1 A Comprehensive View of Simulation

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Overview

We will start off this chapter by tracing the history of simulation and reflecting on its use in educational contexts, mainly in higher education. Unfortunately, the literature in the area of simulation and training within the field of teacher education is limited (Clarke, Clarke Technology, Pedagogy and Education 22:121–131, 2013; Vlachopoulos & Makri, Vlachopoulos and Makri International Journal of Educational Technology in Higher Education 14:1–33, 2017). However, literature in the area of simulation and training does exist in professional training in several disciplines. We describe some of the institutions using simulation and serious games and the leading simulation associations worldwide.

Keywords

Simulation · Serious games · Higher education · Professional training

Learning Objectives

Readers of this chapter will explore

- the concept of simulation;
- relevant simulation applications in different disciplines;
- simulation effect across disciplines;
- institutions using simulation and the leading simulation associations worldwide.

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1.1 Simulation

Let us first define simulation. A simulation refers to an activity in which participants are assigned duties and are given enough key information about the problem to carry out these duties without play-acting or inventing key facts (Jones, 2013). A simulation is based on a representation of a system, with key information to carry out tasks, debate, negotiate from different points of view, and seek a solution to a specific problem (Klabbers, 2009).

According to Crookall and Thorngate (2009), simulations can be classified as follows:

- Knowledge-to-Action (K-A) events, which are designed, run, and debriefed primarily to enable or encourage participants to apply previous knowledge to some practical situation.
- Action-to-Knowledge (A-K) events, which are designed, run, and debriefed primarily to enable or encourage participants to generate understanding, learn new skills, and gain new knowledge from a concrete experience.
- Integrating-Action-Knowledge (I-A-K) events, which are designed, run, and debriefed primarily to enable or encourage participants to make connections between their actions and the related knowledge.

This categorization of simulation draws an analogy with what is expected in teacher education: interaction to apply previous knowledge; development of a broader understanding of educational issues and the gain of new knowledge; and the integration of multiple teaching goals in a single process by connecting actions to knowledge. Thus, simulations create a natural context where pre-service teachers become acquainted with a variety of educational realities and problems; they interact, debate, and make proposals (García-Carbonell et al., 2014; Angelini, 2021). At this point, we can argue about the transformational effect of simulation. Transformative teaching/learning allows educators to inspire students to challenge their preconceived beliefs, assumptions, and values through dialogic practices in the simulation (Parker & Myrick, 2010). So the simulation becomes an immersive teaching/learning platform (Erlam et al., 2017) which should carefully be built on the principles of behaviorism, constructivism, and cognitivism (see Chap. 2 "A Roadmap to Simulation in Education"). Figure 1.1 highlights the different skills potentially developed by learning through simulation which are collected in specialized literature about teaching and learning methodologies.

Thiagarajan (2003) classifies simulation into "high-fidelity" and "low-fidelity". High-fidelity simulations (HFSs) give participants a true-to-life experience, in which they can discover underlying principles and develop specific and soft skills. They have traditionally represented replicas of on-the-job tasks and thus they have been categorized as scoring high on fidelity. In turn, "low-fidelity" simulations are simplified models that only include a few chosen factors from reality (Thiagarajan, 2003; Massoth et al., 2019). These are especially used to uncover underlying

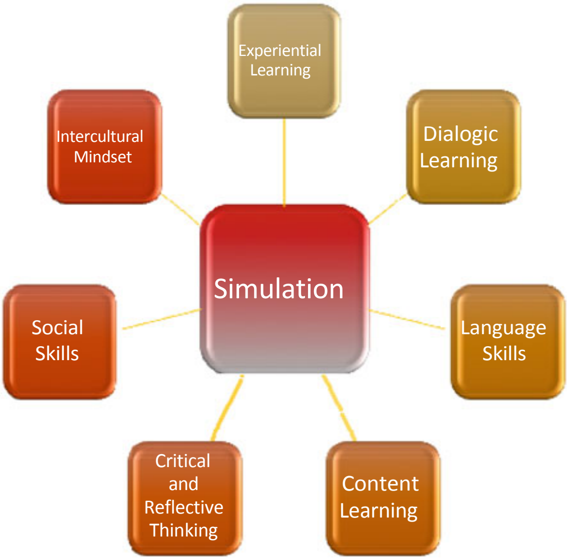

Fig. 1.1 Specific and transversal skills through simulation (Angelini, 2021)

principles and practice procedural skills. These are not really new inventions; in fact, they existed prior to World War II. Motowidlo et al. (1990) coined them “low-fidelity simulations” because participants had to act out in work-like scenarios solving a problem by choosing an alternative outcome from a list of predetermined responses (Lievens & Patterson, 2011 in Angelini, 2021).

1.1.1 Tracing Simulation

Historically, military games have always been predominant. In the article “Historical Roots and New Fruits of Gaming and Simulation”, Willy Kriz (2017) clearly describes the transition of warlike games into simulations. Starting with GO, from China about 400 BC, CHATURANGA and CHESS, from India about 500 AB, subsequent games appeared as the NEWLY INVENTED GREAT KING’S GAME by Christoph Weickmann in 1644 and the BRUNSWICK WARGAME in 1780 by Johann Christian Ludwig Hellwig. It is precisely this latter, which was originally entitled “Attempt of a tactical game based on chess and played by two or more persons”, that turned out to be a war “simulation”, simple in terms of rules at the beginning but evolved into complex simulations to train officers to build attack and defence strategies (Angelini, 2012).

It was Hellwig’s initiative to use the BRUNSWICK WARGAME for his teaching and training of military officers of the Prussian Army (Kriz, 2017). The simulation was aimed at developing strategic and tactical skills and, at the same time, enhancing military operations in a more authentic and realistic way. Also, more sophisticated business war simulations were designed as, for example, the American Management Association (AMA) TOP MANAGEMENT DECISION

SIMULATION. It became the first computer simulation in 1956 (Kriz, 2017). In 1958, the first business board game appeared under the name BUSINESS MANAGEMENT GAME. Designed by Gerhard Andlinger and Jay Greene, the game simulated several companies competing on the market (Andlinger, 1958). More recently, simulations have been adopted by different fields in an attempt to develop skills such as foreign languages, cultural training, and future application areas (Michael & Chen, 2006).

In the case of politics, for instance, simulations are used to deal with crisis management, terrorist attacks, disease outbreaks, policy issues, city planning, and traffic control, among others (Duke & Geurts, 2004; Michael & Chen, 2006; Squire & Jenkins, 2003). By using simulation, it is guaranteed the practice of situations that are too dangerous, impossible, or too expensive if carried out in reality.

Corporations have also applied simulation to train workers. Digital simulations and serious games are common as there is a great number of employees who are familiar with them and whose interest is easily caught by interacting with them. Michael and Chen (2006) identify some skills trained by simulation and serious games: teamwork and how to perform well within the department; job-specific skills or how to use specific software/hardware for the job, etc.; organization skills or how to organize resources and time, etc.

Simulation also offers many advantages for medical education. Fletcher (1995) identified several benefits such as the reproduction of complete clinical settings with no threats to patient safety. Also, through simulation, active learning occurs and knowledge is applied to specific patient situations. Errors can be corrected and discussed straightaway. Different responses and actions can be compared by the students-participants. In surgical training, for example, it has been proved that experience with simulation correlates with better performance surgeries such as laparoscopic or shoulder arthroscopy (Ahlberg et al., 2002; Cook et al., 2013; Fried et al., 1999; Goldstein et al., 2014; Gomoll et al., 2007; Keyser et al, 2000; Krishnan et al., 2017; Lorello et al., 2014; Mundell et al., 2013; Sroka et al., 2010).

In addition to these benefits, communication, teamwork, and delegation can be simulated. Thus, a mix of technical and non-technical experiences is offered. Harwayne-Gidansky et al. (2017) carried out a study about the effects of mannequin-based immersive simulation on medical education. They found that a scenario-based immersive simulation (with a structured debriefing) added to standard clinical educational methods notably improved the assimilation, retention of information, and proper application of medical knowledge and participants' decision-making.

1.2 Some Relevant Research on Simulation Effect Studies

A large number of studies address simulation from an immersive learning perspective (Beckem, 2012; Bogost, 2007; Chang et al., 2010; Deen, 2015; Ekker, 2000; Gegenfurtner et al., 2014; Harteveld, 2011; Klabbers, 2009; O'Flaherty &

Phillips, 2015; Polanyi & Sen, 2009; Wedig, 2010; Wiggins, 2012). Kolb's experiential learning cycle (see Chap. 4, Sect. 4.3.3. "On designing learning loops with pre-structured questions and stimuli") can be addressed as the main conceptual framework used for experiential learning in simulation (Kolb & Kolb, 2018). Experiential learning is considered a process through which knowledge is built by transforming the experience. Learners go through concrete experience, reflection, conceptualization, and experimentation. The cycle begins with the learners' involvement in a specific experience (simulation); then they reflect on the experience from different viewpoints (reflective observation). Through reflection, learners create generalizations and principles and draw conclusions (abstract conceptualization when explaining or thinking). The learners then use these principles and conclusions in subsequent decisions and actions (active experimentation such as applying or doing) that lead to new concrete experiences (Kolb & Kolb, 2018; Kolb et al., 2014). Other authors have been inspired by Kolb's learning cycle in their research on simulations. Table 1.1 offers a sample of studies chronologically organized that add value to how simulation games contribute to learning.

On balance, results indicate that simulations have a positive impact on learning goals. Most researchers agree on three main learning outcomes: cognitive, interactive, and affective. The authors provide enough evidence on the virtues of simulation for pedagogical purposes and such evidence also provides potential options and pathways for future research.

Table 1.1 Studies based on simulation games

Studies	Effects	Added value
Crookal and Oxford (1990)	Practical aspects of using simulation/gaming in language learning	Application of simulation/gaming to specific areas; computerized language learning simulations; theoretical aspects; sample simulations
Klabbers (2001, 2009)	Simulations learning and instructional resources	A springboard for interactive learning; develops expertise and tacit knowledge
Kriz (2003)	Simulations convert problem-oriented learning into purposeful action	Simulations favor change processes in educational organizations;
Ekker (2004)	Simulation invigorating learning	Simulation is a reality in itself
Levine (2004)	Telecollaborative exchanges and global simulations	Immersive, simulated environment; student-centered, task-based alternative to conventional curricula
Leigh and Spindler (2004)	Chaos theory as a framework for identifying skills and knowledge to anticipate and respond to the uncertainties	Understanding of chaos theory, coupled with skills to apply this knowledge to open simulations, enables educators to more quickly and accurately select and apply appropriate learning-centered interventions

(continued)

Table 1.1 (continued)

Studies	Effects	Added value
Halleck and Coll-García (2011)	Telecollaborative exchanges and global simulations	Web-based simulations affect the development of language abilities, critical thinking, and intercultural awareness
Alklind et al. (2012)	Simulations help improve the learning experience	A coaching framework: instructors-facilitators taking up a role as participants in the simulation
Burke and Mancuso (2012), They identified. They asserted that	Debriefing phase from a social cognitive theory, metacognition, and simulation Debriefing helps build students' self-efficacy and regulation of behavior	Core principles of intentionality, forethought, self-reactiveness, and self-reflectiveness in simulation environments
Rising (2009)	Simulation to learn languages	Greater exposure to the target language
Andreu-Andrés and García-Casas (2011)	Simulation to learn languages	More purposeful interaction, input more comprehensible for learners
Watts et al. (2011)	Simulation to learn languages	Affective filter lowered, anxiety reduced
Woodhouse (2011)	Simulation to learn languages	Sociocultural aspects related to communication in the target language, and greater powers of decision, persuasion, and assertiveness in communication
Michelson and Dupuy (2014)	Simulation to learn languages	Learners' awareness of language and other communication modes as social signifying practice, and their abilities to draw upon multiple Available Designs in making meaning
Reeve (2013)	Simulation to learn languages	Simulation to develop or reinforce theoretical understanding
Ranchhod et al. (2014)	Simulation to learn languages	Management experience and professional skills
Michelson and Dupuy (2014)	Simulation to learn languages	Simulations to boost students' awareness of the target language together with other communication codes
Kriz and Auchter (2016)	Overall increase in the participants' knowledge of business administration and business plan preparation skills	Significant gender-based differences identified related to entrepreneurial attitudes and motivation; participants initiating start-ups at a higher rate

(continued)

Table 1.1 (continued)

Studies	Effects	Added value
Angelini (2016)	Flipped learning instruction and simulation-based lessons to optimize class time by using and designing simulations with prospective secondary school teachers	Benefits of using simulations that are based on literary extracts with a substantial social component
Blyth (2018)	Simulation to learn languages	Web-based simulation as immersive technologies in foreign language education; what constitutes immersion—virtual or otherwise
Hamada et al. (2019)	Understanding of the state of the art of the simulation and gaming research field	Familiarizes readers with examples of simulation and state-of-the-art gaming in education, social problem solving, and experimental research; insights into handling simulation and gaming from clinical theory to problems faced by an individual
Angelini and Muñiz (2021)	Virtual exchange and simulation	Cross-cultural collaboration as the strongest benefit; critical awareness developed through comparing and contrasting their knowledge and experience
Naweed and Leigh (2021)	Examines instances where awareness of self and/or others influences how facilitators operate within simulations	Facilitators may experience greater anxiety than those managing non-facilitation settings Understanding the impacts of the gaze within and beyond A simulation may enable facilitators to prepare internally and perform externally. A conceptual framework is developed to assist facilitators reflect and identify applications
de Wijse-van Heeswijk (2021)	A three-layered framework of perspectives on ethical facilitation	Tangible perspectives with scientific foundations can be established and applied on the continuum of open and closed simulation games
McGue et al. (2021)	Simulation-based medical learning	Simulations used to develop understanding and empathy for psychiatric patients among trainees in medical schools
Schijven and Kikkawa (2022)	Ethical issues on game design	Cultural aspects and ethical issues

1.3 Where to Find Simulation and Training?

More and more institutions have been designing and applying simulation. Here we present some initiatives that may be of interest.

The School of Modeling, Simulation, and Training (SMST) at the University of Central Florida, U.S (https://www.ist.ucf.edu/), conducts cutting-edge human-centered simulation research and executes a world-class transdisciplinary graduate program to create leaders in modeling, simulation, and training. SMST houses a series of interdisciplinary graduate degree programs in modeling and simulation, designed primarily for students with backgrounds in STEM who wish to pursue careers in any number of fields, including academia, government, defence, entertainment, technology, service, and manufacturing.

The ICONS Project (2001) at the University of Maryland (https://www.icons.umd.edu/) creates simulations and scenario-driven exercises to advance participants' understanding of complex problems and strengthen their ability to make decisions, navigate crises, think strategically, and negotiate collaboratively. For many years, ICONS was part of the Government and Politics department and its Center for International Development and Conflict Management (CIDCM). In 2016, ICONS became an affiliated unit of the National Consortium for the Study of Terrorism and Responses to Terrorism (START), a research and education center based at the University of Maryland. While ICONS continues to maintain and pursue its mission to develop simulations on a wide range of topics and skill sets, the partnership with START has created further opportunities to collaborate on research and education.

The Simon Fraser University-carries out the project "Simulation and Advanced Gaming Environments for Learning" (SAGE) that focuses on health-related learning, aiming at learning: (a) how people learn through technology-based simulations; (b) which cognitive, human, and social factors contribute to making simulations engaging, motivating, and effective for learning; (c) how to integrate new technologies and theoretical knowledge of learning to create effective learning simulations in real-world settings (e.g., schools, hospitals, businesses, and communities); and (d) how to improve methods and tools for research and evaluation on learning with simulations. Another project is "HEALTHSIMNET" (part of a national network of research on simulations, games, and learning). The project models "the ontology of healthcare for HIV/AIDS sufferers and their networks of professional and lay support". The model forms the basis for the development of an interactive simulation game that will be used to review performance from individual and organizational perspectives. Yet another project is "Advanced Gaming Technology for Training Business Majors", which explores emerging technologies for business strategy gaming, and their implications on the pedagogy of business education. The project focuses on "active intelligent agents", which, if necessary, would allow removal of the human player from the simulation loop to speed up the game. Intelligent agents…offer such new opportunities as benchmarking the actions made by the learners during the game". The aim is to develop "new technical solutions to business strategy gaming and recommendations on bettering the pedagogy of gaming".

At the University of Birmingham, several continuous professional development courses and modules are offered. Academics with experience in education and simulation-based training and experienced clinicians based at the University Hospital Birmingham have designed programs that offer the opportunity to study the principles of experiential learning theory in healthcare simulation, the process of creating simulation scenarios, and the concepts underlying safe and effective debriefing. In addition to theoretical study, the course aims to promote the wider use of simulation modalities, non-technical skills, and human factors in healthcare teaching, learning, and practice.

In Stuttgart, Germany, the Zentrum for Management Simulation (ZMS) works on the ongoing optimization of simulation applied to the university and business contexts. The aim of ZMS research activities is to train today's students for tomorrow. They have several ongoing projects using simulation.

In the Netherlands, there are many organizations and educational institutes to choose from. Since the 70s, simulation and gaming have increased in popularity.

Applied university level

- Master Serious Gaming, NHL Stenden, Leeuwarden, Master deeltijd, 2 years.
- Post Bachelor Gamedidactiek, Hogeschool Utrecht, Utrecht, Post Bachelor, 3 months.
- Game Design, Game Art & Game Animation, SAE Institute, Amsterdam, 3 years, English only.
- Game Design, HKU Utrecht, Utrecht, Bachelor, 4 years.
- Creative Media and Game Technologies, Saxion, Enschede, Bachelor, 4 years, English only.
- Communication & Multimedia Design, HAN, Arnhem en Nijmegen, 4 years.
- Create a High End Video Game, HAN, Arnhem en Nijmegen, Exchange Course.
- CreativeMedia and Game Technologies, Hogeschool Rotterdam, Rotterdam, Bachelor, 4 years.
- Game Design, Hanzehogeschool Groningen, Groningen, Bachelor, 4 years, English only.
- HBO-ICT: Game Development, Hogeschool van Amsterdam, Amsterdam, 4 years.
- HBO-ICT: Game Design, Windesheim, Zwolle, Bachelor, 4 years.
- HBO-ICT: Game Design, Fontys, Eindhoven/Tilburg. MBO-level (middle-level education).

These institutions offer different learning tracks in which game design is a part of the course.

- Media- en Gamedeveloper, Mediacollege Amsterdam, Amsterdam, MBO-BOL, 4 years.
- Mediatechnologie, Grafisch Lyceum Rotterdam, Rotterdam.
- Software Developer, ROC Friese Poort, Drachten, MBO-4, 3 years.

- Game Developer, ROC A12, Ede, MBO-BOL, 3 years.
- Digital Design and Motion, Sint Lucas, Eindhoven, 4 years.

Online Courses

- MOOC Serious Gaming, Erasmus Universiteit Rotterdam, 10 h, online course op Coursera.
- GameSkool: Gaming in het Onderwijs.
- Game Designer LOI, HBO niveau, 4 months, self-study.
- Game Designer NHA, 4 months, self-study.

University level

- Creative Media en Game Technologies, Breda University of Applied Sciences, Breda, Bachelor, 3 years.
- Master Game Technology, Breda University of Applied Sciences, Breda, Master, 1 year.
- Game and media Technology, Universiteit Utrecht, Utrecht, Master, 2 years.

In Sweden, the KTH Royal Institute of Technology offers a meta-disciplinary game education course in which students acquire the knowledge and ability to assess what problems can be approached with a gaming simulation. They can understand the process of conducting game sessions; the different stages of game sessions; and the roles of facilitators, players, and note-takers in game sessions. They are able to draft the design specifications of a gaming simulation and may become contributing members of a game design team.

In Germany, the Centre for Simulation and Gaming at DHBW Stuttgart provides a selected list of companies that offer simulation games.

Summer schools and game jams worldwide

- The Global Game Jam® (GGJ)8 is the world's largest game jam event taking place around the world at physical locations. It is a non-profit volunteer-run event with a single goal: to bring together people all over the world to have a great time making innovative games. Global Game Jam is not a competition; it's a worldwide creative collaboration. Breda University of Applied Sciences has been providing a location for the Global Game Jam since 2012.

Simulation Associations Worldwide

Between the 1960s and 1970s, several gaming and simulation associations were founded (e.g., North American Simulation and Gaming Association—NASAGA, International Simulation and Gaming Association—ISAGA, Association for Business Simulation and Experiential Learning—ABSEL, Society for the

Advancement of Games and Simulations in Education and Training—SAGSET, etc.), and the journal Simulation and Gaming was established (Kriz, 2017).

• ABSEL	Association for Business Simulation and Experiential Learning
• DiGRA	Digital Games Research Association
• INDSAGA	Indian Simulation and Gaming Association
• ISAGA	International Simulation and Gaming Association
• JASAG	Japanese Association of Simulation and Gaming
• NASAGA	North American Simulation and Gaming Association
• SAGANET	Simulation and Gaming Association—The Netherlands
• SAGSAGSwiss	Austrian-German Simulation and Gaming Association
• SIETAR-USA	Society for Intercultural Education, Training, and Research—USA
• SSAGSg	Society of Simulation and Gaming of Singapore
• SSSG	Social Simulation and Serious Games
• ThaiSim	Thai Simulation and Learning Association—Thai SALA

The establishment of gaming and simulation associations shows two more important points. First, it is important to notice that they are not only communities of experts who design and use games and simulations for interactive learning. It was always another main goal—also of the journal—to support and pioneer game and simulation-based research in order to build and test theories in various scientific domains. Second, we should be aware of even older roots of gaming and simulation in the tradition of war games (even if we may oppose the purpose of these games). The North American Simulation and Gaming Association for example dates back to 1962. Originally, this association was founded as “East Coast War Games Council” and only later changed the name to express that the association had shifted toward other forms of gaming (including, e.g., business and economic gaming).

1.4 Summary

This chapter puts forward the diversity in applications of simulation and identifies three main learning outcomes from the use of simulation in education: cognitive, interactive, and affective. We find that simulation is less widespread in teacher education than in other areas such as engineering, nursing, or medicine, to mention some. We have also identified some of the institutions using simulation and the leading simulation associations worldwide. We hope that by initiating your journey through this book, you find motivation, ideas, and resources to help you apply simulation in your own professional area.

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