

Immersion and Perspective Taking in Healthcare Technology

Supporting Healthcare Professionals with Daily Tasks and Clinical Procedures

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Abstract

A core of the education of medicine and nursing students is to understand, learn and train the use of clinical procedures. Health professionals are required to apply existing clinical procedures and acquire new ones as they are developed and incorporated into clinical practice. In order to improve clinical effectiveness and increase patient safety, these clinical procedures would ideally be easily accessible and provide a didactic explanation of the steps to be followed. In this way, digital clinical procedure libraries provide health professionals and students a useful tool for learning and practice. In this context, the International Bilateral Research and Innovation Cooperation (INT-BILAT) project on evidence-based interactive clinical systems aims at studying the usability and learnability of clinical procedures libraries in a health transnational context. This paper presents early stages of the research including the results of a survey among health professionals about using electronic clinical procedure libraries or guidelines at work. The research argues that electronic procedure libraries are a steppingstone of experiential learning in healthcare education and practice, where clinical procedures are learned through experience, reflection and conceptualisation. The analysis of the survey's answers and interviews showed the need for an enhanced digital clinical library with interactive features, drawing from immersive techniques and perspective taking (e.g., video guidelines, self-paced video instructions). The next steps of the research include a game design framework outline using immersion techniques for learners and practitioners.

Keywords

Clinical library, clinical procedure, immersion, perspective taking, gamification, usability, human-centred design, eHealth.

1 INTRODUCTION

Healthcare technology systems that aim at improving safety and quality of care and clinical workflows are increasing in number and complexity [1]. Among the different types of healthcare technologies, electronic clinical procedure libraries (eCPL) are meant to support healthcare professionals during their training, daily routines and continuous professional education. An important component of eCPLs is the clinical procedure. A clinical procedure is defined as “any practice of a health practitioner that involves a combination of special skills or abilities and may require drugs, devices, or both” [2]. In an eCPL, the explanation of a clinical procedure's objective and steps, content and visualisation, are key to healthcare professionals (e.g., eCPL users) being able to understand and successfully perform it.

Existing research (in German and Norwegian) about current versions of eCPLs [3] [4], showed that pictures and short animations were used to demonstrate specific steps of several procedures. The authors of this paper previously researched stakeholders' needs for digital technology support (research question (RQ) 1), looking into how to adapt the presentation of clinical procedures and improve outcomes (RQ2); both in a health learning context [5]. Stakeholders' needs (RQ1) varied depending on several factors, such as skill level, role as a health professional and context in which a procedure guideline was used. The optimal visualisation (RQ2) depended on evidence-based guidelines as a source for content but also on visualisation

options such as video, picture and re-creation of procedure-steps in visual and/or auditory ways to support the understanding and accuracy of procedures.

The aim of this paper is to follow-up the study of the usability and learnability of clinical procedures libraries in a health transnational context. The authors created a survey based on the preliminary investigation of stakeholders' needs and background knowledge, educational and professional requirements and gamification potential. We describe the results from such survey and the gamification analysis, focused on learning and professional use in the context of eCPLs.

2 METHOD AND RESULTS

The survey was designed based on literature review and preliminary interviews with healthcare professionals with ethical approval under review by the Norwegian Centre for Research Data (reference number 111924).

2.1 Survey Results

The survey's questions addressed the early stages of a human-centred design process [6], including the analysis of users' needs and inclusion of end-users into the design process. The selection of the methods was guided by their feasibility in the context of the project to comply with the user-centred design, usability and technology adoption in healthcare settings. Nineteen participants from 6 different countries (Germany, Norway, Denmark, Switzerland, United Kingdom, Iceland), answered the questionnaire with 19 questions (Table 1), with a gender distribution of

15 female and 4 male participants. Participants' education background ranged from master and PhD students to professor, including retired health professionals.

Table 1 Survey questions.

#	Question text
1	How old are you?
2	What is your nationality?
3	What is your gender?
4	What is your educational background?
5	What is your profession?
6	How many years of work experience do you have as a health professional?
7	In which country do you currently work?
8	What technologies do you use in the hospital on a daily basis?
9	Any additional comment regarding the technologies you use at the workplace?
10	Where do you look things up to follow the steps on a clinical protocol/procedure/instrumentation or medical device?
11	How often do you encounter procedures that you may not know by heart (e.g. that you have to look up the steps on how to proceed)?
12	How do you keep yourself up to date with new or updated clinical procedures, medicine, etc?
13	Please could you mention a complicated procedure that you had to look up recently to be able to conduct it?
14	Do you have a digital library/ a computer system to look up how to do certain procedures? E.g. what materials are needed and what to do in which order?
15	How did you learn (and remember) clinical and medical procedures?
16	Have you heard about evidence-based procedure libraries?
17	What support would you like to have to help you in your daily work related to clinical procedures?
18	Can you imagine using a mobile device (e.g., smart phone, tablet) dynamic situations (accident, outdoors injury, ...)?
19	Additional information about your needs, ideas, and wishes in case you want to say anything else

Q11 asked about frequency of use of clinical procedure guidelines and/or protocols. The majority answered that they had to look up information related to clinical procedures. Participants answered that they had to look up procedures “weekly” (47.3%), “monthly or twice a month” (36.8%) and “less than monthly”, “varying” or “did not answer” (15.9% the sum of the three categories). Most of the participants had heard about evidence-based procedures (63.2%), however less than half of them do not use them at work (“know about them, but do not use them”: 15.8%; “do

not use them”: 52.6%). Q8 asked about types of technology used daily at work. Most participants selected “electronic health records (EHR), calculators, clinical procedure libraries”. However, some participants stated that they did not use anything (at least not regularly), neither digital nor paper-based information collections such as books, folders and personal notes. Q17 asked about the ideal support in their daily work related to clinical procedures. More than half of the participants (52.6%) stated that updated and easy-to-access information would serve as a good support. One participant argued “up-to-date videos could instruct how to perform a procedure”. Q15 asked about learning and remembering clinical procedures. Participants underlined the importance of revisiting the procedures learned, mentioning repetition as one of the key methods to remember them: “I learned by reading or seeing the procedure, and by performing it repeatedly myself”.

2.2 Gamification Analysis

The authors found several issues during the research on the usability and game-design elements in the context of electronic procedure guidelines. A context analysis and a scope review of the literature were carried out focused on the usability and learnability of the eCPL. They resulted in the first steps of a gamification framework based on game-design elements to increase engagement, motivation and help solve existing issues from a different perspective. The analysed game-element categories (Fig. 1.) include aspects of the framework, such as immersion, support for interactivity and progress [7]. Immersion can enhance retention and knowledge transfer from simulated environments [8] [9] to the real-world using elements such as animations, pictures and procedure descriptions. Immersion is a complex concept with different levels, or degrees, of involvement. Those degrees can be categorised ranging from lowest to highest level of immersion as: engagement, engrossment, and total immersion [10]. The goal is then to search for any improvement of degree of immersion that can potentially lead to improved healthcare quality, learning and information retention in healthcare. For a meaningful research outcome, the level of immersion and quality improvement will be evaluated at a later stage.

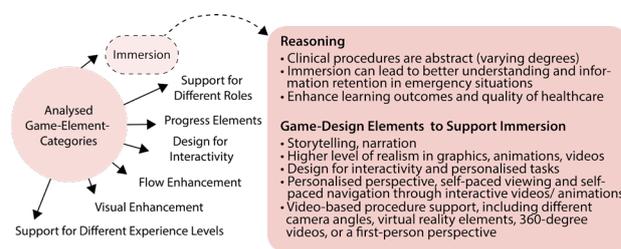


Figure 1 Framework of analysed game-element categories with further details for the category “immersion” [7].

2.3 Immersion in Game Design

Immersion in games can be created by high interactivity [11], storytelling, realistic graphics, and identification with (main/own) character. These elements can be perceived differently and with varying intensity by the users. It can be differentiated between (1) sensory (visual and/or auditive

aspects) immersion; (2) personalisation, narration (or plot) and story-based immersion; and (3) interactive-based (e.g. tasks) to improve immersion possibilities [10]. In games, these aspects do not usually exist without the others but can be used to different extents. However, a player’s immersion derives from more than only the visual presentation, it is also influenced by a complex playing experience [12].

(1) Sensory (visual and auditive) immersion:

This type of immersion is described by [13] as sensory immersion, which is related to the audio-visual design and experience of games. Elements to enhance the sensory immersion are “audio-visually impressive design”, and “three-dimensional and stereophonic worlds” [13]. Aspects of this type of immersion can also be related to the realism of the “game world” or to the atmospheric sounds [10]. Realism is not always necessary to create immersion but can be a contributing factor. These aspects can further be enhanced through blocking of sensory information from the real-world using headphones, headgear or other overpowering types of technology.

(2) Story, narration or plot-based immersion:

Narration-based immersion, or “imaginative immersion” can be seen as separate immersive qualities from sensory qualities [13] [14]. Story or narration can be designed separately from their sensory aspects, but often complement each other.

(3) Interaction-based immersion:

Interaction-based immersion is described in [14] as related to ludic pleasure (“challenge-based immersion”) [14], since the flow state [15] can only be achieved through the “active collision of challenge and skill”. This includes active participation (interaction with the game) and decision making [14]. Games usually offer various types of interaction; they can include interaction with objects, non-player-characters (NPCs) or other players. They may also require decision making in different situations such as: direction taking, to follow or not follow a given task/quest, path, tactic, role, alignment of the character or group, goal orientation and difficulty level. Games also often offer different interaction possibilities and decision making in the designed interface or other meta-level parts of the game that are not directly part of the story, such as: skills, secondary skill, or a profession. Player-NPC or player-

player interactions can include interaction-feedback mechanisms such as reputation or friendship-level.

2.4 Immersion through Video and Perspective taking in a Health Context

Perspective taking consists of viewing a situation or becoming aware of something from a specific alternate point-of-view. Thus, a given situation may be recorded and presented from a first- or third-person perspective, differing in the perception, attitude or experience of each of the perspectives [16]. There is evidence that health perspective is useful in certain health contexts, such as reduction of racial disparities in pain management [17]. In this research, perspective-taking aims at providing successful retrieval of critical information for the clinical decision making in the future. For it, it is necessary to visualise the perspective of one's own self and learning cues that will be useful in the procedure [18]. First-person perspective of video recorded clinical procedures was used to analyse clinician’s activity in an experiment somewhere else [19]. Clinicians retrospectively observed the steps followed in a radiological clinical procedure and investigated the information necessary to accomplish the task. Radiologists wore high-definition recording spectacles for a first-person experience evaluation.

All procedures were audio-visually recorded from a third- and first-person perspective, the latter using high-definition recording spectacles. Oral descriptions by clinicians while simultaneously visualising their own audio-visual recordings of the operations in first-person (i.e. HD spectacles camera) and third-person perspectives (i.e. front, rear and bore) were used to provide a concise description of the task at hand visualised in the recordings. The material collected through the experiment sessions were considered by the radiologists as a primary source of learning tools for radiology students. The video explanations would allow a new student to firstly observe the behaviour of an expert in a first-person perspective and secondly, learn why, how and when the actions should be performed during an intervention. In addition, observers could learn from the visualisation of errors, potentially increasing the error prevention rate.

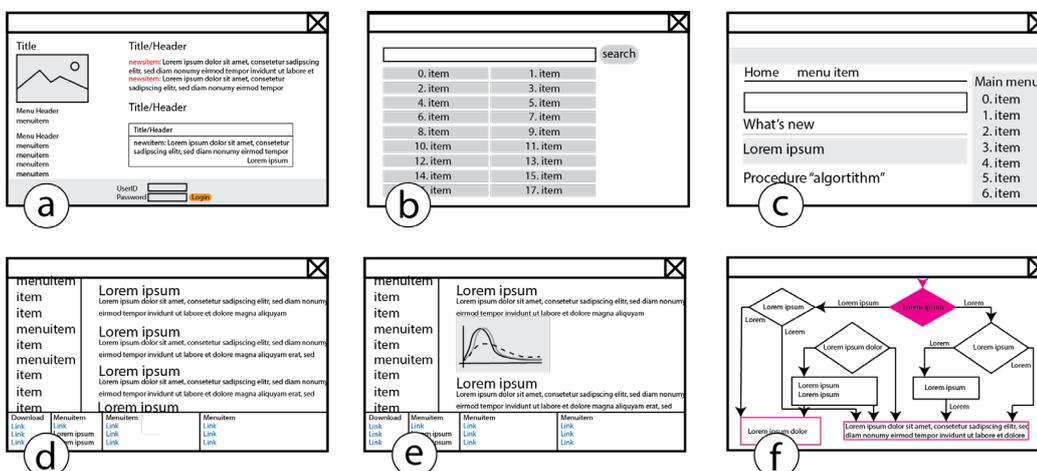


Figure 2 Wireframes representing the OU system.

2.5 Implications for eCPL

Following the summary of immersion and perspective taking aspects in games from previous sections, we revisit them by discussing how they can be integrated into eCPLs.

Sensory Elements to Improve Immersion

Improvements of visualisations may inform redesign for healthcare systems [20]. Appropriate visualisations can increase the quality of patient-centred care, support safe care, decision making, continuous learning and minimize information loss [20]. Pictures and other graphics in existing eCPLs are noticeably abstract, presented in various forms such as textual description or still pictures and schematic animations. Procedure guidelines often focus on textual descriptions with occasional graphics, still pictures, tables (medicine related) and graphs. An example of the latter is the procedure guideline system used at the Osaka University Hospital that shows graphs for medications (Figure 2. f). Another eCPL example is a system called VAR, currently deployed in several European countries (e.g. Norway, Denmark, Germany), which uses basic visualisations. The visual structures analysed are summarised in Figure 3. One finding of the analysis of the VAR system is that the text descriptions are separated from their visual representations (see Figure 3. d). In other cases, procedure steps are directly linked to a picture or a short animation where the next step features the next picture. Based on game visuals that draw on a direct connection between a story and its visual representation, the latter is a preferred option that could be populated across the entire eCPL. Another element is an increased level of perceived reality in pictures, animations or videos. Abstract and real presentations both have their advantages; being able to choose between visualisations can support the information transfer from the eCPL to the real environment. For the level of perceived reality, video and perspective taking can play a relevant role. That means, including different camera angles, virtual reality elements, 360-degree videos, and a first-person perspective can improve video-based procedure learning.

Story and Narrative Elements to Improve Immersion

A story or narrative can be represented by adding the context to clinical procedures or their steps. Procedures do not feature frequently made errors, nor how to prevent or spot them. Neither do they feature related, easily confoundable symptoms present in more than one clinical procedure. Learning from common errors and, more importantly, knowing how to prevent them are key information that could be incorporated into an eCPL. This could be done by health professionals themselves who perform and record a specific clinical procedure offering their first-person perspective and their own narration of why to select that specific clinical procedure and how to avoid common mistakes. Another way, not mutually exclusive with the previous one, could be a specifically designed immersive experience as described in [13] [14]. The difference to the previously described narration-based immersion is that this one transports a user/player into the world through identification with characters and other story elements. This type of immersion can be built through (real or fictive) patient stories connected to procedures and their outcomes, providing a new space for patient education [21] and involvement [22]. Another game-design element that is strongly connected to imaginative immersion is the element of interactivity, to feel and be part of the story and to be in charge of the character's experience.

Interactive Elements to Improve Immersion and self-paced interaction

Perspective and interaction can enable healthcare professionals with an option of switching between first- or third person perspective in a self-paced manner, adding control and immersion. Animated elements, interactive video elements, and instructional videos showing procedure details on request would contribute to self-evaluation and self-paced learning.

3 SUMMARY AND CONCLUSION

Existing eCPLs provide a useful tool for health professionals and scholars. However, a recent survey among 19 health professionals from 6 different countries showed that there is a potential to enhance the visualisation, user experience and human-computer interaction of eCPLs. This paper presents the results of the survey and describes two game design elements relevant for such enhancement:

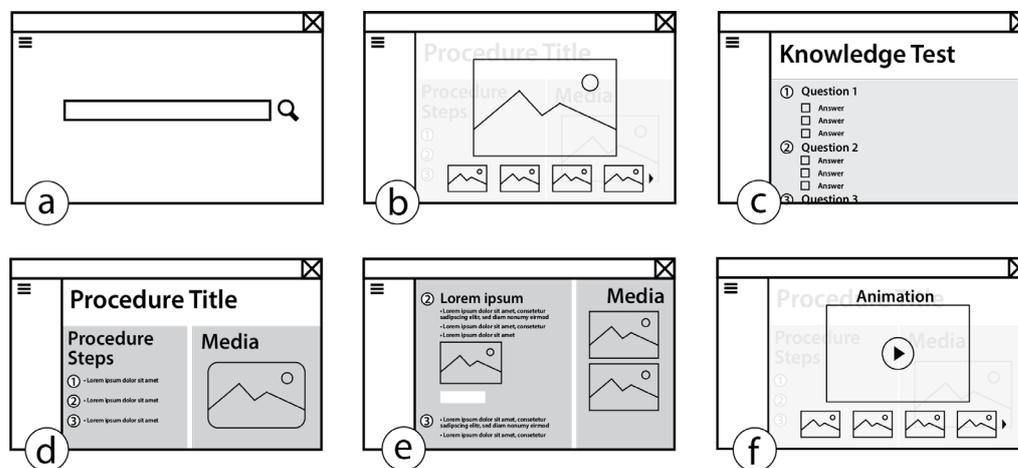


Figure 3 A wireframe summarising visual structures in the VAR eCPL.

immersion and perspective taking. The immersion has previously been successfully used in a learning context. Enhanced visualisations, improved narration and increased interactions can improve immersion. However, they are closely interconnected and therefore require an informed selection, so that an effective level of immersion (i.e. for enhanced learning and in-situ collection of information) can be achieved. Perspective taking has been used in early research for learning of clinical procedures and for common error prevention. Alternating between first- and third person perspective in videos can provide sense of control, and, more importantly, a tool for learning procedures from a different and own perspective, helping to prevent common errors. Follow-up interviews with the respondents will provide a deeper understanding of the results presented here. This research is the second step of a research project that aims to improve the learnability and usability of eCPLs in an international and professional health context. Future research includes evaluation of the elements described in this paper inside an existing eCPL.

4 REFERENCES

- [1] Aspden, P., Corrigan, J. M., Wolcott, J., and Erickson, S. M. "Key Capabilities of an Electronic Health Record System: Letter Report" in *Patient Safety: Achieving a New Standard for Care*. National Academies Press (US), 2004.
- [2] Gelijns, A. C. "Technological innovation: Comparing development of drugs, devices, and procedures in medicine", National Academies, 1989.
- [3] Rotegård, A. K., Holter, I. M., Jensen, U., Lerdal, A., and Tackenberg P., "Für mehr Patientensicherheit: VAR Healthcare - Norwegens digitale Göttin der Weisheit" in *Pflegezeitschrift* 2017, vol. 70, no. 2, pp. 1-3, 2017.
- [4] Rotegård, A. K., and Fossum, M. "Fra oppslagsverk til beslutningsstøtte – VAR Healthcare som case" in *Digitalisering i sykepleietjenesten – en arbeidshverdag i endring*, p. 177–200, Oslo: Cappelen Damm Akademisk, 2019.
- [5] Schulz, R., Martinez, S., and Hara, T. "Usability and Procedure Learnability of Evidence-based Interactive Clinical Systems: Roadmap for a Norwegian-Japanese Research Fellowship" in *Proceedings from the 16th Scandinavian Conference on Health Informatics 2018*, no. 151, pp. 107-108, Linköping University Electronic Press, 2018.
- [6] "DIN EN ISO 9241-210: 2010. Ergonomics of human system interaction - Part 210: Human-centred design for interactive systems" International Standardization Organization (ISO), Switzerland, Standard, 2010.
- [7] Schulz, R., Martinez, S., and Hara, T. "Towards a Game-Design Framework for Evidence-Based Clinical Procedure Libraries" in *2018 IEEE 7th International Conference on Serious Games and Applications for Health (SeGAH)*, IEEE, 2019, (in press).
- [8] Alexander, A. L., Brunyé, T., Sidman, J. and Weil, S. A., "From gaming to training: A review of studies on fidelity, immersion, presence, and buy-in and their effects on transfer in pc-based simulations and games" in *DARWARS Training Impact Group*, vol. 5, pp. 1-14, 2005.
- [9] Morris, C. S., Hancock, P. A., and Shirkey, E. C., "Motivational effects of adding context relevant stress in PC-based game training" in *Military Psychology*, vol. 16, no. 2, pp. 135-147, 2004.
- [10] Brown, E., and Cairns, P. "A grounded investigation of game immersion" in *CHI'04 extended abstracts on Human factors in computing systems*, pp. 1297-1300, ACM, 2004.
- [11] Kelle, S., Klemke, R., and Specht, M. "Design patterns for learning games" 2011.
- [12] Jennett, C., Cox, A. L., Cairns, P., Dhoparee, S., Epps, A., Tijs, T., and Walton, A. "Measuring and defining the experience of immersion in games" in *International journal of human-computer studies*, vol. 66, no. 9, pp. 641-661, 2008.
- [13] Ermi, L. and Mayra, F. "Fundamental components of the gameplay experience: analysing immersion" in S. Castell and J. Jenson (Eds.), *Changing Views: Worlds in Play*, Digital Games Research Association Conference Proceedings, Vancouver, BC, 2005.
- [14] Bizzocchi, J., Ben Lin, M. A., and Tanenbaum, J. "Games, narrative and the design of interface" in *International Journal of Arts and Technology*, vol. 4, no. 4, pp. 460-479, 2011.
- [15] Csikszentmihalyi, M. "Flow: The psychology of optimal experience" New York: Harper & Row, 1990.
- [16] Martinez, S., Isaacs, J., Fernandez-Gutierrez, F., Gilmour, D., and Scott-Brown, K. "Building bridges between user and designer: co-creation, immersion and perspective taking" in *Advances in Design for Inclusion*, pp. 117-129, Springer, Cham, 2016.
- [17] Wandner, L. D., Torres, C. A., Bartley, E. J., George, S. Z., & Robinson, M. E. "Effect of a perspective-taking intervention on the consideration of pain assessment and treatment decisions" in *Journal of pain research*, vol. 8, pp. 809–818, 2015.
- [18] Ryskin, R. A., Benjamin, A. S., Tullis, J., and Brown-Schmidt, S. "Perspective-taking in comprehension, production, and memory: An individual differences approach" in *Journal of Experimental Psychology: General*, vol. 144, no. 5, pp. 898-915, 2015.
- [19] Fernández-Gutiérrez, F., Martínez, S., Rube, M. A., Cox, B. F., Fatahi, M., Scott-Brown, K. C., Houston, J. G., McLeod, H., White, R. D., French, K., Gueorguieva, M., Immel, E., and Melzer, A. "Comparative ergonomic workflow and user experience analysis of MRI versus fluoroscopy-guided vascular interventions: an iliac angioplasty exemplar case study" in *International journal of computer assisted radiology and surgery*, vol. 10, no. 10, pp. 1639-1650, 2015.
- [20] Rossetti, S. C., Yen, P. Y., Dykes, P. C., Schnock, K., and Cato, K. "Reengineering Approaches for Learning Health Systems: Applications in Nursing Research to Learn from Safety Information Gaps and Workarounds to Overcome Electronic Health Record Silos" in *Cognitive Informatics*, pp. 115-148, 2019.

- [21] Mazzuca, S. A. “Does patient education in chronic disease have therapeutic value?” in *Journal of chronic diseases*, vol. 35, no. 7, pp. 521-529, 1982.
- [22] Arora, N. K., and McHorney, C. A. “Patient preferences for medical decision making: who really wants to participate?” in *Medical care*, pp. 335-341, 2000.

5 ACKNOWLEDGEMENT

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