Towards an enhanced conceptualization of fidelity for instructional design in simulation-based respiratory therapy education

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Despite the apparent centrality of fidelity to clinical simulation instructional design and practice in respiratory therapy education, it remains one of most contested constructs in the simulation literature. Fidelity has been described as educationally under-theorized resulting in an emphasis often being placed on technological sophistication rather than theory-informed design, particularly in respiratory therapy. This article critically examines various conceptualizations of fidelity in the field of clinical simulation in an effort to inform its instructional design practices. We adopt the perspective that a shift in the theoretic lens from individualistic to a more socio-cultural orientation may better support our understanding of learning in simulation environments. The instructional design framework (IDF) developed by the Canadian Network for Simulation in Healthcare provides a solid pedagogical foundation on which to base clinical simulations design. The IDF has also been a platform upon which designers can frame the characteristics of simulation environments. We propose an enhanced IDF informed by contemporary education theory describing the joint learning relationship that exists between learners and technology-enhanced learning environments. The enhanced IDF includes each of the interdependent design elements in the original model and incorporates a socio-culturally informed conceptualization of fidelity. The framework will be useful in fostering the relationships that support an effective clinical simulation learning environment. This will be of particular value to practitioners, researchers, and theorists in the clinical simulation-based respiratory therapy education field.

Key Words: *simulation; education; fidelity; respiratory therapy; instructional design*

BACKGROUND

Long established as an approach to training in aviation and other industries, the use of clinical simulation in the education of health professionals has expanded remarkably in recent decades [1–3]. The usefulness of learning within simulated environments as a means of improving clinical and nonclinical skills and reducing risks to patients has become well established in the literature [3–6]. While clinical simulation has been a useful tool for improving technical skills for decades, its prominence as a strategy for development of competencies related to patient safety and teamwork is more recent [1, 7, 8]. Technological advances in simulation have further prompted its adoption to address the relative scarcity of opportunities to practice many clinical procedures in clinical settings and the risk that practicing on patients may entail [6].

Respiratory therapy is a competency-based profession, where practice occurs in clinical settings. Respiratory therapy education, therefore, necessarily occurs in both the classroom and in clinical practice environments, through which students are required to learn the skills, attitudes, and behaviours of professional practice. Clinical simulation-based education has, in part, been rapidly adopted by respiratory therapy educational programs because it offers an authentic environment for learners to develop professional skills without the risk of causing harm to actual patients [9].

Clinical simulation employs a technology-enabled leaning environment (TELE) to help replace or amplify real experiences with guided immersive experiences that are intended to replicate some degree of the real world [2]. It is often assumed that clinical simulation leads to valuable learning experiences because of its effectiveness in replicating real-life scenarios [1]. Fidelity is a common measure for the degree of realism and is typically considered an essential aspect of the technology that has substantial impact on learning [10, 11]. For simulation to be immersive and replicate the real world, it seems logical that a high degree of realism, or likeness to real life, would be essential.

Despite the apparent centrality of the concept of fidelity to clinical simulation in respiratory therapy education, the concept has been used inconsistently, while at the same time it is widely considered in the simulation literature [9, 12]. Moreover, clinical simulation has remained educationally under-theorized with emphasis placed on technological sophistication rather than theory-informed design [6, 9]. As no consistent conceptualization of fidelity in clinical simulation is evident in the literature, the relationship between learning and fidelity therefore remains not well understood [4, 11]. Some frameworks for instructional design in clinical simulation propose best practices for practitioners in which the contested concept of fidelity features prominently [e.g., 11, 13]. Building on a narrative review of the clinical simulation literature [14], this article offers a critical examination of emergent conceptualizations of fidelity in an effort to inform instructional design practices in the field of respiratory therapy education.

Shahoumian et al. [6] suggested that a shift in the theoretic lens from individualistic to a more socio-cultural orientation may best support our understanding of the learning that occurs in simulation environments. By adopting a socio-cultural perspective, it is recognized that learning is embodied, relational, and situated in social and cultural contexts. The perspectives offered in this paper are informed by the position of Jonassen et al. [15] who suggested a refocus in the debate between objectivist and instructionist conceptions of learning that exist in the field of instructional design for environments enhanced with technology. Jonassen et al. [15] posited that learning is contextual and that the experience of the learner is based on their experience with the environment. This idea that learning is distributed between the learner,

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the technology, and the context is supported by contemporary theories of knowledge building and distributed cognition [16–18]. Consistent with this perspective we contest that in the context of clinical simulation in respiratory therapy, instructional design should focus on supporting learner cognition with TELE rather than simply expecting that learning occurs as a result of technology.

DIFFERENTIATING FIDELITY ALONG TECHNOLOGIC LINES

In outlining a future vision of simulation Gaba [2] offered 11 dimensions that represent key attributes of clinical simulation. These dimensions provided a broad view of the design considerations of simulated environments, encompassing the purpose, educational level, and discipline of the participant, and the aspects of environment being simulated. Within these dimensions technology is identified as a key attribute, which can be differentiated along a continuum spanning from role playing (at the lowest end), to electronic patients (e.g., mannequins), to realistic replication of the clinical environment (at the continuum's highest end) [2]. While the term fidelity is not explicitly used to describe aspects of simulation here, the continuum represents technology-centric perspectives that have emerged in the field of clinical simulation. In particular, technology-centric perspectives on learning have previously been identified and problematized in the context of respiratory therapy clinical simulation practices [9]. The idea that the most lifelike technology may lead to the best learning outcomes might be implied in such perspectives, and indeed the correlation between the learning performance measures and the types of technology has also emerged as a subject of quantitative inquiry in the field [e.g., 19, 20]. It is most concerning that inquiry focusing on the qualities of the technology as a causal determinant of learning may fail to recognize the importance of learner experience with the environment. Our review of the literature suggests that clinical simulation practice is often being informed by literature that takes such a technology-centric perspective on learning.

In their systematic review of the effectiveness of clinical simulation Issenberg et al. [21] sought to identify the design features that best support cognitive and affective change and learning related to skills acquisition and professional competence. Of those included studies that reported on simulator fidelity, the degree of realism with which the simulator replicated complex clinical situations was found essential for improving learners' perceptual skills or response to critical incidents. It should be noted that investigations included in the analysis defined high-fidelity as simulation technology that is responsive to user demands as opposed to those that simply remain static [3]. While seemingly encouraging, these results were based on a body of literature characterized by a narrowly defined conceptualization of fidelity and were not designed to sufficiently explain how or why learning occurred.

Following the results of their more recent meta-analysis on clinical simulation McGaghie et al. [10] presented best practices that educators "should know and use" (p. 51). Amongst these best practices McGaghie et al. [10] promoted the idea that the fidelity of the simulation technology needs be closely matched with educational goals of any given clinical simulation. For example, low-fidelity technology (e.g., simple task trainers, which are devices that replicate a single body part) may be used for learning procedural skills, whereas high-fidelity technology (e.g., lifelike full-body mannequins or virtual reality simulations with a high degree of realism) is best used for complex clinical events. The promotion of such design practices may be highly influential in cultivating the objectivist perspectives on fidelity that prevail in the field. Uncritical acceptance of these perspectives has likely been at the expense of adoption of more theory-informed design principles [6].

An analysis by Cook et al. [22] that considered the impact of various designs of computerized virtual patient simulation on learning offers additional insight. The findings of this analysis are in contrast with some of those commonly held conceptions in the field regarding the impact of fidelity on learning. While overall, the use of virtual patients was demonstrated to be associated with large positive effects, the analysis identified associations across a number of studies indicating neutral or negative associations of learning outcomes with increasing patient fidelity [22]. Such findings should lead us to question "whom, in what contexts, and for what outcomes greater realism is beneficial" [22].

Other critiques of the traditionally accepted construct of fidelity as either a high or low replication of reality are focused on its overemphasis on the technological aspects of simulation to the detriment of the broader instructional design [1]. Such a conceptualization also fails to recognize fidelity as a multidimensional construct [23]. This pervasive adoption of a technologically centered perspective throughout the health professions might be best contextualized by McGaghie et al. [10] who stated "medical education technology shapes and channels medical education policy as research advancements inform new ways to educate and evaluate doctors." Educators should be concerned with how adopting such a conceptualization may negatively influence the instructional design of clinical simulations.

A CRITICAL LOOK AT AN INSTRUCTIONAL DESIGN FRAMEWORK FOR CLINICAL SIMULATION

In effort to account for the fact that clinical simulation is a complex concept, an instructional design framework (IDF) was developed by the Canadian Network for Simulation in Healthcare (CNSH) [11]. The IDF is intended to provide a solid pedagogical foundation on which to design the characteristic of a variety of clinical simulations. The IDF describes clinical simulation design as existing within four levels, where each encompasses a set of specific characteristics and where each progressive level constitutes the foundation for the next. The framework reveals the principal mode of delivery of instruction (level 1), the simulation mode used for teaching and learning (level 2), the instructional method (level 3), and the presentation (level 4) [11]. The concept of fidelity is embedded with level 4, or presentation, which refers to how the simulation activity is shaped and designed in ways other than through instructional methods (e.g., choice of media) [11].

Indeed the IDF addresses a wide variety of factors that may impact the clinical simulation learning environment and that are worthy of consideration in a design. The authors note that the IDF fills a void in the area of clinical simulation, and that it is hoped that it will "serve as a catalyst for the simulation community … to engage in a discussion about the educational characteristics of simulation and to encourage future research in this field" [11]. Heeding those words it seems reasonable that the conceptualization of fidelity presented within the IDF be evaluated, particularly in light of the limitations of earlier conceptualizations already noted. The IDF defines fidelity as "the realism of the experience" [11], a conceptualization that has been adopted from the aviation industry [12]. Given its prominence in the framework as an "intrinsic characteristic of simulation … that can affect learning" [11], we carefully consider its origins and applicability to the clinical simulation context.

Responding to calls for a reconceptualization of fidelity in simulation, the Fidelity Implementation Study Group (FISG) presented their expert recommendations on a new taxonomy for use in the field of aviation [12]. Recognizing the subjective limitations of traditional low to high definitions of fidelity, Gross [12] identified the need to develop a more objective measure to accurately describe the construct. Fidelity was thus redefined as "the degree to which a model or simulation reproduces the state and behaviour of a real world object or the perception of a real world object … in a measurable or perceivable manner" [12]. The new definition further explains that any description of fidelity should be made in relation to the measures, standards, or perceptions used to evaluate it. What becomes problematic then is determining how those quantitative measures, standards, or perceptions should be determined and described. Gross [12] contends that to address such measurement issues a definition of the real world must be established that enables comparison between it and the simulation.

Recognizing that using the real world as a comparative is too cumbersome and complex of a measure to be useful, more commonly understood and practical measures need to be employed. Gross [12] suggested that in the field of aviation the minimal characteristics of real-world features that are needed for a given educational experience should be used as a proxy fidelity referent. Gross [12] expounded on the means of determining realism in aviation by contending that there are specific dimensions and features upon which to base any comparative analysis of fidelity with the real world. These proxy referents include: physical fidelity, visual fidelity, audio fidelity, motion, environment, temporal fidelity, behaviour, and aggregation. The FISG also suggested that analysis of fidelity should be based in two metrics: resolution and accuracy [12]. Resolution refers to the whether the referent is reproduced in the simulation and accuracy to the degree in which the referent is reproduced in the simulation.

Chiniara et al. [11] extrapolated the ideas proposed by Gross [12] to the CNSH framework for simulation in healthcare. Chiniara et al. [11] suggested that, for example, using a task trainer such as a lifelike arm might provide sufficient fidelity to recreate the experience of inserting an intravenous line. However, if the goal of the educational session was to include interaction with the patient, the fidelity of the simulation would, therefore, be insufficient. Moreover, Chiniara et al. [11] adapts the referents proposed by the FISG for use in the CNSH framework suggesting that physical, environmental, and temporal fidelity are appropriate measures on which to base comparisons of simulated environments with the real world. While the CNSH framework brings a variety of complex environmental design factors to the fore, the conceptualization of fidelity contained within it remains problematic. Specifically, the measurements and referents proposed by Chiniara et al. [11] are technology-centred and thus do not acknowledge the integrated nature of learning, technology, and the environment. This technologically centric approach to practice echoes that which has previously been noted to persist within the field of simulation-based respiratory therapy education [9]. A further reconceptualization of fidelity might therefore focus less on the attributes of the simulation technology and more on the attributes of the respiratory therapy learner and their experience with the technology [14].

MOVING BEYOND TECHNOLOGICAL CONCEPUALIZATIONS OF FIDELITY

Maintaining focus on the technological attributes of the simulation design may come at the unfortunate cost of deemphasising the understanding that learning is situationally dependent [14]. In the field of respiratory therapy education, we might therefore broaden our conception of simulation technology as "multiple sets of affordances that are predicated on the perceptions of users and the context in which they are used" [15]. In doing so we should be prompted to think of the design features of simulation technology, including fidelity, as an integrated part of a learning environment. We propose an enhanced IDF for clinical simulation in respiratory therapy (see Figure 1) that incorporates a reconceptualization of fidelity, recognizing that what makes simulation lifelike or immersive is multidimensional, contextual, and perceptible. In the following, we elaborate on basic premise of this enhanced IDF, including blending multiple modes of realism, the interdependence of design elements, and the joint learning system.

Blending multiple modes of realism

Starting from the middle of Figure 1, we argue for an augmented conceptualization that recognizes the phenomenal, semantic, and physical aspects of fidelity as a means of discerning reality in designing clinical simulation environments. Laucken [24] forwarded three modes that she theorizes are each necessary to understand any situation that we encounter: physical thinking, semantical thinking, and phenomenal thinking. Recognising clinical simulation as a social practice, Dieckmann et al. [25] adopted Laucken's theory to frame how one experiences a sense of reality in this context where participants interact with a complex network of learners, technical artifacts, and the environment. The physical mode concerns characteristics that are measurable (e.g., the weight of an infant mannequin). In this way physical fidelity might be described as the reality of simulator equipment, measurable elements of the environment, or physical aspects of movements of such characteristics [25]. The semantical mode concerns those parts of the simulation experience that are "facts only by human agreement" [25]. Semantical fidelity describes "concepts and their relationships ... presented as text, pictures, sounds,

FIGURE 1.

The enhanced instructional design framework for clinical simulation in respiratory therapy. Each element of the framework, including a socio-culturally informed perspective of fidelity, interdependently fosters the joint learning relationship between respiratory therapy learners and simulation environments.

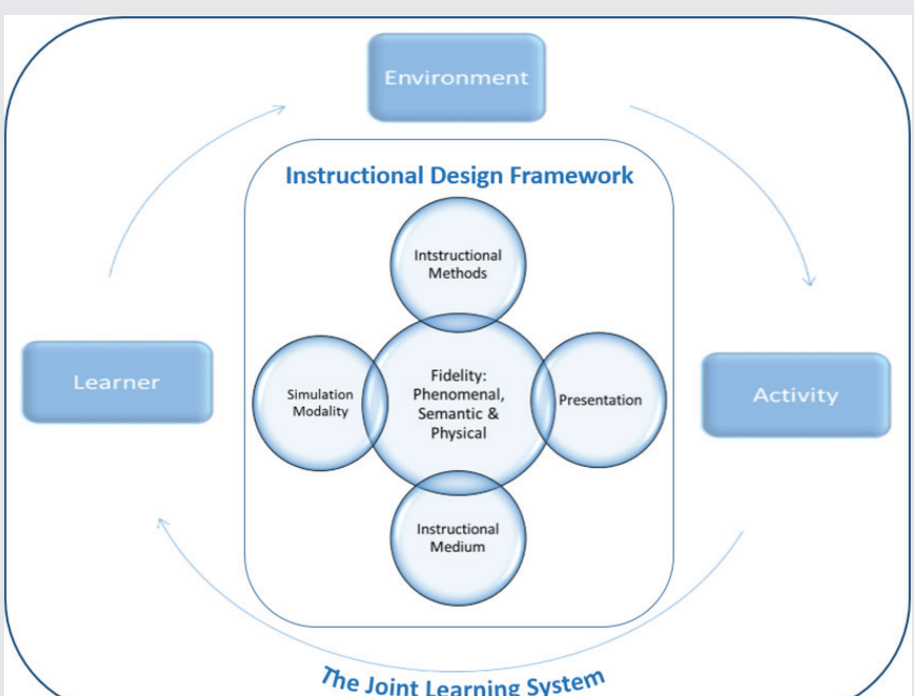
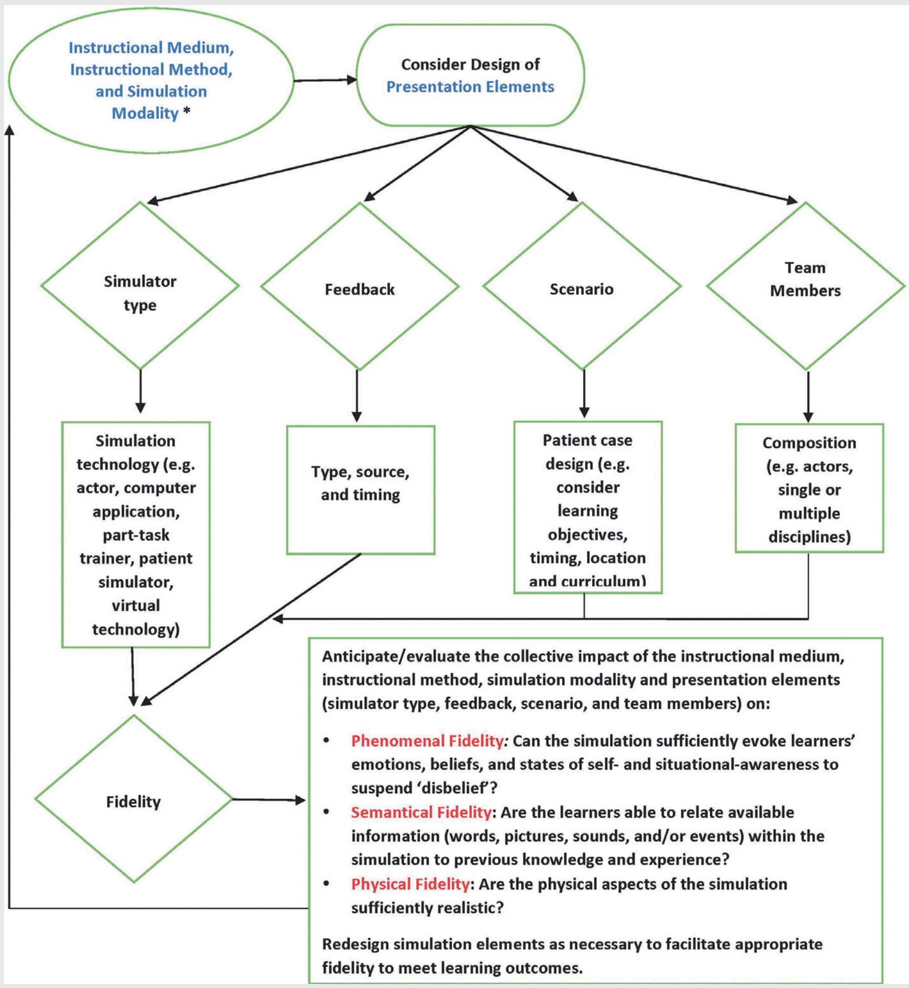


FIGURE 2.

Design chart for presentation elements and fidelity within the enhanced simulation instructional design framework for respiratory therapy. Diamond shapes correspond to key decision points (questions) and rectangles correspond to design considerations. The four levels of instructional design in simulation (blue) and enhanced conceptualizations of fidelity (red). *Instructional medium, method, and simulation modality chosen according to media and simulation modalities selection charts A and B in Chiniara et al. [11].



or events" [25]. Semantical fidelity is therefore assured only when the information presented is interpretable as realistic (e.g., when a simulated patient's heart stops beating it is also made to stop breathing as is natural). The third mode of reality is concerned with participants' understanding of how the simulation event relates to another real situation, clinical practice for example (e.g., team interaction within a simulated trauma scenario feels lifelike despite obvious physical differences compared with real life). This phenomenal fidelity depends on the "emotions, beliefs, and self-aware cognitive states of rational thought" [25] experienced by participants in simulation.

Diekmann et al. [25] contended that a sense of phenomenal reality is more closely associated with the degree of semantic fidelity as opposed to physical fidelity. Participants therefore most readily accept limitations in physical fidelity compared with any lack of semantic fidelity, given that they understand how the simulation relates to their clinical practice and that it is plausible. By examining the perceptions of a group of clinical simulation participants regarding their learning experiences Shahoumian et al. [6] sought to build understanding of the nature of fidelity in clinical simulation presented by these theoretic frameworks. Through their preliminary analysis of clinical simulation participants, Shahoumian et al. [6] found that the complexity inherent in clinical simulation has begun to surface indicating that "individualistic learning theories are unable to capture the whole learning process in this versatile environment." Interestingly, participants reported that their learning was most related to aspects of phenomenal fidelity as evidenced by the strong influence of collaboration, peer engagement, and reflection [6]. These findings echo a recent paradigm shift noted by Bleakley [26] in medical education—a movement from predominantly pedagogy-informing learning theories that are individualistic in nature and focused on autonomy (e.g., adult learning theory) towards social learning theories that are focused on collaboration.

In building on the three modes of realism proposed by Dieckmann et al. [25], Rudolph et al. [27] noted that "skillful blending of the three … will allow our trainees to 'suspend disbelief' that this is a situation with real relevance to them." Advancing the idea that this reconceptualization might influence instructional design in clinical simulation, Rudolph et al. [27] also noted participant engagement is based on no single element of realism but assures that no single element "violates their expectations in a way that disrupts their engagement." These understandings call on us, in the field of respiratory therapy education, to reframe our conceptualizations of fidelity in clinical simulation. An augmented conceptualization that recognizes the phenomenal, semantic, and physical aspects of fidelity as a means of discerning reality will be useful in designing respiratory therapy simulation environments, including the use of available media that sufficiently address reality based on contextual needs. To that end we suggest incorporation of this conceptualization of fidelity into a redesigned and enhanced IDF for respiratory therapy, based on the CNSH model [11].

Interdependent design elements

The enhanced IDF proposed here includes the four levels of instructional design from the CNSH model (i.e., instructional medium, simulation modality, instructional method, presentation) but represents each as interdependent parts of the design, rather than as being discrete and existing along a priori scale. The enhanced IDF also incorporates a socio-culturally informed conceptualization of fidelity adopted from Dieckmann et al. [25] as a central design element. As such, each design element of the framework can be seen to relate to any aspect of fidelity (phenomenal, semantical, and physical). Recognition of this relationship can prompt designers to consider the relevance of each design element in facilitating sufficient realism for a given context and to ensure that no one element violates learner expectations. In doing so, fidelity needs to no longer be considered as a phenomenon to be compared with an external set of measurable proxy referents. Rather, it may be seen as a learner-centered lens through which other design elements may be contextually considered by the instructional designer. Further extending on the work of Chiniara et al. [11], who presented two charts to assist in the selection of appropriate media and simulation modalities, Figure 2 offers a guide to the design of presentation elements and fidelity based on the enhanced IDF.

The joint learning system

We contend that the learner, activity, and environment develop relationships as the joint learner system in learning situations, which we should consider in the instructional design process. Knowledge-building theory is predicated on the idea that knowledge is a social product, created by members of a community, and that it adds some type of value to that community [17]. Extending this to TELE, Kim and Reeves [28] offered a relevant lens through which learning with clinical simulation in respiratory therapy can be viewed. Their enhanced perspective sees technology as forming part of a joint learning system along with the learner and activity [28]. Kim and Reeves [28] explained that a relationship exists between the learner and the technology that grows over time. “Learning … is not a process that happens only at the beginning but is rather an ongoing process; learners discover more affordances of tools and even refine their own abilities as they master the tools and develop more effective distributive relationships.” Viewed in this way, fidelity may also be considered as providing insight into the relationship between the learner and the clinical simulation environment, highlighting the importance of also fostering a relationship that can support enhanced fidelity. The enhanced model not only incorporates a renewed conceptualization of fidelity as a central design element, but it also identifies the learner within the joint learning system. This inclusion highlights those relationships within the joint learner system that need to be key considerations in the instructional design process. We contend that the inclusion of this reconceptualization of fidelity as a design element can therefore be useful in fostering the relationships that support effective clinical simulation learning environments in respiratory therapy.

CONCLUSION

In respiratory therapy, fidelity is frequently conceptualized as the degree of realism of the technology in clinical simulation, and higher physical fidelity often felt to lead to the best learning outcomes. Informed by educational theory, this paper identified a commonly held technologically centered conceptualization of fidelity and examined the limitations of literature that suggest high physical fidelity alone relates to more effective learning. This paper also discussed alternate conceptualizations of fidelity, and noted that taking a socio-cultural perspective can better inform those conceptualizations and our understanding of how we depict and theorize the learning that occurs in clinical simulation.

A conceptualization of fidelity was promoted that encompasses three modes of thought: physical, semantical, and phenomenal. This conceptualization may be quite useful in respiratory therapy if viewed as a lens through which we can understand the joint relationship that exists between the learner and the clinical simulation environment. The proposed IDF for respiratory therapy builds on earlier iteration developed by the CNSH. The framework, augmented by a socio-cultural informed definition of fidelity and informed by educational theory on knowledge-building in TELE, may be of value to practitioners, researchers, and theorists in the field of simulation-based respiratory therapy education.

DECLARATION OF INTEREST

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

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