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Serious Games in Radiology Education: Building MR Safety Awareness

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Abstract

Introduction: Magnetic Resonance (MR) safety is critically important in any Radiology Department, and MR-related accidents are preventable. Serious games provide opportunities for learners to build MR safety awareness through play in an immersive learning environment by using simulated scenarios such as screening virtual patients and managing an MR-related accident.

Methods: We developed a serious game, in partnership with a game developer, introducing MR safety concepts to learners as they navigate through a virtual 3D Radiology department. Drag-and-drop minigames are incorporated to aid the learner to identify hazards in and around the MR environment. Virtual patients are placed in waiting areas to provide realism, and learners are tasked to screen them as part of MR Safety Screening checks. A simulation of an MR-related accident prompts learners to make decisions or take actions to ensure safety and mitigate further risks during the accident. The learner also role-plays as a Risk Officer to identify the multiple key incidents that led to the accident. These formative assessments, with instantaneous feedback, assesses the learners' knowledge of MR safety.

Results: Pilot feedback of this serious game revealed that it is realistic, engaging and relatable. The instructions within the game were clear and aided learning. The game has also been scaled up and customised for the radiology departments of 3 other healthcare institutions.

Conclusion: Serious games provide a training solution to raise MR safety awareness by simulating real-life scenarios in an immersive learning environment. It supplements face-to-face training and is scalable to other healthcare institutions.

Keywords: *Medical Education, Technology-Enhanced Learning, Gamification, MR Safety, Workplace Safety, Simulation*

I. INTRODUCTION

Magnetic Resonance (MR) safety plays a critical role in any Radiology Department to ensure the safety of patients and healthcare workers. MR is an imaging tool that uses a magnetic field to acquire detailed images of the body for the investigation of diseases.

MR-related incidents are prevalent; for instance, the US Food and Drug Administration (US FDA) received 1568 adverse events reports for MR-related incidents over 10 years between 2008 and 2017 (Delfino et al., 2019). These reported adverse events included mechanical events (eg. crushed injuries) and projectiles that are caused by objects pulled in by the magnetic field.

Hence, caution must be taken as the MR scanner's magnetic field is always on and poses safety risks when MR safety protocols are not adhered to. Ferromagnetic objects can become projectiles within or near the magnetic field and pose a danger to patients and staff members present within it. MR-related accidents are preventable and are caused by MR safety lapses, occasionally resulting in deadly outcomes. Hence, building MR safety awareness for all levels of healthcare staff, from ward staff to those who work in the radiology department, is crucial.

Today's generation of learners, coined as 'digital natives' are accustomed and receptive to the digital world and game-based learning (Girard et al., 2013). Serious games refer to digital games with the specific

purpose of training learners to meet an educational objective (Girard et al., 2013). It has been used as an educational tool to realistically simulate incidents for disaster risk management (DRM) and to raise awareness (Solinska-Nowak et al., 2018). Similarly, it has also been used as training tools in health professional education for patient safety (Ricciardi & De Paolis, 2014).

Serious games can virtually replicate the MR environment and simulate MR incidents that are too dangerous to re-enact in the real world, thus preparing the healthcare professionals for such scenarios. The serious game is an ideal training solution to complement face-to-face training of healthcare professionals on MR safety and can be incorporated into the standardised curriculum design. The intended learning outcomes can be achieved through the constructive alignment of learning activities (within the game and on-the-job) and coupled with assessment and in-game feedback.

Using a learner-centric approach, serious games provide learners with risk-free decision-making opportunities, enhancing MR safety competency through play within an immersive, yet safe, virtual learning environment. These allow learners to exercise the safety behaviours and actions required at the workplace to handle situations that they may encounter.

This short communication aims to describe how this serious game was developed and how the game was evaluated at the pilot stage.

II. METHODS

The team was awarded the Learning Technology Adoption Grant in January 2020 offered by SkillsFuture Singapore (SSG). It is a grant to fund medical education serious games in SingHealth. SingHealth Academy partnered the team with game developers, including instructional designers who helped with the game development.

MR safety lapses can be deadly, and the learning outcomes of the game are to gain knowledge of MR safety and accident risk management, and to be able to demonstrate understanding of these concepts by application of knowledge in the application scenarios within the game and at the workplace.

The target audience for this game includes radiology staff, healthcare staff or ancillary staff, such as housekeeping personnel, who may enter the MR environment and thus, are required to ensure MR safety in their line of work.

The game sets out in a virtual radiology department, modelled after the Neuroradiology department at the National Neuroscience Institute. The virtual world includes virtual patients, staff as player and non-player characters in institutional uniforms, and medical devices that mirror real-life equipment in the radiology department.

Two games were created in the MR safety series. In the first game, learners navigate as an avatar to interact with objects in the MR environment, such as medical devices and virtual patients. The learning outcome of the first game is to understand the key MR safety concepts which follow the American College of Radiology (ACR) guidelines (American College of Radiology, 2020).

The second game was modelled on an MR-related accident. Learners assess the accident scenario (Fig 1a) and consider strategies for risk management, evaluating their options within the game. Critical wrong decisions or actions made during the gameplay may trigger an abrupt end to the game. This emphasises the urgency of actions required in an MR-related accident when a life is in danger and the immediate steps required to be taken to reduce the risk for further injuries. Beyond the virtual accident, the learner role-plays as a Risk Officer to assess and identify several key incidents that led to the accident as part of a root cause analysis investigation.

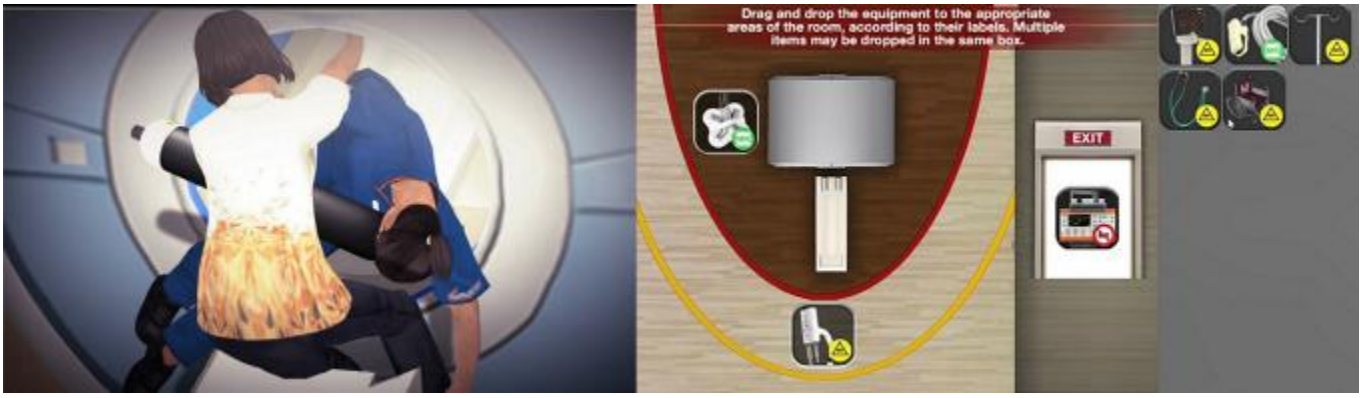

Figure 1a (left): MR accident scenario within the serious game
Figure 1b (right): Application of MR safety labelling near the MR scanner

Minigames are used as formative assessments, and learners receive instantaneous in-game feedback from their attempts. By screening virtual patients and placement of medical devices in their appropriate location, as part of the MR safety screening checks, the game assesses learners' ability to identify hazards in and around the MR environment (Fig 1b), with correct placement demonstrating their learning.

For the purpose of game development, beta testers from the Neuroradiology department were included to gather preliminary feedback about the game through implied consent. A survey was administered, and responses ranged on a Likert scale (1=*Strongly disagree* to 5= *Strongly agree*).

III. RESULTS

In the initial phase of game development, beta testing of the game was conducted on 11 staff, including radiographers, radiologists, radiography assistants, radiology nurses and administrative staff with differing years of MR work experience. Beta-testers were also selected for their experiences in playing games, ranging from none to some experience. Data reported below as 'agreed' is aggregated to reflect 'agreed' and 'strongly agree' responses (Cheng et al., 2021).

In terms of the learning instructions, all respondents (100%) were aware of the learning outcomes. 81.82% found the instructions clear, and they knew what to do at every stage.

In terms of the virtual game environment, respondents generally felt the game has realistic engagement regarding the design. All respondents (100%) agreed that the game environment was realistic; the avatars (player characters) and objects in the game resembled those at the workplace (100%), and the background sound aided the engagement with the game (81.82%). 90.91% of respondents could also relate to the main player character within the game.

On the contrary, some respondents had trouble operationalising the game mechanics; 27.27% had trouble using the controls, and 36.36% found it difficult navigating within the game.

Overall, 90.91% found the game was fun, and engaging (100%). 81.82% agreed that their past experience helped them to overcome some of the obstacles in the game. Furthermore, 81.82% agreed that the results are a fair reflection of their skill and competency in MR safety.

Arising from the positive preliminary feedback of this serious game, the game has been shared and further adopted by radiology departments from three other healthcare institutions [Singapore General Hospital (SGH), KK Women's and Children's Hospital (KKH) and Sengkang General Hospital (SKH)]. The respective teams are working with the game developers to customise and adapt the environment to the local site, including medical devices and safety labels in their local settings for MR safety education.

IV. DISCUSSION

The MR safety game is an educational tool to assess and align MR safety competency for healthcare staff. Furthermore, the game can be incorporated into the orientation curriculum of radiographers as part of a competency checklist onboarding package, supplementing face-to-face training.

Being accustomed to the digital games, 'digital natives' as the target generation of learners would find this mode of delivery more relatable, engaging and realistic (Girard et al., 2013). At the same time, it also incorporates a structured learning design, constructively aligned with clear learning outcomes, learning activities and assessment coupled with instantaneous in-game feedback.

However, we acknowledge that some learners may experience difficulties with navigation in a virtual world. Hence, clear instructions by the facilitator on gaming instructions need to be incorporated in the pre-briefing to learners for more effective engagement and outcomes.

As learners navigate the virtual environment, they pick up MR safety knowledge and apply them to game scenarios as part of active learning. Role-playing as a Risk Officer also makes them more aware of the possible safety lapses that may occur and lead to an MR-related accident. Post-game play feedback should also be incorporated for learners to align the behaviours expected of learners at the workplace.

Beyond the institution, it is scalable to staff from other radiology departments and hospital ward staff, such as nurses and doctors who have no prior knowledge of MR safety but would have adhoc opportunity to be in the MR environment, for example, accompanying a patient to the radiology department for an MR scan.

Finally, through experiential learning, the game emphasises that everyone plays a critical role in MR safety and that safety lapses can lead to accidents.

V. CONCLUSION

Purpose-built simulation serious games that mimic a virtual radiology department provide an ideal training solution for MR safety education. Serious games provide an immersive learning environment where simulated scenarios such as safety screening of virtual patients and MR-related accidents is made possible. Simulation of dangerous scenarios that are impossible to recreate in the real world provides opportunities to raise MR safety awareness and is also scalable to the wider healthcare community.

Notes on Contributors

Cheng Qianhui contributed to the conceptualisation and design of this serious game, drafting the manuscript and approved the final version to be published.

Joanna Pearly Ti contributed to the conceptualisation and design of this serious game, revised the manuscript for intellectual content and approved the final version to be published.

Yu Wai-Yung is a mentor to the team, revised the manuscript for intellectual content and approved the final version to be published.

Oh Hui Ping contributed to the conceptualisation and design of this serious game, revised the manuscript for intellectual content and approved the final version to be published.

Sitoh Yih Yian is a mentor to the team, revised the manuscript for intellectual content and approved the final version to be published.

Ethical Approval

Review not required as stipulated by CIRB (CIRB Reference No.: 2021/2397).

Data Availability

The beta testing evaluation data presented in this manuscript is available in the Figshare data repository: https://doi.org/10.6084/m9.figshare.14473074.v1

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Declaration of Interest

The authors declare no conflict of interest.

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