DESIGN AND MEDICAL TRAINING
EXPERIMENTAL HYPOTHESES FOR TRAINING IN IMMERSIVE ENVIRONMENTS

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ABSTRACT

The current orientation in medical education defines how the experience gained through simulation is at the basis of the development of clinical experience. As in many forms of innovative teaching, postgraduate students implement clinical practices in environments that simulate real situations through active learning. In this context we describe the state of the art regarding the main tools for managing critical events in the medical field, through an experimental research that investigates the potential offered by communication design for *medical training* in immersive simulation environments, also in relation to narrative medicine.
Starting from the most widespread simulation methodologies that take place in reconstructed real environments, case studies regarding emergency intervention were selected, in order to analyse risk situations**.**
The study spurred the organization of design considerations in relation to the main practices and guidelines related to emergency management, with the aim of identifying how to integrate communication design and achieve better performance on behalf of the involved actors.

KEYWORDS

Communication design, checklist, immersiveness, narrative medicine, simulation

Introduction

In the last decade of medical research, the Stanford University School of Medicine (SOM) - Stanford, CA - has developed several learning and simulation tools for anaesthesiology and intensive care.
In 2012 Stanford Anaesthesia Cognitive Aid Group released the first version of an *emergency manual for perioperative critical events,* characterized by contents optimized to facilitate clinical use in those typical conditions of high stress to which doctors are subjected, tested by the *Stanford Simulation Group* and by the *Stanford Anaesthesia Informatics and Media* (AIM) Lab (Howard et al., 2011).
Other emergency manuals and *medical checklists* were developed later by Ariadne Labs (Boston, MA) and by the Harvard School of Public Health[1]. These are examples of tools designed to support the team during a crisis in the operating room and to lead to greater efficiency in the management of critical events.
These handouts, which exist in paper format, are still considered among the first examples of content organization for verification and control; in the form of checklists, they are used in different health sectors for emergency management.
In medical education the current orientation defines how experience, acquired through simulation, even in virtual environments (Bowyer et al., 2008), is essential for the development of on-the-field competences (Gaba, 2004). This

contribution presents some reflections that arise from the application of design to immersive simulation environments for medical training.

Digital Applications for Critical Events

The study, carried out in the context of medical checklists in order to understand functions and limits, allowed us to identify two different applied examples, whose content organization was subjected to studies that test their validity of use: *Pedi Crisis* and *IResus* (D. Low et al., 2011). These are two models that, in compliance with the guidelines defined in the emergency management manuals, have the aim of providing different checklists for different crisis situations. Below is a brief description of their evolution and application.

The Society for Pediatric Anesthesia (SPA) developed *Pedi Crisis*, a manual for managing critical paediatric events, consisting in 27 checklists; both a paper document and a digital version of the SPA checklists for simulations were created.[2] There is also a mobile application, *Pedi Crisis 2.0*, a free resource which supports medical operators' responses to critical events within the paediatric age. The application allows the operator to quickly browse an alphabetical list of 26 paediatric emergencies, listed in the "events" tab; it also provides emergency numbers relevant to the specific emergencies and also offers suggestions regarding the dosages of drugs based on the weight of the young patients.

The Resuscitation Council (UK) and Cranworth Medical Ltd. developed, similarly to the SPA, an attempt to translate the contents of the checklists to the digital environment, creating the *IResus* mobile application.

This allows access to cardiopulmonary resuscitation algorithms for adults and new-borns without the need for an Internet connection during a simulated medical emergency, using tablets or mobile devices.

The Role of Communication Design

The checklist refers to a complex list of actions to be performed during critical events, in order to ensure that a procedure, or an activity, are performed as planned; or in order to check that all the necessary preparations have been completed in advance and correctly. In general, in fact, in emergency situations, the required procedures are too complex to simply be performed from memory. A verification table or list of intervention options, such as a list of items to check off, can already constitute an effective support.

The problems reported concerning the effective use of checklists often concern refer to human factors, but there are still unsolved complex logistics and organizational issues, which introduce the importance of the role of communication design in the professional health system.

The amount of information and the level of detail to be included in medical checklists are among the most difficult issues to control during the development process of these tools, since there is no universal model of representation regarding iconography, text length, density of information, number of steps, colours, fonts and, in general, regarding any of the elements involved in the system.

Design inserts itself in this context, in which the strategy of the actions to be carried out requires transparency and quick and easy access, adequate interfaces and adequate usage contexts. Both the medical expert and the medical student must be able to perform with the help of suitable reference points to address the critical issues of a surgical procedure or an emergency, whether they are real or simulated criticalities (Aggarwall et al., 2010).

In the hospital, the use with administration of checklists for surgical procedures takes place in the operating rooms, including emergency rooms; in this case we speak of a *checklist for safety in the operating theatre*. When used during an emergency, on the other hand, we speak of *procedural checklists for critical events*. In both cases, the use of the checklist seems (unfortunately too often) a distraction from the important task of assisting the patient in need: a mechanical procedure perceived as superfluous, to the point that its use is unpleasantly imposed in most cases (Buscemi, 2013).

Considering the enormous value of the control procedure administered through checklists, as attested by the statistical results, the problem of their non-use (or attributed lack of importance) is very serious and dangerous.

The design of the experience in simulation environments is assumed to be another valid approach in the realization of a training that stimulates the active participation of medical students, making the use of checklists accessible at all levels of the procedures.

Within the *Interdepartmental Laboratory of Environmental Design and Multisensory Experience* (EDME), located within the Bovisa campus of the Design Department of the Politecnico di Milano, some perceptive evaluations in an *immersive environment* make use of projections on three interactive walls (CAVE) with E-Real technology. Starting rom the analysis of the most widespread simulation methodologies in reconstructed real environments, case studies concerning emergency interventions were selected, in order to virtually experiment risk situations. The study commenced the analysis of training and simulation models using E-Real technologies (Salvetti & Bertagni, 2018), with the aim of identifying the tools for a better performance on behalf of the involved actors.

The State of the Art

According to recent studies reported by Aico (Surgical Area and Operating Room Nursing Association), the administration of the check-list is associated with a concomitant reduction in the rate of mortality and post-operative complications, but some checklists encounter difficulties in application and the refusal of their use is growing (Paonessa, 2017).

The problems reported often concern human factors, but there are still unresolved complex logistics and organizational issues.

At a first level of observation, it is evident that the design of spaces dedicated to medical environments, operating rooms or first aid units, does not allow adequate *flexibility* to intervene quickly during critical events; the problem concerning "space" is not considered except as a general problem in this contribution.

At a second level we observe a preparation that is not always adequate concerning the use and purpose of the checklists; here the problem is very complex. In fact, even the most effectively designed checklist requires training on its use, but also actual medical training. It can be observed that for any different clinical need, design could support the design of suitable checklists.

A third level deals with the problem of duplication of information: the repetition of content can occur when a checklist relates to other existing checklists or other security checks. In this case, design could once again intervene through control systems structured in coherent interfaces.

The fourth level shows a poor integration with coexisting workflows; there is no reference model thanks to which checklists can be effective without causing interruptions to the flow of medical activities.

Finally, on a last level, it is possible to observe how the barriers linked to common prejudices compromise the correct use of checklists, which many still believe are indicative of lack of experience, as they are linked to student training.

As of today, there are no guidelines for nomenclature and for the design of checklists in the medical field, and therefore the checklists are deeply inhomogeneous. It could be possible to attempt organization by type; in principle, it is possible to group them on the basis of the intended use and on the basis of the fruition methodology.

The Italian Ministry of Health[3], with the *Guidelines for Surgery*, distinguishes the context of use in which the check-lists are applied, dividing them: on the one hand for the operating room/emergency room; on the other hand as procedural check-lists for critical events.

1. WHO (World Health Organization) checklist for operating room/emergency room. These checklists are applied when the patient is in the operating room, in order to avoid clinical risk. They are used in paper or digital format by the checklist coordinator. They include 20 items (*checklist controls*) to be performed and marked in three phases:
   - Sign-In: before induction of anaesthesia;
   - Time-Out: brief moment of "surgical break" which takes place after the induction of anaesthesia and before skin incision;
   - Sign-Out: aims to facilitate the appropriate transfer of information to the team and to the personnel responsible for the assistance of the patient after the procedure.
2. Procedural checklist for critical events, which can be distinguished here, for ease of understanding, as *outdoors* and *indoors* (for training).
   The checklists for critical events that we call *outdoor* are applied during on-site rescue, often with a red code (cardiopulmonary resuscitation episodes, fibrillation). They are usually used in paper format and are applied directly on the first-aid trolley as support for medical personnel.
   Checklists for critical indoor events are applied during the training phases to *simulate* first aid interventions, often using a mannequin. They can be viewed and utilised on a digital screen in a dedicated environment, such as a CAVE.

It also possible to identify, always in the view of providing an overview of the state of the art, an interesting subdivision of the types of checklists with reference to their fruition methodology (Gawande, 2011).

- "Do and confirm" method, which refers to checklists used to verify that the actions have been performed or that the information has been collected.
- "Read and Do" method, which refers to checklists used to guide the actions to be carried out step by step, in real time.
- “Flow” method (e.g. flight manual), similar to the “Read and Do” method, concerns the choice/consequence pairing, along the lines of the flow chart model. One can therefore decide to follow a path rather than another on the basis of previous answers, according to the case one is dealing with. Each checklist can be used by one person or by two or more people, with the text read silently or aloud.

While in the aviation and nuclear sector the checklists have evolved from paper-based systems to computerized systems, therefore optimizing their design and their use, traditional analogue tools persist in the healthcare sector.

Immersive Scenarios In the Medical Field

New technologies offer many possibilities to create interactions with an immersive approach, linking images, sounds, three-dimensional visualizations and multisensory stimulations.

Virtual and immersive reality are fundamental for the development of a neuro-feedback scenario, especially in the recovery of patients with cognitive disorders and accident victims (Ravasio, 2011).

In innovative didactic, through *active learning* methods thanks to which students have an active part, it is possible to define teaching methods based on self-learning and learning by doing including any activity as long as it is cooperative and with a timely feedback. According to the results of the analysis conducted by Freeman (2014) on the teaching methods of the STEM scientific-technological disciplines (Science, Technology, Engineering and Mathematics), the average failure rate dropped from 34% with traditional lessons to 22% with active learning.

The teaching-training methodology based on simulations is the most involving among the so-called "active" methodologies, since it requires subjects to "play" and "act" in first person, as well as too manage complex phenomena and relationships. The active methodology is a didactic method, developed in-depth in the pedagogical and formative context, which consists in presenting the contents of teaching as concrete problems to be solved, providing the learner with all the information and means necessary to manage the situation. It is based on learning through doing and experimenting with situations or activities that stimulate the reflection of both the individual and the group.

The term "simulation" implies a multidisciplinary approach, as it becomes part of very different fields. In general terms, it can be said that simulations are used when there are valid and profound reasons that do not allow direct experience in the field. It is therefore a process that is based on single or group interaction, through a continuous exchange of input and feedback. The simulation therefore creates a "protected climate" within which it is possible to learn and teach even through error, using it as a didactic element to learn. It also involves sensory perceptions, as happens in all situations that involve psychophysical involvement.

For these reasons, the medical health context is among the contexts where simulation has found, since 2000, a wide consensus (Murabito, 2012). In this case the simulation technique is generally based on the use of dummies and 3D virtual reality systems or CAVE, which reproduce various types of environments. The participants in the simulation will be able to transfer the simulated experience to daily work practice; it is evident that these solutions succeed in making the level of realism and the degree of immersion even higher. Francesco d'Orazio (2003) underlines the connection between experience and immersiveness. In fact, direct experience creates a very strong, physical feeling of involvement, a "bath of sensations" that is *immersive and memorable*. Experience and sensation derive from the interaction between space and body.

The simulations, in addition to being used for education and training, also serve to establish and evaluate individual and group performance, to prepare for particularly complicated procedures or to study the validity of protocols such as checklists.

The interdepartmental laboratory of Environmental Design and Multisensory Experience (EDME) of the Politecnico di Milano was used as a theatre for the digital display of checklists for medical training, as it is a virtual multimedia and multisensory environment composed of three interactive walls.

Narrative Medicine and Storytelling

Medicine is also made up of stories, tales and individual cases that can provide useful information for diagnosis and prognosis; therefore Medicine also deals with *biographies*.

In the doctor-patient relationship the narration of the disease (anamnesis, from the Greek verb meaning "to remember") is at least as important as the physical examination; although, necessarily, more subjective.

If we consider the current model of the NBM (Narrative Based Medicine), we understand that the disease is not only a deviation from the norm, but also a biographical event rich in meanings that can (and should) enter the diagnostic and therapeutic relationship.

Narrative medicine, which enters the panorama of medical sciences and humanities thanks to medical education scholars such as Hunter, Shapiro and Charon (Charon et al., 2016) under the name *Narrative-Based Medicine* deals with the use of patients' stories as an effective teaching tool in medical education (Easton, 2016).

The "narrative method" takes place in the context of specific clinical objectives, with the aim of building a personalized therapeutic path, which is also useful for building training scenarios. Digitalization can become an extraordinary tool for the dissemination of this approach, useful for collecting information related to personal experience without necessarily having to make use of direct dialogue.

The method of learning based on narrative is based on the premise that an effective way to transmit educational messages is through the connection of new knowledge with existing experience, in order to give meaning to the narratives and to offer a greater involvement to those participating in the training.

Learning is therefore intended as a construction of meaning starting from experience.

In other words, there is a natural predisposition to make sense of experiences and actions through true storytelling, in order to encourage the development of relevant connections or nodes and providing a relevant context for understanding; a "hook" to engage the public and as a stimulus to memory.

There are strong pedagogical and theoretical arguments to be made for the benefits of learning through narratives or stories in medical education, in particular for the creation of meaning or the improvement or memory, promoting

empathy and developing clinical reasoning (Lanza, 2014). The report of the operations inevitably assumes the physiognomy of a narrative and as such acquires the dimension of a story. Clark and Rossiter (2007) have actually been arguing for many years that experience must be transformed into *narrative form* in order for the student to draw meaning from it.

Conclusions

The "sensation of being present in the scene as if it were real" has long been considered a central quality of virtual environments, for the evaluation of their effectiveness and their quality (Skarbez et al., 2017).

An immersive virtual environment could improve learning and memory recall by utilizing the integration of proprioceptive inputs.

Leveraging the use of immersive digital environments and learning methods more prone to memorization, it will be possible to foresee a better use of checklists in medical practice within training situations in the future, with the aim of creating integration for a clinical use of emergency manuals in patient care.

The role of design in the development of medical checklists lies in the construction of experience in immersive environments, which make the critical steps during training memorable for real future applications. The design of the experience intervenes in the construction of environments that simulate reality also through interactive checklists; the development of a narrative thus becomes the design tool that makes stabilizing memories possible.

The future approach of research intends to organize and test some narrative and checklist models in line with the hypotheses and reflections presented.

Notes

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[3] www.salute.gov.it

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