively. For that, they could view the video as many times as they wish. About 20-25 minutes were given to the participants to carry on this activity. Next, each group was asked to present their completed form to all participants and to comment on the decisions made for designing the animation. A general discussion was then stimulated by the researcher to deepen the participants views on the proposed Methodology. The focus group outputs were recorded in writing and analysed qualitatively as follows.

4.1.1 Results of the Focus Group

The participants gathered into two groups to carry out the focus group activity. They all filled in the *Structuring Form* adequately and used the *List of Recommendations* during the activity. Similar decisions were made by both groups regarding the identification and arrangement of the different contents of the surgeon-knot video: (a) title as the introductory information; (b) thread, gloves and scissor as inventory information; (c) warnings about the position of the surgeon fingers in particular steps, (d) number of steps; and (e) the closing content indicating the end of the procedure. Participants also agreed in the graphic representation of warnings (*X* to convey prohibition). None of these were in the video.

The participants' opinion on the usefulness of the proposed Methodology were unanimous. They found that both the methodological phases and the supporting tools (*Structuring Form and List of Recommendations*) were valuable and would help them in the production of animations of medical procedures in UNA-SUS/UFMA. Some participants pointed that until then - before learning about the Methodology and its theoretical foundations - they had no discernment between procedural and non-procedural contents (inventorial information and warnings). Therefore, they believed that all contents constituted a single narrative about a procedure to be animated. The following figure shows a moment of completion of the *Structuring Form* by the participants while viewing the video.

Figure 4: A moment of completion of the *Structuring Form* by the participants while viewing the video.

Source: The authors

Despite the positive opinions of the participants, suggestions were also made to improve the *Structuring Form* and the *List of Recommendations.* These allowed adjustments in the Methodology and its tools for supporting decision-making to design animations of medical procedures in UNA-SUS/UFMA.

5. Conclusion

Based upon the outputs of the focus group, it is possible to conclude that the proposed Methodology is useful to design animated pictorial instructions of medical contents within the context of UNA-SUS/UFMA. The methodology phases and tools seemed to aid the decision-making in the design process regarding graphic and content aspects of animations.

Considering the views of the UNA-SUS/UFMA coordinators, it is plausible to assert that the proposed Methodology meet their demand for supporting tools in the production process of procedural animations, what might lead to efficiency in the process.

Moreover, the approach employed to develop the Methodology seems to be appropriate as it led to a useful design process. Thus, integrating analytical study (animation sample) with context analysis (developers and students) provides valuable inputs to build up a methodology to design animations.

Acknowledgment

This paper is an output of the science project 'Health instructional animation design: A methodology proposal for UNA-SUS, Open University of the Unified Health System' which was funded by the CNPq- National Council for the Scientific and Technological Development of The Ministry of Science and Technology of Brazil. Thanks are due to the CNPq (Project Process 310104/2015-7) and to the participants who volunteered to this study.

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