Experiential learning and cognitive tools

Chapter 4

Experiential Learning and Cognitive tools: The Impact of Simulations on Conceptual Change in Continuing Healthcare Education

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Abstract

Conceptual change involves the acquisition of new cognitive resources (e.g., mental models) for thinking, problem solving, and decision making. Conceptual change, especially the development of robust mental models related to complex phenomena, is essential in continuing healthcare education (including medicine, nursing, public health, and social work). Jonassen's work related to *mindtools* (also known as cognitive tools) and conceptual change has been influential in the development of interactive simulations designed to foster experiential learning opportunities for healthcare professionals. Experiential learning results when people engage in purposeful reflection about their experiences. The experiences that foster the kind of reflection and meaning making necessary for new conceptual change can occur in the real world (e.g., stitching a wound) or in a virtual world (managing a cancer patient

within an interactive multimedia simulation). Cognitive tools are ‘‘technologies that enhance the cognitive powers of human beings during thinking, problem solving, and learning’’ (Jonassen & Reeves, 1996, p. 693). This chapter reviews the literature on simulations as cognitive tools that enable experiential learning in support of conceptual change in continuing healthcare education. In addition, the chapter prescribes an educational design research agenda to advance the state-of-the-art of simulation development and theory in this area.

Keywords:

Cognitive tool: A cognitive tool is any technology such as mathematical notation or a computer program that enhances or extends the mental powers of human beings during thinking, problem solving, and learning; a computer simulation of the public health management decisions that must be made during an avian flu epidemic is a type of cognitive tool that can be used for continuing healthcare education.

Conceptual change: Conceptual change occurs when an existing concept (e.g., pain is best relieved though pharmacological agents) is modified by some form of learning (e.g., a person could learn that acupuncture can provide pain relief from actual interactions with veterans whose suffering has been decreased by this non-pharmaceutical procedure or through a computer simulation of such interactions); conceptual change is more than an addition to long term memory or the development of a specific skill; it requires that a complex mental model is fundamentally changed in ways that allow to learner to make better decisions and solve real world problems.

Continuing healthcare education: Continuing healthcare education (CHE) involves the formal provision of learning opportunities for healthcare professionals in fields as diverse as medicine, nursing, public health, and social work; designed to maintain, modify, and/or extend the competencies of healthcare professionals, CHE is provided in many forms including direct instruction, print materials, video, simulations, and games that are delivered face-to-face, online, or in a blended format; CHE is especially important given that it is estimated that healthcare knowledge doubles every seven years.

Educational design research: Educational design research is distinguished from other forms of scientific inquiry conducted by educators by its commitment to developing theoretical insights and practical solutions simultaneously in real world (as opposed to laboratory) contexts; it is most often conducted through long-term collaboration among researchers, practitioners (e.g., teachers) and other stakeholders.

Experiential learning: Experiential learning in its simplest form refers to learning from experience in contrast to learning from some type of formal instruction; as a pedagogical strategy for fostering meaningful learning, Kolb (1984) defined experiential learning as "…the process whereby knowledge is created through the transformation of experience" (p. 38).

Simulation: Within the context of continuing healthcare education, a simulation is type of learning environment wherein critical aspects of professional performance are replicated with some degree of fidelity so that learning and assessment are enabled; simulations can be designed to enable healthcare professionals to develop specific skills (e.g., inserting an intravenous line into a patient's arm) as well as to promote higher order conceptual change (e.g., acknowledging that acupuncture can relieve pain).

Introduction

Professor David H. Jonassen has made and continues to make enormous contributions to multiple fields including educational technology (cf. Jonassen, 2004a), instructional design (cf. Jonassen, 2004b), and the learning sciences (cf. Jonassen, 2011). His unique characterization of *mindtools* as well as his consistent focus on conceptual change as an important outcome of meaningful learning have influenced the thinking and work of researchers and practitioners at all levels and across all forms of education and training.

Among his academic peers, Jonassen is noted for being direct in stating the implications of his research. For example, in his 2006 book, *Modeling with Technology: Mindtools for Conceptual Change*, he wrote: "The goal of learning should be conceptual change and development" (p. xiv). Jonassen, Strobel, and Gottdenker (2005) defined conceptual change as "changes in conceptual frameworks (mental models or personal theories) that learners construct to comprehend phenomena" (p. 15). Jonassen (2006) contended conceptual change is critical to problem-solving and decision-making in all professional fields. Conceptual change, especially the development of robust mental models of complex phenomena and the capacity for decisive decision making under duress, is absolutely essential in healthcare fields such as medicine, nursing, public health, and social work.

The primary purpose of this chapter is to review the evidence that continuing healthcare education using simulations as cognitive tools (mindtools) instantiates experiential learning, and, in turn, fosters conceptual change. This review is important because, although conceptual change is often one of the most desirable outcomes of continuing healthcare education, such change is also one of the most difficult goals to accomplish. This chapter concludes with a call for more widespread pursuit of educational design research by members of the global continuing healthcare education community.

Background

Medical practitioners such as physicians, nurses, public health officers, and social workers often resist conceptual change even when faced with compelling evidence of the need to change a foundational mental model underlying treatment decisions. Millard (2011) described in excruciating detail the extraordinary suffering that President James A. Garfield endured for nearly 90 days after being shot by an assassin in July 1881. Garfield's physicians, despite having been strongly advised to use the disinfection procedures developed by Joseph Lister twenty years earlier, continued to probe the President's wound with unclean fingers and unsterilized instruments, thereby introducing the massive blood infection to which President Garfield eventually succumbed.

Despite the evidence-based movement in medicine and healthcare (Sackett, Straus, Richardson, Rosenberg, & Haynes, 2000), the challenges that physicians and other healthcare practitioners face when they need to engage in conceptual change are still evident today. For example, Gawande (2009) documented the difficulties he has confronted in convincing fellow surgeons to adopt a simple checklist that could prevent tragic errors that are all too common in operating theaters. Thagard and Zhu (2003) revealed how Western physicians, especially in the USA, have struggled to give acupuncture, a practice derived from traditional Chinese medicine, a fair evaluation because of the perceived incommensurability of the different world views of medical practice in the East and West. More recently, Jonas, Walter, Fritts, and Niemtzow (2011) detailed the difficulties they have experienced as American military physicians getting other healthcare practitioners who treat wounded

American soldiers returning from Iraq and Afghanistan to accept the positive results they have found in relieving pain with acupuncture.

Continuing education for healthcare professionals often has conceptual change as one of its major goals. Unfortunately, continuing healthcare education continues to be inadequate around the world, even in the wealthiest counties. For example, a recent report from the Institute of Medicine (2011) in the USA concluded that:

> Every segment of the healthcare workforce must comprise professionals who provide high-quality health care and assure patient safety. However, the nation lacks a comprehensive, effective system of continuing education in the health professions, and this gap contributes to knowledge and performance deficiencies at the individual and system levels. (p. 39)

The inadequacies of continuing healthcare education in the still developing countries are even more alarming. Consider something as basic as hand washing. Although Gawande (2008) warned that the failure to sterilize hands before interacting with patients is a serious problem in even the most advanced hospitals in the USA and Europe, it is a major cause of death in the developing world where the proportion of patients infected by their caregivers frequently exceeds 25% (Pittet, Allegranzi, Storr, Bagheri Nejad, Dziekan, Leotsakos, & Donaldson, 2008). Allegranzi and Pittet (2009) wrote:

> Healthcare workers' hands are the most common vehicle for the transmission of healthcare-associated pathogens from patient to patient and within the healthcare environment. Hand hygiene is the leading measure for preventing the spread of antimicrobial resistance and reducing healthcare-associated infections (HCAIs),

> but healthcare worker compliance with optimal practices remains low in most settings. (p. 209)

In light of such reports from the World Health Organization and other public health agencies, it seems like many healthcare practitioners have not progressed sufficiently beyond the unclean habits of the eminent physicians who arguably killed President Garfield in 1881. In this and other areas of healthcare practice, the need for conceptual change among healthcare professionals is clear.

Experiential Learning through Simulations

How can continuing healthcare education foster conceptual change more effectively? The U.S. Institute of Medicine (2010) and others (cf. Vesper, Kartoğlu, Bishara, & Reeves, 2010) have recommended increased adoption of experiential learning as a pedagogical strategy that can foster meaningful learning. Kolb (1984) defined experiential learning as "…the process whereby knowledge is created through the transformation of experience" (p. 38). Experiential learning may be categorized into two different types: one that is personal and informal (e.g., learning from experience that one should always begin a patient interaction by addressing the patient by name to establish rapport), and another type that is a designed event encompassing learning opportunities to which people are intentionally exposed (e.g., a continuing nursing education seminar focused on advanced disinfection techniques).

Interactive simulations have been demonstrated to be effective vehicles for enabling experiential learning within the context of continuing healthcare education (Kneebone, Arora, King, Bello, Sevdalis, Kassab, Aggarwal, & Darzi, 2010; Levine, Schwartz, Bryson, & DeMaria, 2012; Rogers, 2011). According to McGaghie, Siddall, Mazmanian, and Myers (2009), "A growing body of research evidence documents the utility of simulation technology for educating healthcare professionals” (p. 62). However, McGaghie et al. go on to note that “simulation has not been widely endorsed or used for continuing medical education (CME)” (p. 62).

The low level of use of simulations in continuing healthcare education is alarming given that the link between interactive simulation and experiential learning is often stated in the literature. For example, writing in the *Journal of Continuing Education in Nursing*, Decker, Sportsman, Puetz, and Billings (2009) stated that “Simulation offers a unique mode for experiential learning” (p. 74). Carron, Trueb, and Yersin (2011) wrote:

> Simulation is a promising pedagogical tool in the area of medical education. High-fidelity simulators can reproduce realistic environments or clinical situations. This allows for the practice of teamwork and communication skills, thereby enhancing reflective reasoning and experiential learning. (n.p.; online article)

Similarly, in the context of developing high fidelity healthcare simulations for teaching and learning, Alinier (2011) stated that "Attaining the appropriate level of realism [in a healthcare simulation] will help participants engage in the scenario by making unprompted actions and hence benefit from experiential learning" (p. 9). It would seem that embracing the use of simulations in continuing healthcare education is itself a conceptual change within the profession that has yet to take hold. This may be tied to the complexity of creating high quality simulations.

For experiential learning to be activated within a simulation, some degree of authenticity must be attained. Regarding the use of simulations in nursing education, Campbell and Daley (2009) wrote: “In order for a transfer of knowledge to occur, the student’s role in the simulation must be as authentic as possible” (p. 5). However, authenticity is a complex issue in the design and implementation of learning simulations. Authenticity, like beauty, is often in the mind of the beholder. In this light, Barab, Squire and Dueber (2000) claimed that authenticity occurs “not in the learner, the task, or the environment, but in the dynamic interactions among these various components ... authenticity is manifest in the flow itself, and is not an objective feature of any one component in isolation” (p. 38).

Herrington, Reeves, and Oliver (2010) argued that for an e-learning environment, including an interactive simulation, to be authentic, some degree of “suspension of disbelief is required” (p. 92) on the part of the learners. People regularly suspend their disbelief when they watch a film or read a novel, becoming so cognitively and emotionally engaged that they forget that they are just watching and reading rather than actually experiencing what is happening. Instructional designers and educators in the health professions must strive to develop interactive simulations in ways that allow healthcare personnel to engage in similar levels of suspension of disbelief so that as learners they can “immerse themselves in a learning experience that most closely matches that encountered in real life” (Cheng Duff, Grant, Kissoon, & Grant, 2007, p. 466), and, hence, become engaged in experiential learning. In a chapter focused on simulations, Jonassen (2011) highlighted the importance of learner engagement when he wrote that “as I have pointed out repeatedly, without engagement, there is no meaningful learning” (p. 233).

The Effectiveness of Simulations

Determining the effectiveness of learning simulations is not as straightforward as it might first seem. As described above, the nature of authenticity and how to foster its perception are challenging design problems. Another complicating issue relates to the amount of *scaffolding* that learners need or are given within an instructional simulation. Scaffolding, in the context of a learning environment, refers to the assistance provided to learners so that they can accomplish something that they would not be able to do easily without help. In a comprehensive review of the instructional effectiveness of simulations, de Jong (2011) wrote:

> The overall conclusion is that simulation-based inquiry learning can be effective if the learners have adequate knowledge and skills to work in such an open and demanding environment and if they are provided with the appropriate scaffolds and tools. In those cases where adequate support is given, simulation-based learning may lead to better results than direct instruction or laboratory based exercises. (p. 459)

However, providing too much scaffolding can turn what it is purported to be a simulation into an elaborate tutorial and thus contravene the intended experiential nature of the interactive learning environment (Jonassen, 1996). The learning theory foundations of medical simulations include constructivism, reflective practice, and situated learning (Bradley, 2006). These theoretical perspectives position the learner with more autonomy than a learner typically experiences in direct instruction (Kirschner, Sweller, & Clark, 2006; Kuhn, 2007). Finding the right mix of “support, feedback, and scaffolding that is provided to students” (Rawson, Dispensa, Goldstein, Nicholson, & Korf Vidal, 2009, p. 207) in simulations for continuing healthcare education is a research challenge that continues to go unresolved (Tobias & Duffy, 2009).

Some educational researchers have devoted themselves to searching for the precise mix of multimedia features to incorporate into interactive learning environments such as simulations (Mayer & Alexander, 2011), but definitive one-size-fits-all prescriptions have not been found. Perhaps this search is ill-advised (Reeves, 2011). The authenticity of a learning simulation largely depends on individual differences such as motivation, readiness, and previous knowledge. Melanbacher (2010) reminded researchers and practitioners alike that "we should always remember that [authentic] tasks have both an objective dimension and a subjective one, where the latter represents the learner's perceived experience of the task, whether as simple, dull, complex, or highly engaging" (pp. 234-235). Ultimately the search for universal multimedia design principles may be less successful than the creative crafting of simulation designs, guided by relevant heuristic design principles when available, that are subsequently refined through rigorous cycles of formative evaluation (Harteveld, Thij& Marinka, 2011). This is essentially what educational design researchers strived to do (McKenney & Reeves, 2012).

Educational Design Research for Simulation Development

Over the last 20 years, a genre of research known variously as "design-based research" (Kelly, 2003), "design experiments" (Brown, 1992; Collins, 1992; Reinking & Bradley, 2008), educational design research (van den Akker, Gravemeijer, McKenney, & Nieveen, 2006; Kelly, Lesh, & Baek, 2008; McKenney & Reeves, 2012), "engineering research" (Burkhardt, 2006), and "formative research" (Newman, 1990) has emerged. Anderson and Shattuck's (2012) analysis of the past decade of design-based research studies led them:

> to concur with Dede, Ketelhut, Whitehouse, Breit, and McCloskey's (2009) claim that "DBR offers a 'best practice' stance that has proved useful in complex learning environments, where formative evaluation plays a significant role, and this

> methodology incorporates both evaluation and empirical analyses and provides multiple entry points for various scholarly endeavors" (p. 16). However, as promising as the methodology is, much more effort in this and other areas of education research is needed to propel the type of education innovation that many of us feel is required. (p. 24)

If simulations are to play a major role in fostering conceptual change and others types of higher order learning in continuing healthcare education, they must become the focus of large scale development initiatives employing educational design research strategies (McKenney & Reeves, 2012). Traditional instructional design approaches (Branch, 2009) whereby developers attempt to apply isolated multimedia design principles derived from experimental studies are insufficient for dealing with the complexity inherent in the types of learning simulations that are capable of fostering profound conceptual change among healthcare professionals. Jonassen, Cernusca, and Ionas (2007) delineated the limitations of instructional design as commonly practiced and went on to describe how they conducted design research in developing web-based simulations that help biology students comprehend "the effects of environmental perturbations on gene flow between two populations" (p. 51). The authors stated that whereas formative evaluation within the context of instructional design focuses only on the instructional materials, the formative experiments that characterize educational design research make more of an effort to "consider the process and the context in which learning takes place" (p. 48).

This consideration of process and context noted by Jonassen et al. (2007) is pertinent to the major outcomes of educational design research: an intervention (in this case, simulations) and theoretical understanding. Educational design research begins with the identification of a significant educational problem in need of creative solution and appropriate for scientific inquiry. Enhancing the conceptual knowledge of healthcare professionals represents precisely the kind of challenge that educational design research is intended to tackle. While the scope of any given research initiative can vary, the intention of educational design research is to produce two main outcomes. First, it enables the conceptualization, design, prototyping, and refinement of a practical solution to the complex challenge with which the research project began (Bereiter, 2002; Edelson, 2001). Second, it leads to the development of enhanced theoretical understanding, often in the form of design principles (Bell, 2004; Kali, 2008). Ideally, and in many documented cases, participating in educational design research also fosters professional development for all involved, e.g., researchers, teachers, subject-matter experts, and others (Bannan-Ritland, 2008; Reinking & Bradley, 2008).

Educational design researchers can also probe the reasons why, despite substantial evidence of their effectiveness, simulations have not been more widely adopted within the context of continuing healthcare education (McGaghie et al., 2009). Dornan, Scherpbier, and Spencer (2008) called for more research "to promote the transfer of simulation education to practice settings" (p. 562). This requires a solid on-the-ground understanding of the factors that influence adoption and uptake of new ideas and resources, such as simulations. McKenney and Reeves (2012) offer detailed guidelines for educational design researchers to help them attend to implementation and spread from the onset of an educational design research initiative (see Figure 1).

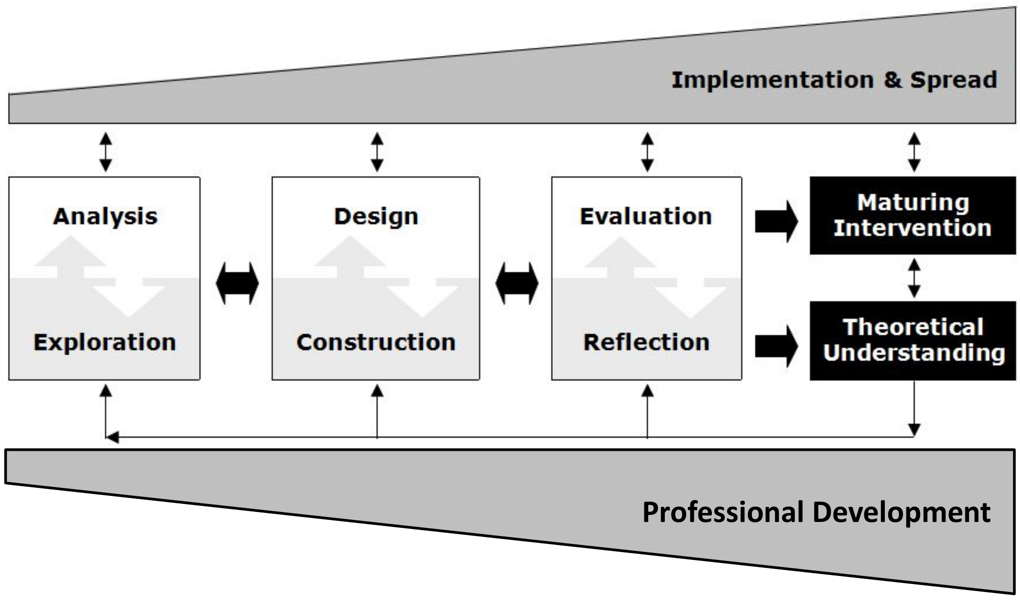

Figure 1. Educational design research model (modified and adapted from the generic model in McKenney & Reeves, 2012).

McKenney and Reeves (2012) defined implementation as the process of adopting, enacting and sustaining interventions within the context for which they are developed, and spread as the process of disseminating and diffusing interventions and insights for use in other contexts. Issenberg and Scalese (2009) identified curricular integration as one of the challenges that anyone involved in developing or deploying simulations in healthcare education must address. According to McKenney and Reeves (2012), a key consideration is acknowledging that implementation does not come after design, but even influences the final product. As they state:

> Even though actual implementation and spread cannot take place until an intervention has been constructed, researchers and practitioners jointly anticipate and plan for it from the very first stage of analysis and exploration, e.g. by tempering idealist goals

> with realistic assessments of what is possible; by taking practitioner concerns seriously; and by studying what intrinsic motives and natural opportunities are already present in the target setting." (p. 159)

McKenney and Reeves (2012) also offer multiple practical strategies that educational design researchers can use to address curricular integration in particular, and implementation and spread in general. These specific strategies as well as the overall design research approach provide highly relevant starting points for creating simulations for continuing healthcare education that stand to be taken up and used by practising professionals.

The Contributions of David H. Jonassen

Although many hurtles must be overcome before simulations are adequately adopted by the continuing healthcare education community, Jonassen has established many of the benchmarks that must be met as well as established several critical signposts on what will inevitably be an arduous journey. For example, his work has established conceptual change as a paramount outcome of CHE (cf. Jonassen, 2006). In addition, his research has defined and refined many of the theoretical constructs underlying the design of interactive simulations for CHE, e.g., constructivism as a philosophy that informs and shapes the pedagogical strategies found in effective learning simulations. He has highlighted the merits of design research as an alternative to traditional instructional design in efforts to develop robust learning simulations (cf. Jonassen et al., 2007). Perhaps above all else he has set the standard for rigorous scholarship that all educational researchers who seek to engage in socially responsible research should emulate (Jonassen, 2011).

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