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Chapter 07. Message Design for Healthcare Simulation

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7. Message Design for Healthcare Simulation

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Key Points:

- Educational simulations use experiential learning to place learners in an environment that mimics reality while minimizing risks to students and patients.
- Well-designed simulations promote learning by structuring each learning experience to include specific learning points, coaching, and feedback.
- Learners gain cognitive, psychomotor, and affective skills through participation in simulation.

Abstract

Simulation is a teaching method that motivates and engages learners (Ifenthaler et al. 2020; Martin & Betrus, 2019), can provide better student performance outcomes compared to traditional classroom education (Chernikova et al. 2020; D’Angleo et al., 2014; Di Natale et al., 2020; Gralnick & Levy, 2011; Pellas et al., 2019), and can even replace some real-world learning experiences (Alexander et al., 2015). Instructional designers who develop healthcare simulations should use relevant learning theory and instructional message design to ensure that the simulation is learner-centered and based in evidence-based practice to maximize the potential for the learning experience.

Introduction

Simulations are used as an educational tool in many different industries. Pilots learn to fly on flight simulators. Students learn chemistry phenomena in digital laboratories. Health care providers learn patient care skills on mannequins and models. If you think about it for a few minutes, you can probably name a few times where you learned something new through a simulation. For instance, have you ever asked "Annie are you OK?" in a cardiopulmonary resuscitation (CPR) class while preparing to start chest compressions?

Simulation has many benefits as an education strategy. This interactive method is linked with increased learner motivation (Ifenthaler et al. 2020; Martin & Betrus, 2019) and improved performance over other classroom strategies (Chernikova et al. 2020; D'Angelo et al., 2014; Di Natale et al., 2020; Gralnick & Levy, 2011; Pellas et al., 2019). Simulation offers an opportunity for students to participate in experiences that might be rare to students in the real world, such as a cardiopulmonary arrest, a stock market crash, or a NATO summit. It also provides an opportunity for students to learn without exposing them to the risks of a real-world situation. The student pilot can crash the simulated plane without getting injured or the expense of plane repair/replacement. Simulation also allows an opportunity for students to deliberately reflect on situations to enhance learning that might be missed in a real-world experience (Chernivokva et al., 2020). The reduction of risks is evident in the Marine Corps' aviation policy that requires achievement of acceptable performance in simulation prior to attempting the skill in a live flight (United States Marine Corps, 2011).

Simulation also allows educators a chance to demonstrate abstract concepts and to speed up time consuming tasks into a single class period. Not only is simulation a more effective strategy for improving student performance compared to traditional classroom based methods, but it can also be an effective replacement for real-world experiences. A landmark study by the National Council of State Boards of Nursing (Alexander et al., 2015) found that up to 50% of clinical experiences could be substituted with simulation. These findings were without any statistically significant differences in pass rates on the National Certification Licensing Exam (NCLEX) or job performance after graduation as compared to students who completed all clinical experiences in a health care setting.

Not all simulations are created equal. A simulation that fails to give feedback to the learner misses an opportunity to maximize germane cognitive load and promote learning. A simulation that includes confusing messages or includes information that is not related to the intended outcome increases extraneous cognitive load and takes away from learning. A simulation that intends to promote behavior change but only allows students an opportunity to practice a physical skill could fail to meet the learning objectives. Simulation experiences without proper planning or a basis in learning theory result in learner confusion and decreased performance (Lateef, 2010).

To maximize the effectiveness of simulation-based learning, the instructional designer should use message design theory to apply instructional and learning theories to design the simulation. The goal of the simulation is to accomplish the learning objectives, meet the learner needs, utilize available technology effectively, and facilitate feedback to both student and educator (Kern, et at., 2016). To assist with the design process of healthcare simulations, this chapter will introduce simulation-based education, review the history of simulation-based education, evaluate research outcomes of simulation-based education, and discuss relevant learning theories. This chapter will also give a general overview of the development of simulations, especially those that are learner-centered in meeting the intended objectives and based on research findings.

What is Simulation-Based Education?

Simulations are a form of experiential learning where learning is accomplished by doing. Simulation consists of an "artificial representation of a real-world process to achieve education goals via experiential learning" (Abdulmohsen, 2010, p. 35). The objects in the learning experience might be real representations of objects, real objects, or virtual objects. In some experiences, real equipment may be altered for learner safety, such as disabling a defibrillator to allow learner interaction while protecting the learner from an accidental shock. Regardless of digital or real-world format, the learner actions and decisions during the simulation alter outcomes in the experience providing feedback to the learner through experiential learning (Heitzmann et al., 2019; Martin & Betrus, 2019).

Simulations exist on a continuum between visualizations and complex games (D'Angelo et al, 2014). Simulations may have elements of visualization with game-like elements. Visualizations are a representation of a phenomenon or a task, such as an ecosystem or a step to perform a task, without learner interaction. Games, on the other hand, are interactive and the outcomes are related to achieving a reward such as points or progressing to a new level. D'Angelo et al. defined a simulation as separate from a visualization because simulation requires learner engagement. They also defined simulation as different from a game because it focuses on behaviors or processes to achieve a learning outcome instead of gaining a point or currency reward.

For example, let's look at the popular game "Angry Birds". In this game, players hurl digital birds with a sling shot to knock down structures and get rid of a few little, green pigs. The process involves physics and principles of projectile motion to aim and shoot the birds. However, users of the game do not leave the experience with an ability to discuss vectors, momentum, or acceleration. While the players may be primed to learn about rules related to these concepts in the future, knowledge of physics principles is not required to score points and move to new levels in the game.

Types of Simulation

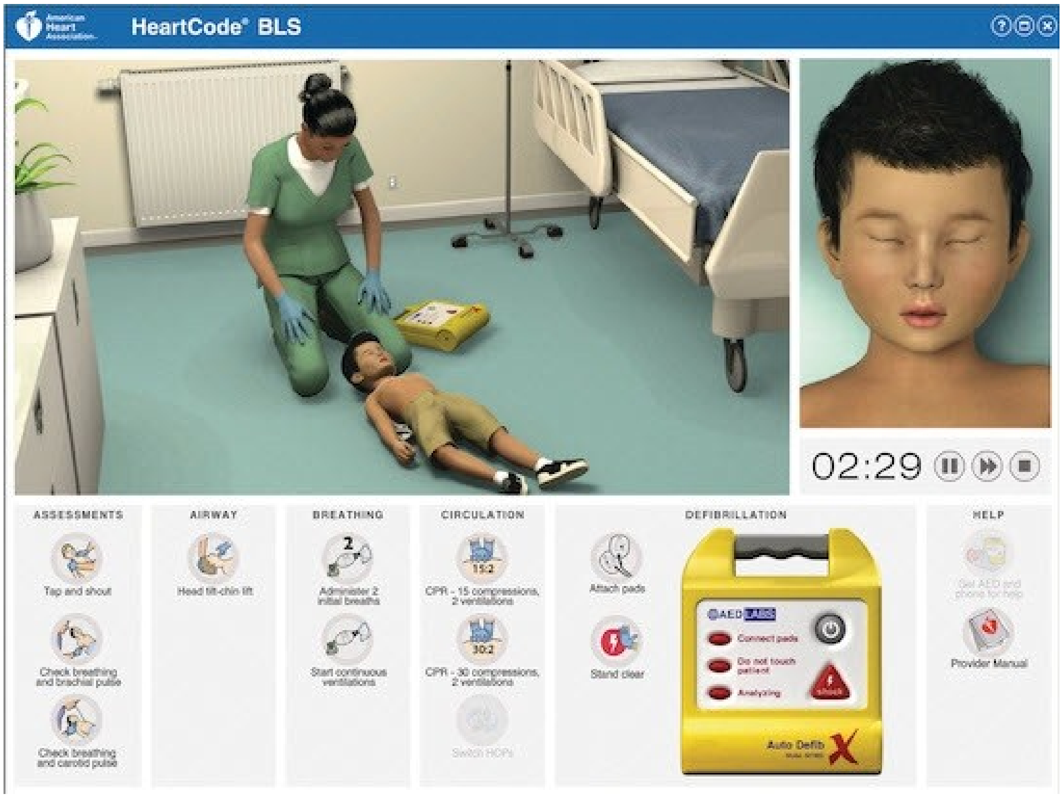
Simulation allows learners to learn by doing. The process of "doing" can be accomplished through many different types of simulation activities. The simulation scenario can be live or computer generated. Furthermore, the range of simulation activities progress from simple role play activities to high-tech devices that mimic real environments or equipment.

In a role play or group simulation, learners are required to take on the role and participate in a situation based on how they imagine their assigned role might behave in the described situation (Elmore, n.d.). Learners are often given some background information or an assignment to look up information on the scenario and/or the roles to help guide them through the scenario. In a kindergarten through 12th grade setting, this might include having learners participate in a mock trial or a model United Nations summit. Health care simulations often use a type of role play with a simulated patient. The patient in the role play is not a learner, but an individual who is trained to portray a set of symptoms or health care problems when interacting with the learner (Chiniara at al. 2013; Wilson & Price, 2015). Live role-play simulations can take place in any setting (Chinara et al. 2013). These simulated clinical immersions could be in a classroom or in a setting that replicates a real-world environment. "In situ simulations" take place in an actual clinical environment and the participants are on-duty providers who are at work.

Simulations can also be digital. These types of simulations take place on a computer screen, as a projection into the real environment, or with the use of a virtual reality headset that immerses students into a virtual environment. Digital simulations can be used to teach the learner how to perform psychomotor tasks and immerse students in real-world situations or virtual worlds for psychomotor, cognitive, and affective learning such as anti-bias training, patient care, economics research, and chemistry experiments (Chernikova et al., 2020; D'Angelo et al., 2014; Guralnick & Levy, 2010). Advancements in technology have made this type of simulation readily available to many consumers. Computer based simulations take place on a computer screen. The American Red Cross includes computer based simulations in the online portion of their Basic Life Support (BLS) course (Figure 1).

Figure 1

American Red Cross BLS Simulation



Note. modified from
https://www.youtube.com/watch?v=7S7fjRYSsN8

In this simulation, students receive a report on the patient in the scenario and then click on tasks to perform CPR during the scenario. At the end of the simulation, students receive feedback on the correct steps taken and areas to improve. If necessary, students must repeat the simulation to earn a passing score before moving to the next portion of the course. Augmented reality (AR) can be used to project images or sounds into the real world. Human Anatomy Atlas is an example of AR used in healthcare education. This app has an AR mode that allows students to project virtual organs or human models onto a flat surface to view or virtually dissect. Virtual reality (VR) uses a headset to immerse the user into a virtual world. Students can use VR to interact with virtual patients, orient themselves to the sights and sounds of a healthcare environment, and/or perform virtual procedures on virtual patients (see Figure 2).

Figure 2
Virtual reality headset

Note. While typical headsets tend to be a bit bulky and heavy, continuous improvements will enhance the wearability of these systems (open source photo from Unsplash Photos for Everyone, photo credit to Bermix Studio).

Hardware and software can be combined to create physical simulators that mimic objects or pieces of equipment (see Figure 3). This type of simulation ranges in levels of fidelity with higher levels of fidelity often associated with increased costs. Simulations that fall on the low end of fidelity often involve task trainers or simple models that students can perform tasks to learn psychomotor skills. In low fidelity simulations, the healthcare student could practice changing a dressing or putting in a catheter. The model does not talk or have vital signs that change in response to student action. Simulations at the high end of fidelity include simulators that give real time feedback to the learner by responding to the learner's actions such as a patient whose oxygen heart rate speeds up after administration of albuterol or whose oxygen saturations increase after the head of the bed is raised. High fidelity simulators, called manikins, can be used in simulations designed to assist with psychomotor, cognitive, and affective domains of learning (Errichetti, 2015). Physical simulators can also be combined with simulated patients for hybrid simulation.

Figure 3
Low resolution and High resolution healthcare simulations

Note. Low fidelity task trainer for wound care and high fidelity manikin in simulation lab (photo credit Maria Satre).

History of Simulation-Based Education

Simulation has a long history in education and training. Military war games that can be traced back more than 1,500 years and were used to simulate bloodless battles and train soldiers in strategic thinking (Errichetti, 2015). In the mid to late 1800s, healthcare students used models of human anatomy for education, and in 1911 the first human mannequin, Mrs. Chase, was developed to allow skill practice on a human-sized model (Singleton, 2020, see Figure 4).

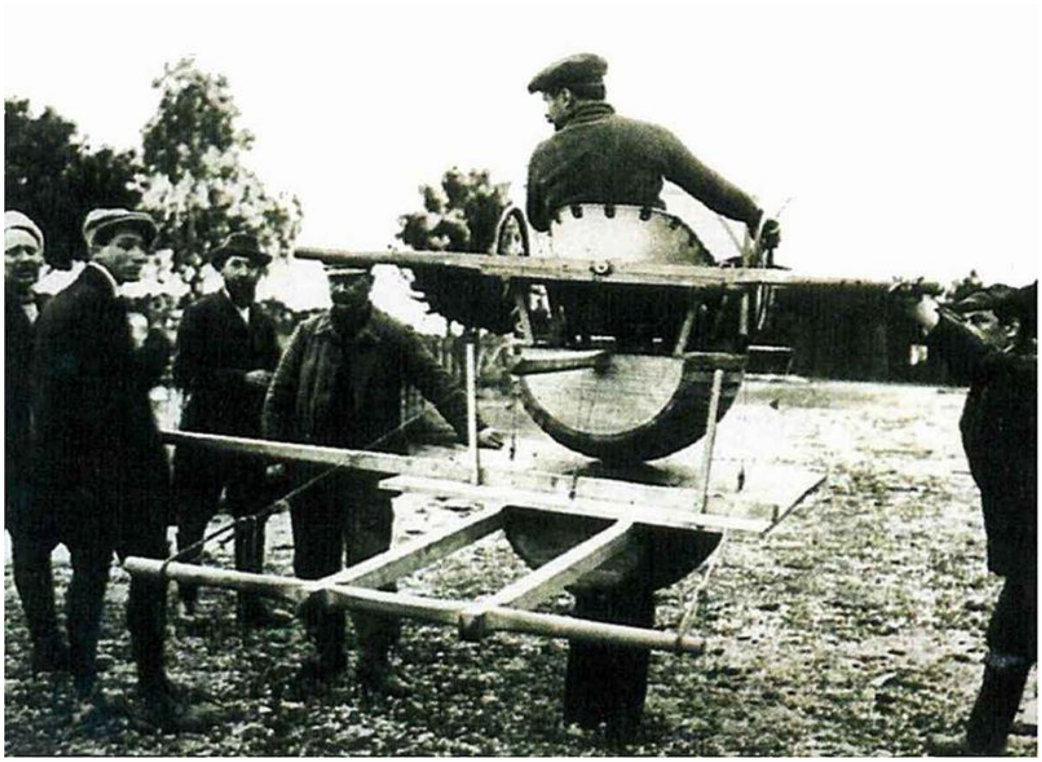
Figure 4
Mrs. Chase human mannequin

Note. The Mrs. Chase human mannequin was a life size doll that allowed for training and practice (Photo credit Hamilton Archives at Hartford Hospital).

Around the same time that Mrs. Chase was developed, several companies started to produce flight simulators to train pilots in flight control and reduce costly crashes (Errichetti, see Figure 5). All of these simulators share common goals to save valuable resources and enhance learner safety.

Figure 5

Early flight simulator for Antoinette aircraft circa 1909



Note. Early in flight training, instructors found it helpful to simulate the experience before taking students on an actual flight (Photo credit https://commons.wikimedia.org/wiki/File:Antoinette_sim_2.jpg).

Development of simulation-based education designed on learning theory became popular in the 1980s with the development of the Institute for Learning Sciences (ILS) at Northwestern University (Guranlick and Levy, 2011). This center brought experts from education, psychology, and computer science together to design educational scenarios. At the time, schools were not equipped with enough computer technology to adopt the programs. The first learning by doing training programs put out by the ILS used coaching and feedback in corporations to train cashiers at a food chain, operators in directory assistance, and guest services at a retail company. Simulation as an education strategy in corporations and in education did not gain significant momentum until the early 2000s. Further advances in online access and e-learning have helped to foster the development and accessibility of computer simulations. Simulation now has a role in diverse disciplines such as corporate training, computer science, physics, engineering, nursing, medicine, political science, languages, and social sciences (Chulkov & Wang, 2020).

While classroom and computer-based simulation developed to give users a hands-on approach to learning, healthcare simulation continued to develop with an urgency to improve patient safety. In the 1950s, Peter Safar and Asmund Laerdal developed one of the most common healthcare simulation mannequins, Rescue Annie, to train individuals to perform mouth-to-mouth resuscitation (Singleton, 2020, see Figure 6).

Figure 6
Vintage Laerdal Rescue Annie

Note. The first simulation system to train and practice cardiopulmonary resuscitation life saving procedures (and was the inspiration for Michael Jackson) (modified from https://www.wcbe.org/arts-life/2021-09-21/the-most-kissed-girl-in-the-world).

In 1966, the first computer controlled patient simulator, Sim One, was developed at the University of Southern California to assist with training anesthesiologists. The patient simulator was placed in a simulated hospital environment with real tools and staff members participated in interdisciplinary communication during simulations (Wang, 2011). Health care simulation gained momentum after the Institute of Medicine published a landmark paper in 2000 documenting the prevalence of medical errors and proposing the use of simulation whenever possible to assist with communication, team work, and critical thinking (Kohn et al., 2020). They provided the incentive for companies to develop commercially available high fidelity patient simulators and for schools and hospitals to implement simulation training programs. Today, high fidelity manikins are widely available in a variety of ages and genders to allow training in a variety of health care settings.

Learning Theories and Learning Domains for Simulation-Based Education

The tenet of simulation as an education tool is that it creates an interactive learning experience. Knowledge of how learners create knowledge in experiential learning can be used to develop simulations that maximize the student learning experience. Previous chapters of this book review several important learning theories, instructional technologies, and communication methods that are essential knowledge for instructional message design. This chapter adds onto that knowledge with a focus on experiential learning theories and learning domains to assist with the development of simulation-based education experiences to assist the participant to assimilate the knowledge presented in the simulation.

Behaviorism

Behaviorism is often described as a stimulus-response theory and is attributed to behaviorists such as Watson, Skinner, Pavlov, and Bandure (Clark, 2018). In this theory, the learner is exposed to a cue or stimulus. The learner's response to the stimulus can be rewarded or punished to reinforce or change the learner response. The goal is for the response to become automatic. Behavioral theories have received criticism due to their inability to describe the learner's motivation for learning and their emphasis on learning in the hands of the instructor instead of the learner. However, the concepts of reinforcements and punishments can be built into a simulation to reinforce intended learning concepts (Whittmann-Price & Price, 2015). Positive reinforcements reward the learner for their behavior such as successful resolution of a problem in the simulation. Negative reinforcement removes an unpleasant stimulus when the learner makes the correct action. In a simulation, this might be a patient monitor alarm that goes silent when the student correctly applies oxygen to the patient. Positive punishment applies an unpleasant stimulus to stop the behavior such as a buzzer that alarms when a student takes a particular action. Negative punishments remove rewards to stop the behavior. This could be incorporated in a simulation such as a lower score for a particular behavior.

Bandura's Social Learning Theory (1997) utilizes reinforcement and social modeling of observed behavior to modify learner behavior. One concept of this theory that is utilized in simulation is self-efficacy, or the participant's perspective that they have the skills required to accomplish the task. Those with low self-efficacy are less likely to replicate the behavior. To promote self-efficacy, the instructional designer should provide opportunities for the learner to be successful as a history of success enhances self-efficacy. Thus, the simulation should have clear instructions and be designed to the level of the learner. Additionally, providing a chance to observe a peer model the behavior can also increase self-efficacy. This can be accomplished through engaging with other media such as a demonstration, web-based learning, or video prior to performing the skills in simulation.

Constructivism

Constructivism is a common theoretical paradigm in education that encompasses many different theories that view learning as an active, learner-centered process where learners build new knowledge by connecting it to what is already known (Whittmann-Price & Price, 2015). Kolb's Experiential Learning Theory (1984) is one such constructivism theory that is often used in simulation

(Whittmann-Price & Price). In this theory, knowledge is created through experience, it requires a resolution of conflicts, and it involves transactions between the learner and the environment. The four main concepts in Kolb's theory are concrete experiences, abstract conceptualization, reflective observations, and active experimentation. The concepts can be included in the simulation design. Concrete experiences can be provided through design of simulations that are built on real-world experiences. Abstract conceptualizations and reflective observations are fostered when the designer builds in opportunities for the participant to think about the actions taken in the experience and reflect on the meaning of the experience to process the knowledge gained. Active experimentation can be included by creating a safe environment for the participant to actively participate and control aspects of the simulation.

Problem Based Learning

Problem based learning is a type of experiential learning that has roots in medical education in the 1960s. This type of education moved into other areas of education such as business, social work, economics, accounting, and architecture (Schmidt et al., 2007). In this learning method, students are given a problem made up of observable phenomena and are then required to activate prior knowledge and develop solutions to the problem presented. The case must be structured in a way that is tailored to the level of student knowledge and provide appropriate scaffolding to assist with problem solving and student independence. The situation should be structured from simple to complex to allow development of schema to reduce cognitive load when students encounter more complex scenarios. The teacher acts as a facilitator to assist when the tasks become too complex and fade to the background when students do not need assistance.
Simulation-based education is built around scenarios and follows the design of problem based learning. The instructional designer should consider concepts of scaffolding and the ability for learners to access a guide or tutor when situations are too complex for their current knowledge level to deepen learning and allow the learner to navigate from novice to expert (Benner, 1982).

Clinical Simulation Conceptual Framework

Extensive research exists on simulation in healthcare domains. Kneebone (2005) developed a conceptual framework out of concern for a simulation trend that was task-based and disconnected from the complexities of real-world clinical practice. The four key areas in Kneebone's framework are: gaining technical proficiency, making sure an expert is available for assistance with task-based learning, learning within the context of the profession, and including affective components of learning (see Table 1). Kneebone's framework is intended to be a lens to evaluate the usefulness of a simulation as a learning activity. The connection of the key areas in the framework to learning theory and educational design can be used by instructional designers in health care and other fields to enhance simulation through inclusion of components such as scaffolding, feedback, realism/accuracy, and positive learning environments to enhance simulation in other fields.

Table 1
Kneebone Clinical Simulation Conceptual Framework

Key Area	Elements to enhance education
Gaining technical proficiency	● Break skills down into smaller units ● Include opportunities to overlearn what is required for initial proficiency ● Include reinforcements to assist with learner desire to improve
Making sure an expert is available for assistance with task-based learning	● Tutor should provide specific feedback to help improve skills ● Tutoring should only be provided when needed ● Tutoring should move from assistance to supervision

Learning within the context of the profession	● Simulations should reflect contextual realities of professional practice ● Learning should be from active participation instead of observation
Including affective components of learning	● Learning experiences should be structures as positive experiences ● Learning environments should be supportive for learners

Learning domains

Learning is often discussed in three recognized domains: cognitive, psychomotor, and affective (Whittman-Price & Price, 2015). Cognitive learning relates to acquisition of knowledge or problem solving skills. Psychomotor learning relates to the ability to perform procedures for skills. Affective learning relates judgment, values, and attitude. Instructional designers can develop simulation-based education that can be structured in a way to enhance each of the three learning domains if they align with the objectives of the simulation (Kardon-Edgen et al., 2010). To incorporate the cognitive domain, the learner can be given an opportunity in the simulation to show an understanding of the subject matter and apply a concept to make decisions during the simulation. Application of psychomotor domain can be included in the simulation by giving the participant an opportunity to perform the skill in a live situation on a task trainer or procedure trainer or in a virtual environment. Affective domain skills are included when the participant has an opportunity to interact with other team members, shows willingness to listen to others, demonstrate professionalism, or treats a group members/simulated individuals with respect (Whittmann-Price & Price, 2015).

Instructional Design and Simulation

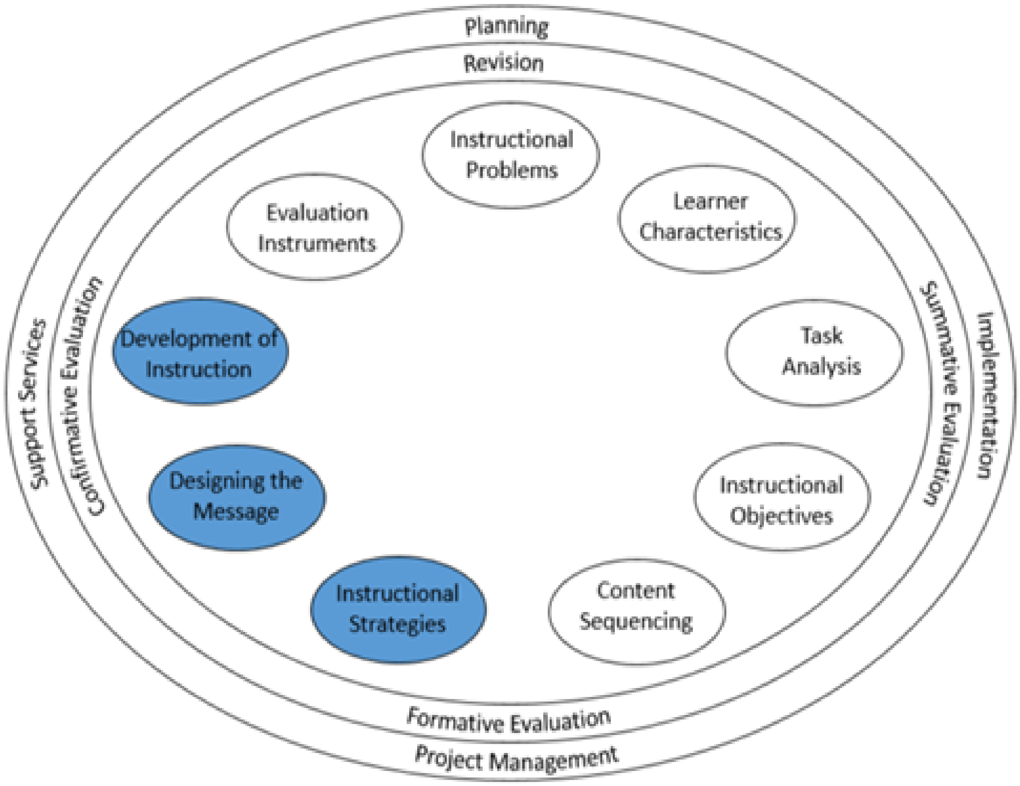
Instructional design is a process that involves identifying a problem that needs to be solved, determining if education can solve the problem, and then designing instruction based on the skills needed to solve the problem (Morrison et al., 2019). Readers of this chapter should have a background in instructional design and understanding of models of design such as the Analyze, Design, Develop, Implement, and Evaluate (ADDIE) model and Gagne's nine events of instruction. The International Nursing Association for Clinical Simulation and Learning (INACSL) Standards Committee has also developed and consolidated best practice guidelines for the development of healthcare simulation:

INASCL Simulation Standards: Simulation Design (2016)

1. Needs assessment
2. Measurable Objectives
3. Structure experience on purpose, theory, and modality for simulation
4. Design scenario to provide context for simulation
5. Use various types of fidelity to create desired realism
6. Develop facilitation that is student centered, objective driven, learner knowledge/experience, and expected outcomes
7. Begin with a prebriefing
8. Include evaluation of participants, facilitator, sim experience, facility, and support team
9. Provide preparation materials and resources to promote learner ability to meet objectives
10. Pilot test simulation before full implementation

However, for this chapter the process of simulation development will follow the Components of Instructional Design Plan from Morrison et al. (Figure 7). In addressing issues of message design in simulation, the focus will be on instructional strategies, message design, and development of instruction. For more information on identifying the instructional problem, determining learner characteristics, analyzing the tasks included in instruction, creating objectives, sequencing content, and developing evaluation instruments, see Morrison et al.'s *Designing Effective Instruction*.

Figure 7
Components of the Instructional Design Plan



Note. The Morrison, Ross, and Kemp instructional design model is a comprehensive approach to the design of instructional systems (Modified from Morrison et al. 2019).

Instructional Strategies

This is the creative step in instructional design. An instructional designer must be innovative in determining ways to present the information or tasks to the learners so that they can connect new knowledge to known knowledge (Morrison et al., 2019). This will assist with scaffolding and help decrease the extraneous cognitive load of the message to improve the amount of available germane load/resources to aid in learning.

Simulation is a tool that instructional designers can use. Alas, it is only a tool, and the message is more important than the tool used to send it. There are many types of simulations available, and the instructional designer must evaluate if simulation is an effective strategy for the learners and learning objective as well as which type of simulation to use.

Determining the Type of Simulation

There are many types of simulations available. For instance, simulations without technology, such as role play, have similar outcomes on student performance as screen based simulations (Chernikova et al., 2020). The largest effect on student performance is found with higher levels of realism, or fidelity, such as live patient simulations or virtual reality (Chernikova et al., 2020. Di Natale et al., 2020). However, high levels of realism, or fidelity, are often associated with increased resource utilization and cost. Simulated human patients in a health care simulation must be trained and scheduled. Physical simulator systems are expensive and require faculty training to run the device. In selecting the type of simulation, the instructional designer should consider available resources, learner characteristics, and learning objectives to determine which type of simulation strategy to use.

Learner Characteristics. The use of simulation as an instructional message should be linked with learner needs and preferences. While several studies show the effectiveness with primary and secondary education, this method of learning is also well linked with the principles of adult learning or andragogy (D' Angelo et al., 2014, Di Natate et al., 2020, Schmidt et al., 2007). Adult learners are drawn to problem based learning, with the hands-on application of theory, that is applicable to real life situations (Swanson, 2011).

Learning Domains and Outcome Competency Goals. Chiniara et al. (2013) evaluated outcomes of health care simulation studies and developed an instructional design map that linked simulation modalities with competency domains (see Table 2).

Table 2
Media and Simulation Modality Selection for Healthcare Simulation Based on Desired Learning Competency Domain

Competency domain	Qualifier	Modality
Rote knowledge	Clinical knowledge	**computer-based simulation*** or Simulated Patient
	Non clinical knowledge	**Non simulation media*** such as models, lecture, reading, videos
Techniques and procedures	Requires psychomotor skill practice	**Virtual Reality*** with self-instruction **Procedural simulator*** with task trainer or high fidelity mannequin with instructor led education
	Does not require motor skill practice	Computer-based simulation, **Non simulation media*** such as videos, e-learning, interactive media
Clinical Reasoning	Self-instruction	Computer-based simulation with **virtual patient***

	Instructor-led	**Simulated Patient***, Simulated clinical immersion in simulation lab, Computer-based simulation
Patient counseling or history	Self-instruction	Computer-based simulation with **virtual patient***, Simulated Patient with feedback from actor, non-simulation media such as readings, videos, and e-learning
	Instructor-led	**Simulated Patient***, Simulated clinical immersion in simulation lab Computer-based simulation
Patient safety	Self-Instruction	Computer-based simulation **virtual world***, non-simulation media

	Instructor-led	**Simulated clinical immersion in simulation lab***
Beliefs, attitudes, and ethics		**Simulated clinical immersion in simulation lab*,** **Simulated Patient***, Computer-based simulation, other media
Situation is dynamic and dependent upon environment		**Simulated clinical immersion in simulation lab*,** **Simulated Patient***, Computer-based simulation, other media

Note. Items in bold with an asterisk designate preferred modality. SP: Simulated Patient; VR: Virtual Reality; SCI: Simulated clinical immersion in simulation lab; CBS: computer-based simulation (Modified from chart in Chiniara et al, 2013).

These researchers divided simulation modalities into the following categories: simulated patient, virtual reality, computer-based simulation, and simulated clinical immersions. A simulated patient (SP) is where an actor was used to role-play a live patient to act out symptoms in interactions with students. Virtual reality (VR) is where students are immersed into a virtual world that recreates health care settings. Computer-based simulation (CBS) is where students use a computer to interact in two dimensional health care scenarios.

Simulated clinical immersions (SCI) are when students interact with mannequins in a laboratory set up with equipment to recreate health care settings. These simulations were not the preferred method of learning when cognitive goals that were not related to clinical or when they needed to learn a new technique that did not require psychomotor skills. Psychomotor skills were best learned in simulations where students could physically perform the skills in the real world or in a three dimensional virtual world. Affective goals were best achieved when students had to interact with an SP or when students needed to complete learning on their own. Chiniara et al. recommended self-contained learning modules such as virtual patients in a computer-based simulation. Affective domain goals and cognitive domain goals require problem solving. Goals that require complex/dynamic situations, are simulations that could be more free flowing and adjusted based on student actions. In these scenarios a simulated patient SP or a simulated clinical immersion SCI were preferred. Overall, Chiniara et al. recommended utilizing the scarce resources of simulation for situations when students are not likely to have an opportunity to experience the scenario in clinical training.

Simulations are also recommended when the clinical problem has a great potential to negatively impact patients or when the real-world skill practice could endanger patients or students. Common scenarios that students are likely to see in school based clinical experiences could be taught using less expensive media. While Chiniara's study was on health care simulation, the link between types of simulation and competency domains provides insight into the potential for simulation with other subjects.

In K-12 learning environments, Di Natale et al. (2006) found that VR offers opportunities for students to learn spatial knowledge, explore scenarios that could be impossible in the real world, improved engagement in the learning process, and improved real-world performance. In a recent literature review of mixed learning environments combining virtual and real-world elements in K-12 education, Pellas et al. (2020) found similar outcomes and reported implementation over a variety of subjects such as art, social science, and physical science. Like Di Natale, they also found that the higher level of fidelity possible in augmented reality increased learning over two dimensional computer simulations and more traditional teaching methods. However, they also found that a high level of visual detail in

VR in biology educational programs lead to decreased learning due to the large amount of extraneous load. This suggests that in selecting this method for instruction, the designer should consider schema development and appropriateness of this simulation method with novice learners.

Designing the Message

Designing the message is a process of combining images and words to clarify the message and to draw the learner's attention to appropriate parts of the simulation to enhance learning (Morrison et al., 2019). This step of the instructional design process can be complex in simulations. There are several aspects of the simulation that should be determined prior to starting the design process.

Multimedia Learning and Cognitive Load

Multimedia learning theory was discussed in previous chapters. This theory states that combining pictures and graphics in the same learning session increases learning. This theory holds true with simulations. Combining simulation with another form of instruction increases learning (D'Angelo at al., 2014). This can be accomplished by adding multimedia such as dynamic representations and scaffolding into the simulation. However, any unnecessary graphics or anecdotes should not be included as they will add to the extraneous load and distract the learner from the intended message (Lunetta & Hofstein, 1981). Additionally, in simulations with a high level of visual content, such as VR, students remember more of the visual content than the auditory content (Pellas et al., 2020)

Multiple types of scaffolding should be built into the simulation design (Chernikova et al., 2020). Scaffolding can include learner prompts with visual or task based guidance, reflection, and expert examples. Chernikocva et al.'s meta-analysis of simulation in higher education found that scaffolding with a single type of scaffold was less effective than a combination of methods. Furthermore, learners with little theoretical knowledge require more instructional guidance during simulations (Schmidt et al, 2007). Scaffolding with prompts and examples is more effective with novice learners (Chernikova et al., 2020). Schmidt et al. (2007) also recommend structuring the simulations from simple tasks to complex tasks when possible to allow for schema development.

Fidelity

The simulation should represent the real situation and be interactive. Outcomes in the simulation should change based on the actions that the student takes or does not take in the experience. The amount of realism in the simulation increases the complexity of the design of the simulation but it also increases real-world performance after students complete the simulation (Diekman at al, 2007; Di Natale et al., 2020; Martin & Betrus, 2019). In simulation, realism is referred to as fidelity. Fidelity may be high or low with high fidelity scenarios having greater detail and complexity than low fidelity scenarios. The scenario can have physical, psychological, equipment, environmental, and temporal fidelity (Diekman et al., 2007; Chiniara et al., 2013). Physical fidelity refers to entities that can be measured. In healthcare simulation, this includes how the patient reacts to actions taken in the simulation (Chiniara et al., 2013). For instance, if the simulated patient stops breathing, then the simulated patient's oxygen level should decrease until the students initiate rescue breathing with a bag and mask.

Psychological fidelity refers to the mental preparation of the learners. Do they have the knowledge required to participate in the simulation? Have they been orientated in what to expect in the simulation? This can be built in with an orientation to the simulation. The designer can have students complete a mock simulation to experience how a computer simulation or physical simulation works. Designers can also incorporate training modules or a preparation assignment to have students review relevant information before completing the simulation.

Equipment fidelity refers to the functionality of the equipment. The equipment should be as close to the equipment in the real-world as possible (Martin & Betrus, 2019). If the equipment must be altered for learner safety, such as disabling a defibrillator, the learner should be oriented to the difference in functionality before the simulation starts (Diekman et al., 2007).

Environmental fidelity refers to how real the surroundings look compared to the real-world setting. Simulation labs can be built to recreate real world settings or the surroundings can be developed in screen based scenarios. Chiniara et al. include interdisciplinary personnel in this category as well.

Lastly, temporal fidelity refers to the flow of time during the simulation. It may flow unimpeded and discuss student performance at the end or take pauses to update the student throughout the simulation (Chiniara et al., 2013). The type of fidelity should be matched to the scenario.

The fidelity should be matched with the characteristics needed for the educational experience (Chinara et al., 2013). For instance, if a learner needs to learn how to use a cash register without making errors, then equipment fidelity should be a priority. If the learner needs to learn how to improve communication skills, then physical fidelity should be a priority. The designer should also consider the complexity of the skills in the simulation and how dynamic the scenario should be to accomplish the task. Affective learning goals and dynamic scenarios require a higher fidelity experience such as simulated patients, virtual reality, and simulated clinical experiences. Chernikova et al. found that the authenticity in the simulation had a greater impact on student learning outcomes than the technology used. It was also found that fidelity had less impact on novice learners as compared to learners who had already developed schema around the knowledge and skills included in the simulation. Diekman et al. (2007) found that incorporating a reality contract (an understanding that the simulation is meant to be a serious scenario) into the simulation also helped students treat the simulation experience as if it were real. The reality of the message design is reviewed at the beginning of the simulation and also includes the boundaries of when the simulation starts as well as any equipment modifications from the real world.

Feedback

The simulation design should include a plan for feedback to the learner since this is an essential characteristic of simulations (Chiniara et al.). Feedback can be provided through task based guidance, visual guidance, text-based feedback, realistic consequences during the simunition, and/or in a summary at the end of the scenario. Immediate feedback is preferred for simple skills and deferred feedback is more effective with more complex skills/dynamic simulations (Guralnick & Levy, 2011). Feedback that is specific to the learner's actions is better at improving student performance than vague feedback (Chiniara et al., 2013; Guralnick & Levy, 2010). Feedback can be included through tutoring immersed and embedded in the simulation design and can be in the form of outcome feedback. Process feedback is more likely to improve performance with complex tasks and a combination of both types of feedback has an additive effect.

The timing of the feedback can also affect learning. Providing feedback during the simulation is effective for procedural tasks but may interrupt learning in dynamic scenarios. Feedback should be reviewed immediately after the conclusion of the scenario to assist the learner in integrating the knowledge gained. Delayed feedback with a time gap after the simulation is associated with less effective learning (Chiniara et al., 2013).

Once a plan is made on the type of simulation, media, fidelity, feedback, and scaffolding, the instructional designer can start to sketch out the plans for the simulation. This starts with a scenario overview and general plan. If using a screen based simulation, the designer should make wireframe sketches with a conceptualization of the screens in the simulation. The learner should be at the forefront of the design with an appropriate color scheme for the audience and the customer. If the simulation is for a corporate client, then company branding for color schemes, logos, or fonts may need to be incorporated (Martin & Betrus, 2019).

Development of the Instruction

The final step in message design of the simulation is the development of the instruction. This is the step of the process where all of the pieces are put together. Steps may include development of written material, recording videos, developing web pages, preparing participant scripts, and recording audio (Morrison et al., 2019). The plan in the past step and should be reviewed to ensure that all necessary tasks are included and any unnecessary tasks are eliminated. Graphics for computer based simulation should be placed in storyboards to get pilot test audience feedback on appearance prior to development and testing of functionality (Martin & Betrus, 2019).

In this step of the design, the instructional designer must write the script for the simulation (Alinier, 2011; Marin & Betrus, 2019). When designing the scripts for a live scenario, the instructional designer should include scripts for non-student participants that include responses to all anticipated student actions and scenario lifesavers. Lifesavers are backup plans to use if students do not understand the scenario, perform an unexpected action, or lack the learning competence required for the simulation (Diekmann et al., 2010; Waseem, 2021). Options include providing a hint to the learners, making the situation in the scenario more obvious by changing the cues to make them more obvious, or altering the scenario to add in aspects related to the participant actions (Diekmann et al., 2010).

In the design phase of the simulation, an instructional designer may create all new materials or expand upon existing simulation materials to help with the cost of simulation. There are simulations that are available for purchase and simulations that are free. Nearpod offers commercial, turn-key simulations that allow students to participate in science and math simulations that are designed for K-12 learners. Zapitalism is a free online program that can be used to teach students about finances. Nobelprize.org has several screen based simulations such as the blood typing game. When using a readily available resource, the instructional designer should assess if the simulation meets the learning goals. The designer may need to develop materials to prepare students for the simulation such as an orientation activity to the simulation and a learning activity to ensure that students have the knowledge and skills required to complete the simulation. The designer may need to develop a feedback activity as well to help learners reflect on what they learned during the simulation.

Chilkov and Wang (2020) provide a good example of utilizing a pre-designed product to create a simulation-based learning activity for students in a higher education finance class. For their course, they utilized a stock market simulation program called StockTrak. The faculty members created learning goals and developed a set of tasks for students to accomplish in trading over a 14 week period. During the simulation, students were able to make trades with allotments for day training, short selling, and trading on margins. They provided learner orientation to the program in class and through the course learning management system. Over the semester, students completed bi-weekly portfolio reports. They also incorporated regular class assignments for students to summarize current events that could influence financial markets. At the end, students reflected on the experience and presented their portfolio performance. Chulkov and Wang's design included scaffolding, regular reflection, regular student feedback, and a strong connection to the learning goals of the course. They found that students who participated in the course section with simulation performed statistically better on course exams. Students also indicated that they felt that participation in the experience positively added to their understanding of course concepts.

After designing the simulation or creating a learning activity from an available resource, the instructional designer should run a pilot of the activity to assess for any needed changes before starting training with the program. After running the simulation, the activity should be evaluated based on simulation design, effectiveness, feasibility, and any possible ethical issues.

Conclusion

Simulation-based education can be an effective instructional message design to promote learning, engagement, and real-world performance as students learn psychomotor, cognitive, and affective skills in a safe learning environment with little risk to themselves or patients. Once students gain proficiency in the simulation lab, they can transfer their new skills to the clinical setting as long as the simulation is well designed. Simulations offer a problem-based learning approach that utilizes stimulus and response to provide real-time feedback to students to help reinforce learning and promote self-efficacy. Instructional designers should select a type of simulation that aligns with the learning goals, student characteristics, the learning domain of the task, as well as available fiscal and physical resources. When designing the message of the simulation, instructional designers should include enough fidelity so that the scenario aligns close enough to live clinical experiences that it enhances transferability of skills, but still exclude unnecessary details to reduce the learner's extraneous load. The message design should align with principles of multimedia design theory and include scaffolding to assist with schmata development. Lastly, the instructional development should include scripts for all non-student participants, a list of needed supplies, a description on how to set up the simulation, a pre-brief script for students, a debriefing plan, and a set of lifesavers to for situations where the simulation may go off track.

Simulation technology continues to evolve and holds great promise for the future of healthcare education, and it is even moving into healthcare practice. For instance, surgeons who learned skills in a virtual lab may perform robotic surgery on live patients with the assistance of virtual or augmented reality. Patients undergoing systematic desensitization therapy may be able to do so in a safe environment with a virtual exposure to their phobia. Patients undergoing cognitive behavioral therapy can complete simulations that link their heartbeat to actions on a computer screen to assist the patient in learning how to use relaxation skills in stressful situations. As technology becomes more accessible, the potential for its instructional message design use in the healthcare field exponentially increases.

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