Beyond technology: A scoping review of features that promote fidelity and authenticity in simulation-based health professional education

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ABSTRACT

Background: Conceptualizations of fidelity in simulation often refer to physical, conceptual, and psychological dimensions. Besides simulator technologies, practical features that enhance the fidelity and authenticity of simulated activities from educators' and learners' perspectives remain nebulous.

Methods: Scoping review (Levac, Colquhoun, & O'Brien, 2010).

Results: From 42 papers, eight features were identified: content drawn from real life, interaction and feedback, performance expectations, preparation of the environment, presence of an actual patient, logical and adaptive scenarios, sociological fidelity, and cueing.

Conclusions: This paper provides guidance in the design of high-fidelity, authentic simulations, even in the absence of technologically advanced simulators.

Keywords: Simulation; realism, fidelity, authenticity; health education; scoping review

HIGHLIGHTS

- Eight features that foster simulation fidelity are identified
- These features also contribute to learners' experience of authenticity
- They can guide the design of realistic simulations when technology is scarce

KEY POINTS

- Fidelity is often equated to the engineering attributes of simulation equipment and used interchangeably with the concepts of 'authenticity' and 'realism'.
- Eight features that promote fidelity or authenticity in simulation-based education are identified, beside technological or engineering attributes of simulation equipment.
- Features include: drawing content from real life, providing opportunities for interaction and feedback, requiring learners to perform actions, preparing the environment to engage learners' senses, including an actual patient, presenting a logical and adaptive scenario, reproducing sociological aspects of the real world, and cueing.

INTRODUCTION

Simulation is an active educational method that consists of replacing real experiences with guided experiences that replicate aspects of the real world in an interactive manner (Gaba, 2004). For educators, simulation provides an opportunity to determine the situations that learners will experience. This opportunity comes with an imperative to portray those situations in a realistic manner, in order to provide an engaging and immersive learning experience. Accordingly, fidelity has become an important topic in the simulation literature.

‘Fidelity’ refers to the degree of realism of a simulation and includes physical, conceptual, and psychological dimensions (INACSL Standards Committee, 2016). However, fidelity is often equated with the technology employed for simulation, thereby overemphasizing engineering attributes of equipment over educational implications. This vision has been criticized by a number of authors (Beaubien & Baker, 2004; Bland, Topping, & Tobbell, 2014; Hamstra, Brydges, Hatala, Zendejas, & Cook, 2014; Norman, Dore, & Grierson, 2012; Tun, Alinier, Tang, & Kneebone, 2015; West, Beaumie, & Parchoma, 2017). In a literature review, Norman et al. (2012) found clear benefits of simulation over other forms of instruction, but little advantages of high engineering fidelity (e.g., computer-controlled manikins) over low engineering fidelity for learning of technical and non-technical skills. Sherwood and Francis (2018) came to similar conclusions in a meta-analysis that revealed small benefits of high versus low engineering fidelity for knowledge, psychomotor, affective, and non-technical outcomes. As Norman et al. (2012) suggested, this could reflect the nonlinear relationship between fidelity and learning, and the multidimensional nature of the concept. This suggests a need to conduct a literature review to clarify the various dimensions of fidelity and the features that contribute to its enactment in simulation-based learning.

CURRENT STATE OF KNOWLEDGE

In early years, fidelity was equated with the resemblance of a simulator to the actual task or equipment it portrayed (Allen, Buffardi, & Hays, 1991). Nowadays, it is generally acknowledged that fidelity refers to the degree to which various aspects of a simulation combine to mimic reality (Bland et al., 2014). Rehmann, Mitman, and Reynolds (1995) proposed a three-dimension typology of fidelity, which was further described by Beaubien and Baker (2004). The first dimension, ‘equipment fidelity’, refers to the appearance and feel of a simulator. The second, ‘environment fidelity’, is concerned with the cues and other sensory information that are available to the learner in the environment surrounding the simulator. The third, ‘psychological fidelity’, is the degree to which learners believe in a simulation (i.e., how they perceived the simulation to be a credible surrogate for an authentic task or problem). Similarly, Dieckmann, Gaba, and Rall (2007) proposed three modes of thinking about reality to describe simulation fidelity: ‘physical’ (characteristics of the environment, equipment, and material), ‘semantic’ (presentation of information and relationships between concepts), and ‘phenomenal’ (learners’ emotions, beliefs, and thoughts).

Recently, Tun et al. (2015) suggested defining the concept of fidelity according to learners’ perceived realism of a simulation instead of the technology used. They argued that fidelity requires an accurate representation of real-world cues along three axes: 1) interactions with the patient, bearing in mind anatomy and physiology; 2) progression and complexity of the scenario; and 3) healthcare facilities (i.e., clinical equipment and environment). In a discussion of simulation-based interprofessional education, Sharma, Boet, Kitto, and Reeves (2011) introduced the concept of ‘sociological fidelity’, arguing that the transfer of interprofessional skills to clinical practice depends on the proper reproduction of sociological issues affecting teamwork, such as power, hierarchy, and professional boundaries. For their part, Hamstra et al. (2014) suggested avoiding the term ‘fidelity’ and prioritizing functional task alignment (i.e., replication of the demands of a real clinical task) over physical resemblance. To maximize educational effectiveness of simulation, they recommended focusing on broader design principles and methods to engage learners and promote transfer of learning to clinical practice, which include not only resemblance to reality but also learner orientation and focused learning objectives.

Beside these various dimensions, the notion of ‘authenticity’ is often associated with the concept of fidelity. Nevertheless, the two terms are not conceptually equivalent: fidelity can be considered as the degree of reproduction of reality, whereas authenticity is a learner’s subjective interpretation of the veracity of a situation in which they interact with a context, other learners, and a simulator (Bland et al., 2014). For example, a high-fidelity simulation can be perceived as predictable (poor authenticity), whereas a low-fidelity simulation can be experienced as highly relevant to clinical practice (high authenticity). Proponents of situated and authentic learning argue that learning should be embedded in authentic activities and environments that reflect the way knowledge will be used in real life (Brown, Collins, & Duguid, 1989; Herrington & Oliver, 2000; Lave & Wenger, 1991). They encourage the provision of authentic contexts that reflect the complexity and affordances of real-world activities, because cognition is inextricably linked to the situation in which it occurs. Another group of scholars, adopting a socio-technical or interactionist perspective, do not consider realism, fidelity, and authenticity as inherent characteristics of a simulation; they rather argue that these are emerging from the interaction between learners and the material world (Ahn & Rimpilainen, 2018; Rystedt & Sjoblom, 2012).

We propose that these conceptualizations can be grouped into three perspectives: 1) fidelity as a property of the simulation as operationalized by educators, 2) fidelity as experienced by learners (i.e., authenticity), and 3) fidelity as emerging from the interaction between learners and a simulation. However, beside the technology employed, practical features of simulation-based experiences that enhance fidelity—and situate the learner in an authentic representation of reality—

remain nebulous (Bland et al., 2014). For an informed use of simulation, there is a need to clarify these features considering the complex social endeavor of simulation (Dieckmann et al., 2007). Based on the three perspectives proposed above, the purpose of the current review was to map features that promote fidelity and authenticity in simulation-based health professional education—besides the type of simulator or technology employed.

METHODS

A scoping review based on the methodological framework proposed by Levac et al. (2010) was conducted and is reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for scoping reviews (PRISMA-ScR) (Tricco et al., 2018). The aim of a scoping review is to summarize and interpret a broad range of evidence related to key concepts underpinning an area of research and can be used to clarify complex concepts. The protocol for this review was not prospectively registered or published.

Inclusion criteria

To determine eligibility criteria and define the search strategy, we used the PCC method (P: population, C: concept, C: context). In terms of population, this scoping review focused on students and licensed professionals from a variety of health-related disciplines, including but not limited to dentistry, medicine, midwifery, nursing, pharmacy, and rehabilitation. The concept of interest was simulation with a particular focus on facets of realism, fidelity, and authenticity. For the context, we focused on studies conducted in educational or clinical settings anywhere in the world.

Thus, to be included in this review, papers had to focus on realism, fidelity, and authenticity in simulation-based health professional education. Papers that did not include a substantive definition or discussion of realism, fidelity, or authenticity (i.e., more than one sentence) were excluded, as well as papers focusing on simulator technologies and engineering capabilities. For the type of sources, papers reporting research or evaluation studies published in English in peer-reviewed journals were considered. Grey literature was not considered because of the large number of empirical studies included in the review and the existence of numerous papers discussing the definition of realism, fidelity, and authenticity based on grey literature.

Study search and selection

The search strategy was developed by a medical librarian, using descriptors and keywords for the following concepts: realism, fidelity, authenticity, learning, and education in health sciences (Appendix 1). The databases used were CINAHL (EBSCO), ERIC (ProQuest), MEDLINE (Ovid), and Web of Science (Clarivate Analytics). Searches were conducted in July 2019, without time restriction. Of note, the search strategy was initially constructed to address health professional education and learning in general, without reference to a specific educational method. Since almost all retrieved papers discussed a form of simulation—including case studies, partial task-trainer, standardized patients, manikin-based simulation, and virtual simulation—we decided to narrow the scope of this review to simulation-based health professional education. The search strategy was not updated because it was already broad enough to retrieve references addressing simulation-based learning.

A first screening based on titles and abstracts was conducted by three independent reviewers (MFD, PL, RN). Then, in-depth reading of the papers was conducted independently by two reviewers (MFD, PL). Disagreements over the selection of papers were resolved through discussion and consensus. Reference were managed with EndNote X8 (ClarivateAnalytics).

Data extraction

The following information was extracted from the papers: country, methods and objectives, conceptual underpinnings, and results. Excerpts addressing the concepts of realism, fidelity, and authenticity were extracted by two reviewers (PL, MFD) using MAXQDA2018 (qualitative data analysis software, VERBI Gmbh), and then categorized according to the three perspectives proposed above: 1) operationalization by educators, 2) experience of learners, and 3) interactionist perspective. Excerpts were coded inductively (Miles, Huberman, & Saldaña, 2014) to identify simulation features that contributed to fidelity and authenticity according to educators, learners, and from an interactionist perspective. Related codes were organized and synthesized into the features that are presented in the next section.

RESULTS AND DISCUSSION

We retrieved 6,595 unique references. After screening, a total of 42 papers were eligible for this review (see Figure 1). The studies (Table 1) used a variety of observational, evaluative, and experimental designs with students and professionals from various disciplines: nursing (*n*=14), medicine (*n*=13), interprofessional (*n*=8), dentistry (*n*=2), paramedicine (*n*=2), environmental health (*n*=1), midwifery (*n*=1), operating department practitioners (*n*=1). Based on the first author's affiliation, studies came from Europe (*n*=20), North America (*n*=12), Australia (*n*=6), and Asia (*n*=4). Studies examined or compared several simulation formats, the most frequent being human patient simulators and computer-based simulations; standardized patients, partial task-trainers, and case studies were less represented.

Based on the three perspectives presented above, we identified practical features of fidelity and authenticity in health professional simulation-based learning. Seven features were described both from educators' and learners' perspectives: content drawn from real life, interaction and feedback, performance expectations, preparation of the environment, presence of an actual patient, logical and adaptive scenarios, and sociological fidelity. Features exclusively described as operationalized by educators, experienced by learners, and related to interactionist practices are reported in separated sections. Table 2 presents the number of papers describing features related to the three perspectives. It is important to note that the concepts of 'realism', 'fidelity', and 'authenticity' and were often used interchangeably in the papers. However, the following results are reported according to the definitions presented in Table 3.

Features both operationalized by educators and experienced by learners

Content drawn from real life

This feature consisted in using real patient data or recreating events that occurred to actual patients. This could be achieved by using existing medical records or databases to define data to present to learners. For example, Ney, Goncalves, Blacheff, Schwartz, and Bosson (2010) provided students with access to a national database to evaluate the risk of thromboembolic diseases in an epidemiology game; Redmond et al. (2018) used data from real cases to develop digital learning activities for wound care education. Others reported recreating cases previously experienced by themselves or others (e.g., patients, professionals). Taylor (2011) described how standardized patients relied on their own experience or research others' experience to portray suffering. Furthermore, she explained that the fidelity of a scenario or performance can be assessed either by experienced professionals or by people living with the condition portrayed. Many studies reported that realistic scenarios or cases contributed to the fidelity or authenticity of simulation for learners (e.g., Goncalves, Croset, Ney, Balacheff, & Bosson, 2010; MacLean, Geddes, Kelly, & Della, 2019; Marei, Al-Eraky, Almasoud, Donkers, & Van Merrienboer, 2018; Sørensen et al., 2015). On the contrary, some learners involved in the study by Sørensen et al. (2015) argued that it did not matter if cases were artificial.

Otherwise, the use of realistic images (e.g., photographs, radiographs) sometimes drawn from previous cases—instead of more abstract representation (e.g., drawings)—was described as a means to improve fidelity, especially when virtual or digital media were involved. Comments from learners in a study by Falconer (2013) support that point.

Interaction and feedback

Interaction was defined by the extent to which learners had the opportunity to engage with the patient and colleagues in a natural and dynamic manner in the simulation. To favor natural interactions, simulations involved opportunities for learners to talk freely (e.g., instead of choosing predefined sentences from a menu; Friedman, France, & Drossman, 1991), real discussions constraints (e.g., not allowing the simulated patient to repeat information at learners' will; Goncalves et al., 2010), and real-time interaction with human beings to allow for a natural flow of conversation (e.g., Durning et al., 2012). In other cases, learners were required to use the same channels of communication as if the situation occurred in real-life (e.g., contacting the head of a department through email [Ney et al., 2010], or a dispatch center on a radio system [Engstrom et al., 2016]). The fact that they were observed interacting naturally with patients, either verbally or non-verbally (e.g., using therapeutic touch), was often mentioned as an indicator that they experienced the simulation as authentic (Ahn & Rimpilainen, 2018; Dunn, Tyas, & Garside, 2016; Engstrom et al., 2016; Falconer, 2013; Ignacio et al., 2015; Ker, Hesketh, Anderson, & Johnston, 2006; Marei et al., 2018; Sørensen et al., 2015). Moreover, some learners commented that their interaction felt so authentic that they forgot that they were interacting with actors or a simulator (MacLean et al., 2019; Sørensen et al., 2015). Conversely, learners' perception that an interaction did not feel natural impeded their sense of authenticity. For example, Goncalves et al. (2010) explain how talking to an answering machine or getting a response by SMS was not perceived as credible.

Closely related to interaction is the type of feedback that learners receive during a simulation. We defined this feature as the opportunity for students to explore and witness the consequences of their actions in real-time, not after simulation (i.e., during debriefing). This imply that the situation unfolds in response to learners' actions—whether they are right or wrong—and does not follow a fixed course. In the sample, the form of feedback considered the most realistic often consisted of verbal reactions from the patient or changes in his or her condition (e.g., vital signs); text-based feedback or cues from educators was described as less realistic (see Dankbaar et al., 2016, for an example). While learners commented that they appreciated natural interactions with patient/colleagues, the papers reviewed did not include data on their experience of feedback.

Performance expectations

This feature was defined by the requirement to perform the actions that are expected in a simulation. Performance expectations can be divided into two subtypes: actual performance and time constraints. Actual performance requires learners to fully execute an action. A study by Engstrom et al. (2016) exemplifies this point: in the basic, low-realism condition, learners could simply inform the instructor that they would give a medication, whereas in the contextualized, high-realism condition, they had to actually prepare and deliver it. Dankbaar et al. (2016) described a partial performance expectation in an electronic module: learners did not have to fully perform an auscultation procedure in a computer simulation but were required to indicate the correct sites of auscultation in order to succeed. For learners, having to fully perform actions that they will perform in real life was perceived as contributing to the authenticity of the simulations (Falconer, 2013; Goncalves et al., 2010; Sadideen, Wilson, Moiemen, & Kneebone, 2016); pretending to perform actions had the opposite impact (Ahn & Rimpilainen, 2018; Engstrom et al., 2016).

The other type of performance expectation required events to occur in real-time or to last for as long as they would in real life. One way this feature was implemented was by imposing time pressures in a scenario that responded in real-time to learners' actions. In other cases, learners were required to perform actions for their true duration. For example, Krogh, Hoyer, Ostergaard, and Eika (2014) compared simulations in which learners had to perform cardiopulmonary resuscitation cycles of 120 seconds or 30-45 seconds, the former mirroring current guidelines. In a comparative study, Engstrom et al. (2016) exposed learners to two pre-hospital care simulations: in one, learners had to load the manikin in the ambulance and were directly transported to the hospital (jump in time and space); in the other, they drove for seven minutes to mirror actual transport time. From learners' perspective, training in real-time and experiencing time pressure and the need to prioritize were seen as increasing authenticity (McKittrick, Kinney, Lima, & Allen, 2018; Ney et al., 2010; Sadideen, Wilson, Moiemen, & Kneebone, 2014).

Preparation of the environment

This feature consisted in reproducing features of the environment where the situation could occur. Besides *in situ* simulation in Sorensen et al. (2015) and McKittrick et al. (2018)—as opposed to laboratory training—many authors (see Table 1) described how they used real props to simulate the environment (e.g., operating table, ambulance) and provided learners with real, functional equipment and devices (e.g., medication, monitors, phones, documentation). However, the lack of familiarity with the environment or an environment being too quiet compromised fidelity of the simulation for learners (Ker et al., 2006; Lee, Carson, Clarke, Yang, & Nam, 2019; Mills et al., 2016).

Another tendency was to engage learners' senses. Simulating sounds that would occur in the work environment (e.g., monitor, surgical equipment) or environmental noises (e.g., dog barking, discussion between actors) was the most frequent features in that category (e.g., Engstrom et al., 2016; Marei et al., 2018; Mills et al., 2016). For learners, an environment perceived as too quiet diminished its authenticity (Mills et al., 2016). In other studies, odors (e.g., smell of tissue burned by an electrosurgical unit [Nanji et al., 2013]) and lighting (e.g., well-lit operating room, dark nightclub [Mills et al., 2016; Sadideen et al., 2014, 2016]) were simulated. Learners generally perceived these features as improving the authenticity of the simulations.

Presence of patient

Including an actual patient—either a manikin or a standardized patient—in the simulation environment was described as increasing fidelity. For example, Adams et al. (2015) compared a simulation with a monitor displaying vital signs—no patient was involved—and a simulation with a manikin in addition to the monitor. Brady, Bogossian, and Gibbons (2015) differentiated between levels of fidelity by providing students with a partial task-trainer, a partial task-trainer on top of an image of a patient, and a partial task-trainer positioned on a standardized patient, respectively. Learners generally appreciated the increased level of fidelity that the presence of the patient allowed (Mangold, 2016; Sadideen et al., 2014; Sørensen et al., 2015). Besides the fact that it allowed for more interaction and feedback, they perceived the psychomotor abilities of a real person—to manipulate material provided by a learner, for example—as enhancing the authenticity of their simulation experience (Mangold, 2016).

Logical, adaptive scenario

While it is expected that simulations unfold according to a scenario (INACSL Standards Committee, 2016), we identified three scenario characteristics that were deemed to improve simulation fidelity. First, higher-fidelity scenarios presented a logical sequence of events that required students to respond more or less urgently (Goncalves et al., 2010; Rystedt & Sjoblom, 2012). Second, scenarios presenting options for learners to explore and evolving according to their own decisions were considered to be of higher fidelity than those who followed a fixed course (see Marei et al., 2018). Conversely, Hotchkiss, Biddle, and Fallacaro (2002) noted that learners' anticipation that something was about to go wrong no matter how they acted in the simulation compromised their sense of authenticity. Third, Mangold (2016) described how demographics of the simulated patient in the scenario were modified to match those of the actor portraying the role. Comments drawn from a study by Marei et al. (2018) revealed that students appreciated coherent storylines and uncertainty about correct decisions to implement in the scenarios.

Sociological fidelity

We identified diverse features that could be linked to the concept of sociological fidelity (Sharma et al., 2011). These features were defined as actions to increase learners' sense that they performed their real professional role, and the involvement of other protagonists in a simulation (beside the patient). Sadideen et al. (2014, 2016) described how various health professionals involved in a burn simulation were asked to perform their own professional role instead of switching to a different role (e.g., a nurse playing a respiratory therapist). Other authors added that learners were asked to wear their usual uniform or attire (Nanji, Baca, & Raemer, 2013; Sadideen et al., 2014, 2016), or to use their personal phone or email application (Goncalves et al., 2010; Ney et al., 2010). Training in interprofessional teams was mentioned as a feature that enhanced fidelity, especially when the composition of teams reflected a credible mixture of professions and experience levels (McKittrick et al., 2018). Moreover, introducing protagonists beside the patient receiving care (e.g., patient's relatives or bystanders) increased learners' perception of authenticity (Mills et al., 2016; Sadideen et al., 2016). In general, these features were appreciated by learners—Sørensen et al. (2015) even found that they were more important than the physical setting of the simulation. Oppositely, the presence of persons not involved in the scenario (i.e., observers) and the absence of characters from the scenario compromised learners' perception of authenticity (Ker et al., 2006; Mills et al., 2016), as well as failures to reproduce hierarchical relationships and unrealistic portrayal of certain professional roles (Hotchkiss et al., 2002).

Feature operationalized by educators

We identified one feature that was solely described from educators' perspective: cueing. Cueing was defined as a method of providing learners with information during a simulation. Sometimes, cues were used to explain limitations and malfunctions of the simulator or the equipment, thereby compromising fidelity (Ahn & Rimpilainen, 2018); Nanji et al. (2013) explained how presenting these limitations prior to a simulation and establishing a fiction contract could preserve fidelity. In other cases, cueing was used to provide learners with scenario information. According to some (Baptista et al., 2016; Brady et al., 2015; Meurling et al., 2014), using the manikin's features (e.g., voice or physical capabilities) or simulation equipment (e.g., patient monitor) was more realistic than having an instructor cue the information verbally (e.g., describing physiological values). Otherwise, Escher et al. (2017) identified four other methods of cueing, which had various impacts on learners' workflow and communication. The four methods consisted of providing cues with 1) a confederate involved in the scenario; 2) a bystander who did not partake in the scenario; 3) a loudspeaker; and 4) an earpiece worn by one of the learners.

Features experienced by learners

We identified three features that were solely described from learners' perspectives. First, learners behaving as if the situation was real and as they would in real life was described as a testimony of their sense of authenticity (Goncalves et al., 2010; Ker et al., 2006). Learners staying in character was perceived as a hallmark of authenticity, whereas interactions outside the scenario or breaches in learners' personification of their character (e.g., laughter, touching the manikin out of curiosity) were described as manifestations of poor authenticity (Engstrom et al., 2016; Goncalves et al., 2010; Rooney, Hopwood, Boud, & Kelly, 2015; Rystedt & Sjoblom, 2012). Second, Mills et al. (2016) reported that learners experiencing a sense of urgency to save the patient during the simulation, rather than being preoccupied with assessment, was another display of authenticity. Finally, Goncalves et al. (2010) claimed that learners feeling that they got too much help in the realization of a task (e.g., more feedback and resources than in the real world), or that they knew an outcome in advance (e.g., performing research analyses while knowing the results from a literature search) were two manifestations of poor authenticity.

Features related to interactionist practices

Authors adopting an interactionist perspective did not describe features of simulation but rather explained how learners and educators interacted with a simulation to maintain, breach, or reinstate its fidelity and learners' sense of authenticity. Five papers referring to an interactionist perspective described how fidelity and authenticity are constantly being enacted in learners' actions and reactions (Ahn & Rimpilainen, 2018; Hindmarsh, Hyland, & Banerjee, 2014; Rooney et al., 2015; Rystedt & Sjoblom, 2012; Seale, Butler, Hutchby, Kinnersley, & Rollnick, 2007). Breaches in fidelity could occur because of discrepancies with real practice, disruptions in usual work-flow patterns, performance of unexpected actions/non-performance of expected actions, and simulator malfunctions. These resulted in learners not enacting their professional role, treating the patient as a manikin and not as a patient, disregarding certain aspects of the scenario, and questioning the simulator's functionalities. Nevertheless, learners and educators performed actions to reinstate or promote fidelity and authenticity during simulations: displaying to each other how to understand the situation, framing tasks under real-life demands, invoking contingencies from the work setting, highlighting differences from real life (including limitations of the simulator), differentiating between aspects of the simulation relevant and irrelevant to real work, and providing excuses for discrepancies.

Limitations

The search strategy was limited to peer-reviewed journals indexed in certain databases and did not include keywords related to simulation-based education. Contrarily to recommendations for scoping reviews, grey literature as well as dissertations and theses were not considered. We did not appraise the quality of the evidence of the studies, and there were major methodological variations in the sample. Therefore, our results should not be considered as evidence of effectiveness. Finally, we only considered features that were explicitly associated with realism, fidelity, and authenticity in the papers. For example, papers that mentioned using real radiographs but did not clearly associated this feature with realism, fidelity, or authenticity were not included in this review. Thus, it is possible that relevant studies were excluded.

CONCLUSION

In this scoping review, we identified eight practical features that can be operationalized by educators to promote fidelity or authenticity in simulation-based education: content drawn from real life, interaction and feedback, performance expectations, preparation of the environment, presence of an actual patient, logical and adaptive scenarios, sociological fidelity, and cueing. Moreover, we identified manifestations of learners' experience of authenticity, as well as interactionist practices that led to enactment of fidelity and authenticity. The features presented above are coherent with current definitions presented in the Healthcare Simulation Dictionary (Lopreiato, 2016) and endorsed by the International Association for Clinical Simulation and Learning (INACSL Standards Committee, 2016). While these features are a powerful analytic tool to enhance our understanding of the concepts of fidelity, authenticity, and realism, they can act as an instructional framework to assist the design of high-fidelity, authentic simulations, even when technology is scarce or unavailable.

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Table 1. Studies included in the scoping review

	Reference Country	Methods and objective(s)	Conceptual underpinning	Features	Relevant results and recommendations
1.	Adams et al. (2015) USA	Randomized control trial (RCT) To compare 4 teaching modalities (lectures, videos, low-fidelity (computer-based) and HPS simulation) and fidelity of simulation levels in teaching resuscitation scenario	Engineering and psychological fidelity (Miller, 1954) Cognitive load theory with respect to the number of stimuli in high-fidelity simulation (Alessi, 1988; Sweller, 1988)	Preparation of environment Presence of patient Sociological fidelity	Video- and simulation-based training was associated with better learning outcomes compared to lectures only. Video-based, low and high-fidelity yielded similar outcomes.
2.	Ahn and Rimpilainen (2018) Scotland	Qualitative To observe HPS trauma simulation to understand what makes a successful simulation (intended learning path and outcomes)	Interactionist perspective: Fidelity emerges from the interplay of the manikin, scenario, and technology, and the active engagement of participants Actor-network theory (Fenwick & Nerland, 2014)	Interaction and feedback Performance expectations Cueing Interactionist practices	Briefing frames what actions are possible and impossible in the simulation, which in turn defines actions that are appropriate and inappropriate. Simulations are emergent and co-constituted by socio-material actors.
3.	Baptista et al. (2016) Portugal	RCT To compare satisfaction and gains perceived in medium and HPS simulation	Patient, clinical, and health facility dimensions of fidelity (Tun et al., 2015) Psychological fidelity	Preparation of environment Cueing	HPS led to higher perception of realism, satisfaction, and perceived gains.
4.	Beaumont, Savin-Baden, Conradi, and Poulton (2014) United Kingdom	Qualitative evaluation study To develop, deliver and test eight PBL scenarios in a 3D virtual world	Authentic PBL (Barrows & Tamblyn, 1980)	Content drawn from real life Interaction and feedback Presence of patient Logical, adaptive scenario	Virtual world provided a rich, engaging environment, which enhanced authenticity of the scenarios.
5.	Bonito (2019) Philippines	Descriptive evaluation study To describe the usefulness of a multimedia case study for learning	Authentic learning (Herrington & Oliver, 2000)	Content drawn from real life Logical, adaptive scenario	Students describe the cases as similar to actual cases seen in hospitals and scenarios as realistic.
6.	Brackney and Priode (2017) USA	Correlational study To examine students' perception of realism in a simulation and to report the strengths and limitations of the *Presence Questionnaire* in HPS simulations	Physical, conceptual, and psychological fidelity (INACSL Standards Committee, 2016)	Interaction and feedback Preparation of environment	The realism subscale of the Presence Questionnaire is a valid measure of simulation fidelity.

7.	Brady et al. (2015) Australia	RCT To evaluate the effectiveness of varying levels of fidelity (PTT, PTT on poster, PTT and SP) on learning experiences and clinical skills development	Environmental and psychological fidelity	Presence of patient Cueing	Progressive and medium-fidelity yielded better outcomes that low-fidelity.
8.	Brydges, Carnahan, Rose, and Dubrowski (2010) Canada	RCT To compare self-guided learning and educator-guided learning formats for simulation-based clinical training	Fidelity as students' perceived sense of realism, and how realistically the simulator responds to their actions (Alessi, 1988)	Preparation of environment Cueing	Progressive and proficiency-based training yielded similar learning outcomes, suggesting that students knew when to switch between simulators. Students preferred progressive training.
9.	Brydges, Carnahan, Rose, Rose, and Dubrowski (2010) Canada	RCT To test the efficacy and feasibility of progressive learning on low-fidelity (computer simulation), mid-fidelity (PTT) and HPS simulation compared with the use of simulators in isolation	Fidelity as realism (Alessi, 1988)	Preparation of environment Cueing	HPS group had better learning outcomes than low-fidelity group. Progressive group scored higher on documentation and clinical performance, and equivalent on other outcomes. Progressive fidelity was resource efficient.
10.	Dankbaar et al. (2016) The Netherlands	RCT To investigate the effects of e-module only, e-module with low-fidelity text-based cases, and e-module with high-fidelity simulation game (computer simulation) on students' skills, engagement, and motivation	Fidelity as a function of the learning task, the learners, and the context (Hamstra et al., 2014); Physical, psychological, functional fidelity Cognitive load theory (Paas, Renkl, & Sweller, 2003)	Interaction and feedback Performance expectations Preparation of environment Logical, adaptive scenario	Learning time was shorter for the e-module only group. No difference between groups in cognitive skills acquired. The game group experienced more cognitive load and engagement than the cases group.
11.	Dickinson et al. (2018) USA	Descriptive evaluation study To assess students' perception of a case-based learning intervention involving a real patient	Authenticity for learning (Knowles, 1984)	Content drawn from real life Interaction and feedback Presence of patient	Students agreed that the activity provided an authentic learning experience, helped to apply science concepts to a case, and increased their engagement.
12.	Dunn et al. (2016) United Kingdom	Qualitative (Phenomenological) To understand students' perspectives and experiences of HPS simulation as a learning and assessment strategy	Engineering and psychological fidelity (Baxter, Akhtar-Danesh, Valaitis, Stanyon, & Sproul, 2009)	Interaction and feedback	Interaction using the manikin's voice improved students' experience.

13.	Durning et al. (2012) USA	Crossover RCT To test the effect of instructional format (paper case, video, live recreation with SP) on students' clinical reasoning outcomes	Authenticity as the proximity of instructional format with actual practice Cognitive load theory (van Merrienboer & Sweller, 2010)	Interaction and feedback Presence of patient	Increasing authenticity of instructional format did not significantly improve students' clinical reasoning performance.
14.	Engstrom et al. (2016) Sweden	Crossover RCT To compare immersion in a basic and a contextualized HPS simulation using the *Immersion Score Rating Instrument.*	Fidelity as physical resemblance and functional task alignment (Hamstra et al., 2014)	Content drawn from real life Interaction and feedback Performance expectations Preparation of environment Logical, adaptive scenario Sociological fidelity Cueing	Immersion was higher in the contextualized simulation. Events disrupting immersion (instructor interventions, jumps in time and space) were more present in the basic condition, whereas signals of immersion (natural interaction with the manikin) were more frequent in the contextualized simulation.
15.	Escher et al. (2017) Sweden	Descriptive qualitative study To examine methods to deliver extra scenario information in HPS simulation	Empirical studies of how gaps between simulations and clinical tasks emerge and can be bridged (Paige & Morin, 2013; Rystedt & Sjoblom, 2012)	Cueing	Four methods to convey information to participants in simulation-based training: 1- a confederate involved in the scenario; 2- a bystander who did not partake in the scenario; 3- a loudspeaker; 4- earpiece worn by one of the learners). The choice of method impacted participants workflow, pace, and team communication.
16.	Falconer (2013) United Kingdom	Case study To evaluate environmental health students' experience of an accident investigation and risk assessment exercise in a virtual world	Situated learning (Lave & Wenger, 1991)	Content drawn from real life Interaction and feedback Performance expectations Preparation of environment	Thirteen factors affected the sense of authenticity in the virtual world. Positive factors: facilitation, presence and authority, visual realism, socialization, comparative reality, engagement, active learning, generalizability and enabling learning from mistakes. Negative factors: public image of virtual worlds, lack of naturalism, unrealistic graphics and lack of tactile sense.
17.	Friedman et al. (1991)	RCT	Design variants in computer simulation: static VS	Interaction and feedback Logical, adaptive scenario	Students' performance varied in each format. Generally, students

	USA	To compare the same simulated case in three formats (pedagogic, high-fidelity, problem-solving) in a computer-based simulation on students' performance	dynamic, amount of feedback presented to learners, data elicitation (free entry VS choice menus)		using the pedagogical format (with a menu to elicit data from the patient) accessed more data but did less with it. Students using the problem-solving and high-fidelity versions (free entry) reported difficulties in accessing information.
18.	Goncalves et al. (2010) France	Exploratory case study To explore the authenticity of an immersive game involving computer simulation and role-play from the perspective of students	Learners' perception of game authenticity from three points of view: realism (likeness with a real-life reference), coherence (internal coherence of the proposed situations) and relevance (with respect to learning goals)	Content drawn from real life Interaction and feedback Performance expectations Logical, adaptive scenario Sociological fidelity Cueing Learner experience	Four attributes of authenticity: mission, *mise en scène*, user freedom, and interactions. Students' judgments of authenticity were complex and specific, with the same cues resulting in opposite judgments.
19.	Hindmarsh et al. (2014) United Kingdom	Qualitative (Ethnomethodology) To explore how tutors and students attend to matters of realism in the course of instructional sequences (PTT and VP).	Interactionist perspective: Realism of simulation training is organized by participants in their interactions	Interactionist practices	Tutors routinely invoke real life (complexities and contingencies of clinical practice) in instructional corrections to compensate for the insufficiency of the simulator.
20.	Hotchkiss et al. (2002) USA	Observational study To assess the authenticity of videotaped HPS crisis resource management simulations with nurse anesthesia students	Authenticity as credibility of the simulation Physical and psychological fidelity	Interaction and feedback Performance expectations Preparation of environment Logical, adaptive scenario Sociological fidelity	Scenarios were rated as extremely realistic by raters. Failure to mirror the operating room culture, high degrees of anticipation that something was about to go wrong, and brevity of the scenarios compromised the authenticity and realism of the simulations.
21.	Ignacio et al. (2015) Singapore	RCT To compare students' stress and performance in SP and HPS simulations	Physical and psychological fidelity	Interaction and feedback	Stress and performance did not differ between the two conditions. Students perceived SP to be more realistic and more effective regarding communication skills.
22.	Ker et al. (2006) United Kingdom	Descriptive evaluation study To evaluate perception of the realism of a ward simulation exercise with SP	Environmental fidelity Realism of simulation content	Content drawn from real life Interaction and feedback Performance expectations Preparation of environment Sociological fidelity	Realistic components included the need to prioritize, tasks reflecting everyday work, team working, and handover.

				Cueing	Non-realistic components included manikins, presence of observers, lack of familiarity with the environment, and lack of noises.
23.	Krogh et al. (2014) Denmark	RCT To test if real-time, 2-min cycle during resuscitation training using HPS ensured better adherence to resuscitation guidelines	Time fidelity	Performance expectations	The real-time group adhered better to the recommended 2-min cycle than the shortened-time group, suggesting that time is an important part of fidelity.
24.	Lee et al. (2019) Hong Kong	Constructivist grounded theory To construct a theory of nursing students' high-fidelity simulation-based learning	Fidelity as reproduction of real-world reaction, interactions, and responses Psychological fidelity (INACSL Standards Committee, 2016)	Interaction and feedback Performance expectations Preparation of environment Presence of patient Sociological fidelity	Theoretical model consisting of four processes and four influencing factors. Lack of psychological fidelity compromised learning.
25.	MacLean et al. (2019) Australia	Mixed-methods To investigate whether students' perceptions of realism influence their level of presence in SP simulation and learning outcomes	Realism as ability of environment, patient, and educators to suspend disbelief Physical, conceptual, and psychological fidelity (INACSL Standards Committee, 2016)	Content drawn from real life Interaction and feedback Presence of patient Sociological fidelity Learner experience	Perceived realism and presence positively affected students' discharge communication skills.
26.	Mangold (2016) USA	Descriptive evaluation study To evaluate learning outcomes of SP simulations for teaching kidney transplant patient education techniques	Authentic learning theory (Knobloch, 2003)	Interaction and feedback Preparation of environment Presence of patient Logical, adaptive scenario	The environment added authenticity. The use of SP allowed for real-time, two-way communication, and awareness of the human aspect of the situation. The use of real educational resources increased relevance to practice.
27.	Marei et al. (2018) Saudi Arabia	Explanatory qualitative study To assess students' perceptions of VP scenarios for developing ethical skills	Situated learning (situativity) theory (Durning & Artino, 2011)	Content drawn from real life Interaction and feedback Preparation of environment Logical, adaptive scenario	High-fidelity VP scenarios were perceived better than low-fidelity scenarios for developing ethical skills.
28.	McKittrick et al. (2018) Australia	Action research To evaluate and revise an interprofessional team training session using HPS simulation for pediatric resuscitation	Fidelity refers to mannequin capabilities, as well as environmental and psychological reality (Beaubien & Baker, 2004)	Performance expectations Preparation of environment Sociological fidelity	*In situ* team training in real-time increased realism. Participants sought diversity in their teams (mixture of experienced and non-experienced staff).

29.	Meurling et al. (2014) Sweden	Case-control study To compare pediatric staff members performance, mental strain, and flow experience during in situ training using a low-fidelity or HPS simulation	Equipment, environmental, and psychological fidelity (Rehmann et al., 1995)	Interaction and feedback Performance expectations Preparation of environment Sociological fidelity Cueing	Performance was affected by the levels of equipment used. Trainees' experiences were similar in both conditions.
30.	Mills et al. (2016) Australia	Mixed-methods experimentation To compare the psychological immersion in low- and high-environmental fidelity HPS simulations	Equipment, environmental, and psychological fidelity (Rehmann et al., 1995)	Preparation of environment Sociological fidelity Learner experience	High-environmental fidelity engendered immersion and a sense of urgency; low-fidelity engendered assessment anxiety and slower performance.
31.	Nanji et al. (2013) USA	RCT To determine whether a visual and olfactory sensory change affected anesthesiologists' and residents' perception of realism in HPS simulation	Physical, conceptual, and emotional/experiential fidelity Realism is a perception of the individual	Performance expectations Preparation of environment Logical, adaptive scenario Sociological fidelity Interactionist practices	The visual and olfactory increment to physical fidelity did not affect subjects' ratings of fidelity, perception of realism and engagement.
32.	Ney et al. (2010) France	Descriptive evaluation study To describe the authenticity of an immersive game (involving computer simulation and role-play students) and the perceived authenticity by players	Four attributes of authenticity: authenticity of character, feedback content, communication mode and channel, and constraints	Content drawn from real life Interaction and feedback Performance expectations Sociological fidelity	Authenticity is defined externally (perceived likeness with real life), internally (perceived internal coherence of the situations), didactically (perceived relevance to learning goals).
33.	Redmond et al. (2018) Ireland	Descriptive evaluation study To evaluate student perceived learning gains in terms of knowledge using digital learning activities	Authentic learning (Herrington & Oliver, 2000)	Content drawn from real life	Reusable learning objects designed using real cases reflect the true complexity of wound care and increased students' perception of their wound care abilities.
34.	Rooney et al. (2015) Australia	Qualitative (Ethnographic method) To develop a conceptually driven argument on the unarticulated potential of simulation in professional formation	Interactionist perspective: Focus on actions and relationships between people and the material world	Sociological fidelity Interactionist practices	Fidelity is an emergent, fragile, and resilient phenomenon shaped by materialities and forces that form the world of practice and the university classroom. Simulation can produce agile practitioners who can navigate the unexpected.
35.	Rystedt and Sjoblom (2012) Sweden	Qualitative Study (Ethnomethodology) To contrast the use of two simulators (screen based and HPS	Interactionist perspective: How simulations are interactively established by users	Performance expectations Preparation of environment Presence of patient Logical, adaptive scenario	Participants experienced glitches in the understanding of the simulation, which they bridge through

		simulations) to explore requirements to establish and maintain authenticity representation of clinical practice		Sociological fidelity Cueing Interactionist practices	orientation to the similarities and dissimilarities with real work. The realism of the simulation was maintained through mutual orientation to what is good clinical practice.
36.	Sadideen et al. (2014, 2016) United Kingdom	Mixed-methods design To explore participants' perception of the fidelity of a portable burn HPS simulation environment	Environmental, psychological, and social fidelity (Maran & Glavin, 2003)	Content drawn from real life Interaction and feedback Performance expectations Preparation of environment Presence of patient Sociological fidelity	Participants were able to behave as in real resuscitation, including the performance of non-technical skills. Experience felt authentic because it had high psychological and social fidelity.
37.	Seale et al. (2007) United Kingdom	Descriptive observational sociolinguistic study To analyze the characteristics of simulated role-play encounters that promote learning of communication skills in general practitioners	Interactionist perspective: Participants sustain authenticity and artificiality through interactional work	Performance expectations Preparation of environment Presence of patient Interactionist practices	Participants' negotiation of the simulations was observed in out-of-frame utterances and enactment of the role-playing frame. Realism, achieved through mimicry, was responsible for learning.
38.	Sørensen et al. (2015) Denmark	Qualitative study To examine how *in situ* (ISS) and off-site simulations (OSS) affect the perceptions and learning experience of staff from a labor ward	Fidelity as faithfulness between two identity to ensure transfer of learning (Grierson, 2014)	Content drawn from real life Interaction and feedback Preparation of environment Presence of patient Sociological fidelity	Physical setting of the simulation is less important than performing in authentic roles.
39.	Stillman, Alison, Croker, Tonkin, and White (1998) Australia	Case study To examine the use of situated learning framework to design an interactive multimedia program on medication administration for nursing students	Situated learning theory (Brown et al., 1989)	Content drawn from real-life Performance expectations Preparation of environment Logical, adaptive scenario	Key aspects of the framework were authentic contexts that reflect the way knowledge is used in real life and authentic activities that learners will be expected to engage in during their career.
40.	Taylor (2011) USA	Qualitative study (Ethnographic investigation) To explore how SP perform suffering in simulation	Realism of SP performance	Content drawn from real life Performance expectations Presence of patient	SP performances reconcile a moral commitment to avoid suffering, with an aesthetic commitment to realistically portray it.
41.	Yoo and Kim (2018) USA	Quasi-experimental study To identify the factors influencing students' flow experience during HPS, SP, and hybrid method simulation	Physical, psychological, and conceptual fidelity (Paige & Morin, 2013)	Preparation of environment Presence of patient	Perceived levels of fidelity influenced students' flow experience

NOTE. HPS = human patient simulator (manikin). PBL: Problem-based learning. PTT = partial task trained. RCT = Randomized controlled trial. SP = standardized patient. VP = virtual patient.

Table 2. Number of papers describing features of realism, fidelity, or authenticity operationalized by educators, experienced by learners, or related to interactionist practices in simulation

Feature	Educators (*n*)	Learners (*n*)	Interactionist (*n*)
Content drawn from real-life	13	4	-
Interaction and feedback	14	15	1
Performance expectations	9	13	1
Preparation of the environment	20	9	2
Presence of patient	10	4	2
Logical, adaptive scenario	8	5	1
Sociological fidelity	9	13	2
Cueing	10	-	2
Learner experience	-	6	-
Interactionist practices	-	-	5

Table 3. Definitions of realism, fidelity, and authenticity chosen for this review

Concept	Definition
Realism	The quality or fact of representing a person, thing, or situation accurately in a way true to life; this enables participants to act "as if" the situation or problem was real (Lopreiato, 2016, p. 39).
Fidelity	The degree to which the simulation replicates the real event and/or workplace; this includes physical, psychological, and environmental elements. The ability of the simulation to reproduce the reactions, interactions, and responses of the real-world counterpart (Lopreiato, 2016, p. 18).
Authenticity	An authentic learning environment provides a context that reflects the way knowledge and skills will be used in real life. This includes a physical or virtual environment that resembles the real-world complexity and limitations (Gulikers et al., 2005, p. 509).
	Interpretation of authenticity is individual (Bland et al., 2014, p. 1113). Authenticity in the context of simulated learning is associated with realism of which fidelity is a potential attribute. Authenticity, however, may bring realism even if the learning environment is unrealistic and fidelity is low (p. 1115).