Learning Clinical Reasoning Through Gaming in Nursing Education: Future Scenarios of Game Metrics and Artificial Intelligence

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1 Introduction

The COVID-19 pandemic has challenged clinical practices, quality of care, and patient safety because of the uncertainties related to the virus itself and patients' clinical conditions, which deteriorate very suddenly. Working in such stressful and rapidly changing clinical situations challenges professionals' clinical reasoning (CR) (Audétat et al. 2020). CR is a complex cognitive process by which professionals use formal and informal thinking strategies to gather and analyze patient information, and evaluate the significance of this information and reflect on alternative actions. CR is one of the most essential competence areas in

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H. Niemi et al. (eds.), *AI in Learning: Designing the Future*,
https://doi.org/10.1007/978-3-031-09687-7_10

clinical care (Hunter and Arthur 2016; European Parliament 2013). Good CR skills ensure patient safety (Mawhirter and Garofalo 2017), whereas incomplete CR skills are related to poor decision-making and even poor patient outcomes (Holder 2018; Simmons 2010). Clinical problems with COVID-19 patients have been ill-defined, and therefore decision-making may change from day to day and thus lead to errors in CR (Audétat et al. 2020). These unfortunate mistakes can be fatal for patients but also traumatic for healthcare professionals. The COVID-19 pandemic has highlighted the importance of professionals' CR skills and thus challenged organizations to consider methods for developing these crucial skills. Artificial intelligence (AI) is one solution for ensuring quality decision-making in challenging situations. Machine learning (ML), deep learning (DL), and natural language processing (NLP) methods can support healthcare professionals' clinical decisions. AI can also be used to support learning CR in healthcare professionals' education and training. Yet studies show that AI use in healthcare education is limited (Randhawa and Jackson 2020), whereas the use of technology utilizing immersive learning environments has increased. In medical education, AI has been used to an increasing extent recently (Sapci and Sapci 2020) but less so in nursing education (Randhawa and Jackson 2020).

CR skills play a major role in identifying and preventing the deterioration of patients' clinical conditions. The special focus of this chapter is nursing simulation games intended for that purpose. Although the use of AI is still limited in nursing education, there exists a positive attitude toward AI (Buchanan et al. 2021); thus, innovations in the field of AI are likely to be seen there in the near future. One potential area of application for AI is simulation games that automatically adjust to the player's abilities and needs. Game metrics could be used to develop adaptive features for educational games. The adaptivity of the content can be achieved by applying techniques from the field of AI, such as dynamic difficulty adoption (Streicher and Smeddinck 2016). Adaptivity refers to the ability of the system to identify the user's preferences or characteristics and customize the system accordingly by analyzing users' previous interactions with the system before making an automatic adjustment (Soflano et al. 2015).

The rapid development of technology has enabled the adoption of diverse types of simulation games in different areas of healthcare education, providing new ways to learn for various learners (McEnroe-Petitte and Farris 2020). These new approaches can offer opportunities for traditional and distance education in healthcare education. Simulation games promote motivation and improve problem-solving (Chang et al. 2020). For instance, simulation games have been used to prepare healthcare students for clinical practices or unexpected situations as well as to support maintaining skills (e.g., Besse et al. 2020; Breedt and Labuschagne 2019). Learning by playing simulation games is also fun and engaging. Engagement can be promoted by creating different and interesting scenarios (Ferguson et al. 2015). Previous studies have revealed that attitudes toward learning with simulation games are mainly positive (e.g., Foronda et al. 2020). CR skills are needed in clinical practice, and therefore, it is important to practice these crucial skills even before encountering patients in real life to avoid patient harm (Peddle et al. 2019).

The purpose of this chapter is to discuss the potential of exploiting AI through game metrics in nursing education for learning CR skills. The next section describes some examples of using simulation games in learning in healthcare education. Thereafter, the current state of using AI in healthcare education is discussed. The possibilities of leveraging game metrics in developing adaptive features for nursing simulation games are then examined. A case study of game metrics in nursing simulation games is presented, and finally, directions for further work are suggested.

2 AI in Healthcare Education

As immersive technologies develop, their use in healthcare education will increase significantly. The immersive technologies in the field of healthcare education include haptic device simulators, computer-based simulations, and head-mounted displays (HMDs), with haptic simulators being the most used and HMD devices the least used (Mäkinen et al. 2020). The use of completely immersive virtual reality (VR) simulations, which are used with HMDs and hand controls or haptics, is still quite rare (Fealy et al. 2019). In nursing education, computer-based simulations are used most often, and they are commonly used to develop clinical decision-making, situation awareness, stress management, and CR skills (Bracq et al. 2019a; Havola et al. 2020). Simulation games have also been used for evaluating nursing students' performance, for example, in resuscitation situations (Keys et al. 2021). Virtual reality simulations have been used to teach teamwork, communication and leadership skills (Bracq et al. 2019b; Kardong-Edgren et al. 2019, Pons Lelardeux et al. 2018), as well as clinical skills, such as urinary catheterization (Butt et al. 2018) and airway management (Botha et al. 2021).

Learners' experiences with using immersive technologies have been positive, and learners have perceived them to be useful in teaching and learning (Botha et al. 2021; Butt et al. 2018). Research has also shown that simulation games are effective learning methods (Chang et al. 2020, Koivisto et al. 2020, Keys et al. 2020, 2021). For instance, nursing students rated their CR skills better after playing a computer-based simulation game than before (Koivisto et al. 2020). Keys et al. (2020, 2021) found that students who played a virtual simulation game performed better in resuscitation situations than students who received traditional preparation. Similarly, in a study by Chang et al. (2020), students who played a simulation game indicated better learning performance, attitude, motivation, and critical thinking than students in the control group, who received only traditional instruction.

Although AI has a long history in healthcare and education, its application is quite limited in the education of healthcare professionals, especially in nursing education (Randhawa and Jackson 2020). In medical education, there have been some advancements in the use of AI. In their systematic review, Sapci and Sapci (2020) evaluated the current state of AI training and the use of AI tools to enhance the learning experience in both medicine and health informatics. AI use includes NLP application to medical education, ML algorithms used for evaluating technical skills in VR simulators, AI analytics for personalizing the learning process, and AI algorithms for assessing surgical psychomotor skills. Shorey et al. (2019) used AI in nursing education by developing Virtual Patients (VP) with virtual counseling apps integrating AI for teaching communication skills. Google Cloud's Dialogflow NLP engine was used to train a voice chatbot that was visualized as a 3D avatar form using Unity 3D. In testing the application, technological limitations were encountered: the VPs were unable to adapt to the conversational context, the program did not recognize keywords to determine appropriate responses, not all computers or microphones were compatible with the app, and the program had difficulties recognizing some students' pronunciations or speech patterns, resulting in translation failures (Shorey et al. 2019). Such challenges may be overcome as technology advances.

Harmon et al. (2021) conducted a scoping review to explore the use of AI and VR in the context of clinical simulation for pain education in nursing. Only four studies utilizing AI within nursing pain education simulations were found, but the review did not report how AI was utilized in those articles. However, it was seen as playing an important role. A scoping review conducted by Buchanan et al. (2021) summarized the predicted influences of AI health technologies on nursing education. Most of the 27 articles reviewed were expository papers; only seven were empirical studies. The literature review indicated that predictive analytics, smart homes, virtual avatar apps such as chatbots, virtual or augmented reality devices, and robots were expected to have an influence in nursing education. In terms of simulation environments, humanoid robots and cyborgs were seen to complement existing high-fidelity simulators. VP gaming apps and virtual tutor chatbots were predicted to be useful for simulating clinical scenarios, and face tracker software using ML could be used to analyze students' emotions during simulation activities. ML could be used to enhance student engagement by analyzing student data and creating more personalized learning pathways. Furthermore, the use of AI health technologies, such as predictive analytics, could benefit nursing students' transition to clinical practice by improving their clinical judgment and CR skills (Buchanan et al. 2021). These prospects indicate that the use of AI in nursing education could have a positive impact on learning experiences, engagement, and learning outcomes.

3 Exploiting AI Through Game Metrics

First, this section introduces the concept of game metrics and their use in performance evaluation in education. Second, the section considers employing AI in game metrics by developing simulation games that adapt to the player's skill level. In previous studies, different game metrics, such as the number of played games, playing time and scores, have been of interest (Kiili et al. 2018; Hamdaoui et al. 2017; Drachen et al. 2013). Kiili et al. (2018) studied game metrics in assessing students at primary schools and their conceptual rational number knowledge skills. Game metrics consisted, for example, of overall game performance, effective playing time, maximum level achieved, collected coins, estimation correctness, and the number of played games. In another study, total playtime per player, the number of quests or missions completed, location of the player at each time and interactions with other characters were investigated (Hamdaoui et al. 2017). Kim et al. (2020) investigated learners' behavior while using immersive virtual reality (IVR) applications in vocational education and training by analyzing the time spent, the number of objects placed, and the number of simulations run by the learners. They found that the quality of learning outcomes was positively correlated with the time spent and the number of objects placed in IVR, whereas a number of simulations were negatively correlated with learning outcomes. Soflano et al. (2015), on the other hand, found no correlation between completion time and learning effectiveness, but they found that adaptive game-based learning applications were better at allowing learners to complete the tasks faster than the nonadaptive game versions.

A closer look at different studies using game metrics shows that the definitions of terms differ. When considering the game metrics regarding time, for instance, Kiili et al. (2018) have used the term "effective playing time" to refer to "the summed-up time that a player took to complete all tasks." Hamdaoui et al. (2017), in turn, have used the term "total playing time," which is understood to mean "the sum of the duration of all played levels." They argue that when metrics regarding time have high value, they refer to players' deep immersion in the game. Since the definitions of game metrics differ, it is always necessary to determine the exact definitions of all game metrics in studies. Plass et al. (2013) highlighted that it is essential to know what data are being collected and to determine what is to be measured and why and how the variables are measured.

The use of AI techniques such as personalization and adaptivity in serious games enables meaningful learning experiences and can promote learning, motivation, and user acceptance by responding to the individual needs of the learner (Streicher and Smeddinck 2016). Game metrics could be used to develop adaptive features for nursing simulation games. Simulation games store a large amount of data about the students' game behaviors, including every action the player takes in gameplay, such as answering multiple-choice questions. The game system also stores how much time players spend interacting with different elements of the gaming environment, how many playthroughs they experience, and how many points they earn. Game analytics, learning analytics, and educational data mining enable monitoring interactions between the player and the gaming environment during gameplay and when analyzing usage data (Streicher and Smeddinck 2016). By calculating and analyzing performance according to specific game metrics, it is possible to demonstrate the player's learning, knowledge, and skills (Drachen et al. 2013; Plass et al. 2013). In other words, analyzing game metrics provides the opportunity to have specific data on how the player is engaged in the game (Drachen et al. 2013). Additionally, game metrics can be used to synthesize objective information about the progress of learners related to learning objectives. Game metrics are also essential when evaluating users' experiences (Hamdaoui et al. 2017). When using simulation games to learn CR skills, game metrics reveal how students interact with a VP. Furthermore, game metrics offer a new and objective way of demonstrating and evaluating nursing students' CR skills (Drachen et al. 2013).

To guarantee efficient learning, simulation games should be able to adapt the gameplay and content of the game individually to all learners (Hamdaoui et al. 2017). An adaptive simulation game can react to learners' prior experiences by offering context-adaptive modifications (Streicher and Smeddinck 2016). One form of adaptivity is adapting the difficulty level of the learning content in simulation games to the current level of the learner based on predefined general parameters or according to a user model. By dynamically adjusting the difficulty level, learners' immersion and state of flow can be fostered. This, in turn, may promote learning outcomes. Adaptivity in learning games can also shorten the completion time of the game (Soflano et al. 2015).

In the initial phase of adaptation, simulation games must implement a performance evaluation to measure certain parameters of the player's performance. This is necessary because, when the player starts the game, the system does not yet have information about the player's skills (Streicher and Smeddinck 2016). Performance evaluation can be done by analyzing the game metrics stored in the game. Game metrics, as parameters, can be used for the classification of players' performances to determine the knowledge or skill levels of the users. Adjustments can be performed based on single or multiple parameters (e.g., game metrics). Difficulty adjustment based on performance may include decreasing the difficulty, not altering the difficulty, or increasing the difficulty (Streicher and Smeddinck 2016). In this case, students' performance in solving simulation game scenarios will respond to their own skill level, which increases motivation. This, in turn, may result in better learning outcomes.

Dynamic adaptive systems in simulation games benefit a heterogeneous group of learners with varying knowledge and skill levels, cultural backgrounds, and previous gaming experience. However, the use of adaptive features in simulation games for learning in a fully automated way in the field of nursing education is still limited, even though AI, including ML and data mining, creates opportunities for developing adaptive systems (Streicher and Smeddinck 2016).

4 A Case Study of CR and the Use of Game Metrics in Nursing Simulation Games

This section describes a case study conducted in Finland (Havola et al. 2021) that used game metrics to evaluate nursing students' scenario performance in simulation games. In this study, playing the simulation game was integrated into the students' studies as one method alongside other teaching methods. Game metrics included the number of playthroughs, the mean score, and the mean playing time.

The validated simulation game was previously developed in cooperation with researchers, nurse educators, nursing students, and game developers, and it has

Fig. 1 Screenshot of the simulation game

become an effective method for learning CR skills (Koivisto et al. 2020). In the game, players are engaged with different clinical situations, such as surgical and emergency settings. In each scenario, the common learning goal is to apply the "Airway, Breathing, Circulation, Disability, Exposure" (ABCDE) approach (Smith and Bowden 2017), which is a validated tool for identifying clinically at-risk patients. By using this approach in the game, a systematic way to assess a patient's clinical condition can be practiced. A previous study has found that students feel that a simulation game allows for the internalization of different treatment protocols (Koivisto et al. 2017). Scenario-specific learning objectives included, for example, recognizing the symptoms of hypovolemia and knowing the right treatment methods for assessing the patient's pain and implementing pain management.

The simulation game is a single-player game that can be played on a computer or with a VR headset (Fig. 1). The gaming environment is a 3D hospital environment, including a VP with specific animations indicating the clinical condition of the patient, such as difficulty breathing or chest pain. When gaming, the player takes on the role of a nurse. In every scenario, the player evaluates the patients' clinical situation, collects and processes information, identifies problems, sets goals and acts in the right order based on the framework of the CR process (Levett-Jones et al. 2010) and ABCDE approach (Smith and Bowden 2017). More specifically, every action that the player wants to take is taken by choosing options from the multiple-choice menu. The nonlinear gameplay allows the player to take actions in patient care in the order determined by the players themselves corresponding to the real-life decision-making situation.

The difficulty level of the game is predetermined by the scenario creators. The level of difficulty is related to the challenge of the patient scenarios, which were defined according to the students' study phase and learning objectives. The difficulty level of patient scenarios varied depending on the clinical situation of the patients (e.g., mild or severe shortness of breath), the various text-based and visual cues provided for players to identify patients' need for care, and the nursing intervention and treatment options available. The level of difficulty did not adapt to the skills of the users but remained the same throughout the playthrough. Furthermore, the difficulty level of the scenario did not change when a player played the same scenario repeatedly. In the game, the student received scores for performance so that each choice was scored: right actions earned points and wrong actions reduced points. Thus, the scores described the students' performance and competence in each scenario.

In the case study (Havola et al. 2021), the computer version of the simulation game, as well as the VR simulation with head-mounted display (HMD), was integrated into the studies of graduating nursing students in one university of applied sciences. The aim was to investigate the effect of simulation games on students' CR skills but also to increase understanding of the use of simulation games, and in particular the VR simulation, as an educational tool in modules. Altogether, 40 nursing students participated in the study. The computer version included nine clinical scenarios in surgical, internal medicine, emergency, and home healthcare settings. For example, in the postoperative observation scenario, the patient's surgical wound was bleeding, and the student needed to get the bleeding under control and prevent the patient from experiencing hypovolemia. The playing time was unlimited. The VR simulation included one scenario. In the scenario, the player had to assess a patient who was experiencing chest pain and administer the necessary treatment when the patient collapsed. At the end of the scenario, the player had to provide post-resuscitation care in the intensive care unit. In the VR simulation, students played the scenarios once with unlimited playing time.

First, graduating nursing students played the single-player simulation game independently using a computer at home. They had the opportunity to play as many times as they wanted. However, they were instructed to play every scenario at least once. The students got access to the simulation game from an electronic learning platform. Second, the students played the VR simulation. VR gaming sessions were conducted at the university of applied science in a game studio. When students arrived at the game studio, one researcher explained the use of a VR headset, and hand controllers were introduced. Students could practice how to navigate in the VR environment before an actual gaming session. One researcher helped students if they needed advice with game technology. Otherwise, help with the content of the scenario was not given by the researcher.

The data consisted of the game metrics stored in the simulation game (Table 1). The analyzed game metrics included the number of playthroughs, scores, and playing time. In every scenario, the maximum score was 100. The number of playthroughs was defined as the number of all playing sessions, whether the player played the scenario to the very end or not. The mean score referred to the mean score of all playthroughs by all players, whereas the mean playing time referred to the mean playing time of all playthroughs by all players (Havola et al. 2021).

Table 1 Playthroughs with the simulation games ($n = 36$–40 nursing students)

Variable	Label	Mean	SD	Minimum	Maximum
Playthroughs with the computer-based simulation game ($n = 494$)					
Mean score[a]	Score	67	8.7	43	82
Mean time (Min.)[b]	Time	4.2	1.0	2.4	7.1
Max score[c]	Score	100[f]	1.4	91	100
Max time (Min.)[d]	Time	7.6	3.5	4.5	21
Average number of played scenarios[e]		13.7	6.6	4	29
Playthroughs with the VR simulation ($n = 40$)					
Mean score[a]	Score	95	9.9	66	100
Mean time (Min.)[b]	Time	16.0	4.2	8	30.5
Max score[c]	Score	95	9.9	66	100
Max time (Min.)[d]	Time	16.0	4.2	8	30.5
Average number of played scenarios[e]		1	0	1	1

[a]Mean score: The mean score of all playthroughs by all players
[b]Mean time: The mean time of all playthroughs by all players
[c]Max score: The maximum score of all playthroughs by all players
[d]Max time: The maximum time of all playthroughs by all players
[e]Number of played scenarios: Frequency of all playthroughs and all scenarios by all players
[f]Score has round to two decimals

In addition, the students' demographics were collected using an electronic survey. Students also self-evaluated their CR skills in three phases using the Clinical Reasoning Skills scale (CRSs) (Koivisto et al. 2020): before and after playing the computer version of the game and after playing the VR simulation.

In the study, 494 playthroughs were conducted by students with a computer, while there were 40 playthroughs with a VR simulation altogether (one per student). The main results demonstrated that students' CR skills were systematically improved after game playing. There was a systematic association between better mean scores and better CR skills in playing both with computers and with VR headsets. Students spent more time in the VR simulation than playing with the computer; the mean student playing time was over 4 min of computer play, with VR simulation play over 15 min. Interestingly, a better mean score was achieved by spending less time playing with the computer. When playing the VR simulation, in turn, a better mean score was achieved when playing longer. On average, the students' mean score was 67 out of 100 in the computer game, while the mean score was 95 when playing the VR simulation.

Taken together, some interesting findings were found in this case study. The notable finding was that students' CR skills improved after playing both games. A clear difference was found when considering the differences between the playing time with a computer and a VR simulation. It is essential to notice the possible effect of the researcher's presence in the VR sessions when considering the differences between gaming sessions with computers and VR simulations. Possibly, students may have felt some social pressure while gaming. However, it can be stated that students were more immersed in playing the VR simulation than in playing with the computer (Hamdaoui et al. 2017).

When using both a computer simulation game and a VR simulation for learning CR, it is essential to examine the order in which the different versions should be used to achieve effective learning outcomes. For example, Kim et al. (2020) found that the effectiveness of immersive VR on learning outcomes was improved when it was carried out after the traditional method (paper-pencil). In this study, students achieved better scores by playing the VR simulation compared to the computer version. This could indicate that the students became familiar with the game's technology by playing first with the computer. Therefore, better scores may be achieved in the second playing session by playing the VR version, even though the content of the scenario was not the same.

5 Directions for Future Work

The purpose of the current chapter was to discuss the potential of exploiting AI through game metrics in nursing education for learning CR skills, since the use of AI is still limited in nursing education (Randhawa and Jackson 2020), even though immersive technologies provide promising opportunities. For good learning experiences and learning outcomes in simulation learning, the level of difficulty of the scenario must be proportional to the learner's competence to achieve optimal flow during the scenario (Csikszentmihalyi 2000), which in turn could promote intrinsic motivation and improve performance. In the best nursing simulation games, learners can achieve a flow state since, in the applications, the game elements and game mechanics familiar from entertainment games have been utilized (e.g., Koivisto et al. 2018). However, to maximize good learning experiences and effective learning outcomes in simulation games, they should provide more personalized content (Hamdaoui et al. 2017). One way to personalize simulation games could be to adapt them to the learner's level of skills, and dynamic difficulty adjustment techniques could be used for that purpose (Streicher and Smeddinck 2016).

Next, future work to utilize game metrics in developing simulation games that adapt to the player's skill level is discussed. The case study has provided preliminary information on how game metrics describe students' scenario performance in a simulation game (Havola et al. 2021). The future aim could be to create simulation games that are adaptive to the skill levels of the players in clinical patient scenarios. This could mean, for example, that the patient's clinical condition changes based on the student's competence level, so that the difficulty level of the scenario decreases, remains the same, or increases (Streicher and Smeddinck 2016).

The first step in developing simulation games into an adaptive system is to determine which aspects of the simulation game should be adaptive (Streicher and Smeddinck 2016). The difficulty adjustment of the patient scenarios based on performance could be selected as an adaptive element. Second, adjustable parameters should be defined, and when talking about game metrics, the parameters could include scores, playing time, and playthrough quantity (Havola et al. 2021). These game metrics could be collected automatically in triggered positions or periodically with a time interval. The different difficulty levels could be determined using previous information about the relationship between playing time and the number of playthroughs with scores. The difficulty levels of the simulation game scenarios can be defined as easy, medium, or difficult. At the easy level, the time spent on playing is short, the number of playthroughs is low and the scores are low, while at the difficult level, a lot of time is spent on playing, the number of playthroughs is high, and the scores are high. To validate the different levels, they need to be tested on a large number of students and a large number of playthroughs.

Third, levels of automation in adaptability, such as adjustment automation, should be identified (Streicher and Smeddinck 2016). Adjustment automation can range from fully manual to fully automated. With a fully manual adjustment level, simulation games could be static games with predefined difficulty levels, as was the case in the case study presented (Havola et al. 2021). In this option, the students choose the level of difficulty themselves. When students play the game, the system collects information about the time spent on playing, the number of playthroughs, and scores, and when students start a new scenario, the game system recommends a level for the students based on their previous performance. However, learners still choose a predefined level.

In a manual adaptive level, the difficulty levels in simulation games could be determined in advance based on previous knowledge of the relationship between playing time and the number of playthroughs with scores. When students execute a scenario, the system automatically directs the players to a certain difficulty level based on their behavior in the game. A fully automatic adaptability level could be developed into simulation games when enough information has been obtained about the performance of a sufficient number of players in the game. When there are a lot of data, machine-learning techniques could be utilized to determine the difficulty levels automatically. In this case, the automation level is fully adaptive: the difficulty level of the game changes automatically during gameplay based on the players' behavior in the game, that is, the time spent playing, number of playthroughs, and scores. To achieve this kind of adaptability, which is based entirely on players' competence, more player data are needed to utilize, for example, ML methods. In addition, research is needed on how automatic difficulty adoption in simulation games affects the students' learning experiences as well as learning outcomes.

6 Conclusion

The COVID-19 pandemic has challenged the clinical reasoning of healthcare professionals in identifying and treating the various clinical symptoms caused by the virus. This global situation has highlighted the importance of CR skills for patient safety in a somewhat frightening way. As mentioned earlier, in clinical work, AI can be used to support decision-making. However, this chapter has concentrated on the potential benefits of AI in healthcare education, especially the use of simulation games in learning CR skills in nursing education. The focus has been on adapting the difficulty level of simulation games based on the knowledge and skills of the learners and suggesting the use of game metrics for doing so. Game metrics have not yet been utilized very commonly in nursing simulation games, although research in other disciplines has shown that game metrics are suitable for demonstrating the achievement of learning outcomes. The empirical findings in the case study presented here create a new understanding of the possibility of game metrics to provide objective information on the CR skills of nursing students. To effectively achieve the learning outcomes for which the game has been developed, students must remain engaged in the game for a prolonged period. Dynamic adjustment of the difficulty level of the patient scenarios could keep students immersed and in a state of flow in clinical scenarios, which, in turn, could contribute to the achievement of learning outcomes, not frustration and boredom. Taking advantage of recent technological developments in AI, playing adaptive simulation games could enable nursing students to achieve even better CR skills for working life and for constantly challenging clinical situations. This ultimately benefits the patient.

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