The medical pause in simulation training

Impact Chapter

The medical pause is about strengthening safety culture. This project deepens the understanding of the medical pause, by producing conceptual models and evidence of its effects on learning in computer-based simulation (CBS). The findings reinforce the discussions on safety culture in healthcare by advancing research, education, and technology. In the following, this contribution is described in three parts: scientific impact (safety culture and medical education, educational science), societal impact (educators, CBS designers, and technology industry), and dissemination activities.

1. Scientific Impact

Safety Culture and Medical Education

Patient safety is one of the major topics in healthcare research. This project provides new approaches to research on safety by connecting existing key concepts such as timeouts,[1,2] checklists,[3-5] and slowing down phenomena,[6-8] and introducing an integral concept of the medical pause. The cognitive mechanisms shared among the previous studies are identified and consolidated based on cognitive psychology, which expands the focus of discussion from strategy (e.g., timeout protocols) to culture (e.g., shared understanding of pausing). This moves the literature on safety culture one step further and allows future studies to build upon the literature through the newly developed understanding and terminology.

For medical education and training, it proposes the medical pause as a professional skill that should be taught already from early phases in training programs. To serve as a translational educational effort, it provides practical techniques to implement pausing in training programs as well as examples of application. This provision may be of value to educators seeking to design better training programs that foster the habit of reflective practice. They can start by introducing simple applications such as checklists that prompt learners to plan and improvise pauses on their own.

Educational Science

For educational psychology, this project further develops the existing discussion on interplay between cognitive load and self-regulation.[9,10] Furthermore, it establishes a new triarchic model of cognitive load with primary, secondary, and extraneous load. This model is particularly powerful in explaining the interconnection between cognitive load, self-regulation, and learning processes. The concepts and terminology presented in this project (e.g., pausing skills, planning and improvising, relaxation and reflection) can facilitate explicit communication between researchers in education, promoting future studies on the interplay between cognitive load and self-regulation.

Research on CBS and gamification also benefits from this project. I developed multiple indicators for performance assessment based on educational theories by using e and eye-tracking data. This provides good examples of the development of reliable measures, facilitating future studies in performance assessment in CBS task environments. Especially, eye-tracking has shown exceptional strengths for research in CBS: It can (1) reveal hidden cognitive processes (e.g., cognitive load, vigilance) that subjective ratings cannot capture, (2) provide support for reflection by recording visual behaviors and presenting them as a cue, and (3) be applied to diverse formats of CBS such as 2D serious games or VR, as these CBS task environments heavily depend on visual stimuli. Future studies on learning in CBS can refer to the methods used in this project to utilize these potentials of eye-tracking.

2. Societal Impact

Educators

Educators and trainers can immediately implement pausing in existing programs. As prompting learners to plan and reflect has already been used as a teaching method in many training programs, pausing to reflect can be readily integrated. As I suggested in Study 1, supervisors should assess the learners' competency beforehand, then discuss how much control on planning or improvising of pausing can be granted to the learners. The terminology from the medical pause can be used to facilitate this discussion.

The use of CBS and eye-tracking to train pausing skills can be integrated in current educational settings, such as problem-based learning and blended learning. In a classroom, a large screen shares what learners are playing in the CBS, while a computer with an eye-tracker is saving the data. In small groups, students discuss with peers on when and how to pause to improve learning and performance. During the pauses, they take turns leading the scenario to apply the newly found solutions in real time. At home, students can repeatedly practice what they learned in the classroom by using online access. Students' performance data can be stored to track their development and replayed for later reflection.

Computer-Based Simulation (CBS) Designers

Although many CBS systems already have a pause function available, CBS designers are not sufficiently aware of the importance of providing support to make pauses contribute to learning. This project presents a good example of this support, namely, cognitive and metacognitive aids (CMAs) with prompts, cues, and leading questions. CBS designers can use this example when implementing a pause function in their systems. CMAs should be designed to fit the learning goals through a task analysis, which requires active communication between CBS designers, educators, and researchers.

Importantly, when implementing a pause function with CMAs, the extra cognitive load that might be imposed on learners should be taken into account. Although the extra cognitive load could contribute to performance (i.e., secondary load), if the total cognitive load exceeds the learners' working memory capacity, it can be detrimental to their learning processes. Thus, especially in case of highly demanding tasks, the designers should consider reducing other types of cognitive load (e.g., lowering physical fidelity of the simulation) to optimize working memory and learning processes.

Technology Industry

As this NWO-funded project involved game developers such as IJsfontein (www.ijsfontein.nl) and Ranj (www.ranj.com), and the game provider of VirtualMedSchool (www.virtualmedschool.com), the research findings have been shared with them throughout the project, and informed them of educational demands of effective CBS design. Since this project is expanded to VR, more organizations (e.g., VR hardware and software companies) can be involved. Such collaboration will allow for more diverse technology in VR to be used in education in the future. For instance, increasing the use of haptic sensors, voice control for communication skills, integration of AI for more realistic virtual patients, multiplayer VR (multiple learners work together in the same scenarios), and adaptive systems that tailor themselves to learners' progress.

While eye-tracking software for 2D stimuli has been well developed by several companies (e.g., SMI, Tobii), the software for VR learning environments is in a very early stage. To develop a functioning software that fits my research purpose, I have collaborated with Vizard (www.worldviz.com), a VR software company in the USA. We developed an eye-tracking package where eye-tracking data can be integrated with data from photo sensors, which is now commercially available. In our ongoing collaboration, we keep developing the software to advance other types of eye-tracking measures (e.g., gaze allocation in VR space), allowing for in-depth research in 3D space and VR training in the future.

3. Dissemination Activities

The research outcomes have been shared by publishing in peer-reviewed journals. Study 1, 2, and 3 were published with open access, while Study 4 and 5 are currently undergoing the review process. Paper presentations and symposia have been arranged at national and international conferences: DSSH (Dutch Society for Simulation in Healthcare) 2019, Association for Medical Education in Europe (AMEE) 2020, ORD (Onderwijs Research Dagen) 2021, EARLI (European Association for Research on Learning and Instruction) 2019 and 2021. In ICLTC (International Cognitive Load Theory Conference) 2018, 2019 and 2021, the application of cognitive load theory to medical education was elaborated. In ECEM (European Conference on Eye Movements) 2019, the methodological aspects of eye-tracking were focused on. Local departmental meetings and interviews were also used to disseminate the findings from my PhD project: Lunch Lecture in Faculty of Health, Medicine, and Life Sciences, Lunch session in Skillslab, Online Learning & Instruction Round Table at Open University in the Netherlands, and Expert Interview for Serious Game in Medical Education at Leiden University.

The research outcomes are also shared through the SHE eye-tracking lab (https://youtu.be/MO9PHBSjOzk) and local networks in Maastricht University such as the FHML VR/AR workgroup, TRI-SIM, and FHML Simulation Day. During this project, IRESIM (International Community for Research on Simulation, https://www.medsimresearch.org) was initiated. It is an international community where researchers, designers, and educators share up-to-date ideas about simulation in medical education. The research findings were shared at the regular webinar of IRESIM, and nurtured through discussion between the members.

References

1. Backster A, Teo A, Swift M, Polk HC, Harken AH. Transforming the Surgical “Time-Out” Into a Comprehensive “Preparatory Pause”. *J Card Surg.* 2007;22(5):410-416. 10.1111/j.1540-8191.2007.00435.x
2. Altpeter T, Luckhardt K, Lewis JN, Harken AH, Polk Jr HC. Expanded surgical time out: a key to real-time data collection and quality improvement. *J Am Coll Surg.* 2007;204(4):527-532. 10.1016/j.jamcollsurg.2007.01.009
3. Pronovost PJ, Vohr E. *Safe patients, smart hospitals: how one doctor's checklist can help us change health care from the inside out.* New York, NY: Plume; 2011.
4. Hales BM, Pronovost PJ. The checklist—a tool for error management and performance improvement. *J Crit Care.* 2006;21(3):231-235. 10.1016/j.jcrc.2006.06.002
5. Pronovost PJ, Bo-Linn GW. Preventing Patient Harms Through Systems of Care. *JAMA.* 2012; 308(8):769. 10.1001/jama.2012.9537
6. Moulton CA, Epstein RM. Self-monitoring in surgical practice: Slowing down when you should. In: Fry H. KR, ed. *Surgical Education.* Springer, Dordrecht; 2011:169-182.
7. Moulton CA, Regehr G, Lingard L, Merritt C, Macrae H. ‘Slowing Down When You Should’: Initiators and Influences of the Transition from the Routine to the Effortful. *J Gastrointest Surg.* 2010; 14(6):1019-1026. 10.1007/s11605-010-1178-y
8. Moulton CA, Regehr G, Mylopoulos M, Macrae HM. Slowing Down When You Should: A New Model of Expert Judgment. *Acad Med.* 2007;82(Suppl):S109-S116. 10.1097/acm.0b013e3181405a76
9. De Bruin ABH, Van Merriënboer JJG. Bridging Cognitive Load and Self-Regulated Learning Research: A complementary approach to contemporary issues in educational research. *Learning and Instruction.* 2017;51:1-9. 10.1016/j.learninstruc.2017.06.001
10. Seufert T. The interplay between self-regulation in learning and cognitive load. *Educational Research Review.* 2018;24:116-129. 10.1016/j.edurev.2018.03.004