Educational Communications and Technology: Issues and Innovations

Brad Hokanson
Gregory Clinton
Monica Tracey *Editors*

The Design of Learning Experience

Creating the Future of Educational Technology

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Educational Communications and Technology: Issues and Innovations

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The 2014 AECT Summer Research Symposium Experience: Learning, Design, and Opportunity Bearing Fruit

The AECT Summer Research Symposium is an extraordinary research and writing support event that has been offered on several occasions since 2006. Each of the symposia has been framed around a distinct theme relating to current trends and interests in the broad field of Educational Technology. The previous symposia have been chaired by Brad Hokanson and Andy Gibbons in 2012 (*Design in Educational Technology*); Leslie Moller and Jason Huett in 2010 (*The Next Generation of Distance Education*: *Unconstrained Learning*); Barbara Lockee in 2008; and Leslie Moller and Douglas M. Harvey in 2006 (*Learning and Instructional Technologies for the twenty-first Century*). The symposium meetings have been strategically scheduled to overlap with the AECT summer leadership meetings and are normally conducted at the same venue as the upcoming AECT convention in the fall. I have assisted with the two most recent symposia and served as a reviewer.

Participation as an author in an AECT Summer Research Symposium entails having an idea or project to write about, submitting a proposal in the form of a chapter draft, and, if the proposal is accepted, reading all the other accepted drafts, attending and actively exchanging feedback at the meeting, and adhering to a publication schedule after the event. Participating in a symposium provides a rich opportunity for robust intellectual discourse, stimulating keynote presentations, lively exchange of ideas, and emergence of creative solutions to problems, not to mention good food and fellowship. The 2014 Summer Research Symposium in Jacksonville was no exception. In addition to the primary content and interaction sessions of the event, which included stimulating keynote presentations by former Kauffman Foundation board member and innovation scholar Dennis Cheek, the gathering included a lunchtime design-reflection excursion to the Jacksonville Museum of Contemporary Art (http://www.mocajacksonville.org) and a dinner trip to Jacksonville Beach.

At the heart of the 2014 symposium experience were the Pro-Action Café sessions (see http://www.artofhosting.org). The adapted version we used, under the able leadership of Brad Hokanson, provided specifically structured, 2-h interaction sessions for authors. These consisted of an initial brief description of projects by those participating as authors for that particular session, followed by a series of feedback discussions around "café" tables (at least there was abundant coffee available in the meeting room, so the name seemed to fit well), with rotating groups of no more than four other participants at a time, with authors remaining stationary; this sequence was followed by only authors remaining in the room at their tables for a time of individual processing, reflection, and note-taking. In these sessions, an author could expect to receive thoughtful feedback from multiple other authors who have read the author's submitted draft.

The 2014 Design Theme

The focus of the 2014 symposium was on design, building upon the theme of the previous design-focused symposium in 2012, *Design in Educational Technology* (Hokanson & Gibbons, 2014). This time, with *The Design of Learning Experience*, the appeal to authors was to go deeper and apply design, and design issues, to questions and understandings as to how learning actually happens. "We have reached the point where we need to move beyond the concept of designing instruction and seek to understand how learning occurs" (Association for Educational Communications & Technology, 2014, p. 1).

With this emphasis more pointedly on the learning experience, but on design as well, the call for proposals could be viewed as inviting a bridge between a learning sciences focus (see Bransford, 1999; Sawyer, 2006) and educational technology/ instructional design. That this focus found expression in the chapter proposals is attested to by the occurrence of some form of "learner" or "learning," in the wording of 10 out of the 17 chapter titles, whereas "instruction" occurs in only two of the titles. While an in-depth discussion of the relation between educational technology and the learning sciences is beyond the scope of this chapter, it may be useful to mention briefly what these labels represent.

Educational technology will be familiar to most of the readers of this book. As a distinct field, it has seen a variety of names; these tend to be used synonymously, but are sometimes viewed as implying different emphases. Commonly used names of the field include, but are not limited to, educational technology, instructional technology, instructional design and technology, and learning, design, and technology. The three areas of inquiry most associated with this field are theories of learning and instructional models; design and instructional design; and integration of technology tools to support learning.

The AECT publication *Educational Technology*: *A Definition with Commentary* (Januszewski & Molenda, 2008) presented a concise definition statement:

> Educational technology is the study and ethical practice of facilitating learning and improving performance by creating, using, and managing appropriate technological processes and resources (p. 1).

The educational technology field traces its roots back to the early twentieth century and the rise of educational research, and counts among key influences all three of the major philosophical perspectives on learning associated with the last century: behaviorism, cognitivism, and constructivism.

A description of the learning sciences can be found in the opening pages of the *Cambridge Handbook of the Learning Sciences* (Sawyer, 2006). At the heart of this description, offered by Keith Sawyer, is a listing of the various fields that have come together to form and pursue interdisciplinary endeavors. It is interesting to see that this list includes instructional design:

> The sciences of learning include cognitive science, educational psychology, computer science, anthropology, sociology, information sciences, neurosciences, education, design studies, instructional design, and other fields (p. xi).

Growth of early research efforts led eventually to the first Learning Sciences conference in 1991. Later, the approach of the new millennium saw the publication of what was widely regarded as a definitive statement about the learning sciences, the U.S. National Research Council report *How People Learn*: *Brain*, *Mind*, *Experience*, *and School* (Bransford, Brown, & Cocking, 2000). This edited book offered a consensus view of what was known about learning, and about the priorities of promoting effective learning, based on research evidence. These priorities have been summed up by Sawyer (2006) and are given here in brief:

- *The importance of deeper conceptual understanding*
- *Focusing on learning in addition to teaching* (Students can only learn deeper conceptual understanding by actively participating in their own learning.)
- *Creating learning environments* (Learning sciences research has identified the key features of those learning environments that help students learn deeper conceptual understanding.)
- *The importance of building on a learner's prior knowledge*
- *The importance of reflection* (pp. 2–3).

As another collaborative effort, *The Cambridge Handbook of the Learning Sciences* (Sawyer, 2006) was presented as the successor publication to *How People Learn*. "The *Cambridge Handbook of the Learning Sciences* (*CHLS*) picks up where this NRC report left off" (p. xii). Major sections cover foundations, methodologies, the nature of knowledge, making knowledge visible, learning together, and learning environments.

This emphasis on deeper learning as over instruction has not only continued in Learning Sciences research; it has also greatly influenced educators and professionals who continue to identify with the educational technology field but draw from a broader literature base. One illustration of this influence is the design studio curriculum within the University of Georgia's Instructional Technology program (now called Learning, Design, and Technology) that has prepared instructional designer/developers and teachers since 1998 (Clinton & Rieber, 2010). This curriculum reflects a constructivist philosophical perspective and incorporates theoretical and pedagogical approaches associated with major contributors to the learning sciences, such as constructionism (Papert, 1991) and situated cognition/situated learning (Brown, Collins, & Duguid, 1989; Lave & Wenger, 1991). The UGA program name change, from Instructional Technology to Learning, Design, and Technology, initiated in 2008, also reflects a conscious updating of the name to better represent the program's emphases as they had existed for more than a decade. (Subsequently, at least two other universities changed their educational technology program names to Learning, Design, and Technology—with minor variations in punctuation: The Pennsylvania State University and Purdue University.)

With all of this emphasis on learning, and with program names being updated, it is perhaps understandable that some instructional designers would begin to search for a more modern title. There is room for caution, however, in regard to adoption of the increasingly popular moniker "learning designer," or expressions such as "learning design" or even "the design of learning experience." On the one hand, scholars and practitioners of various stripes in our field should favor this obvious lens for viewing our work. But designers would do well to remember B.F. Skinner's view of "constructing learning" and its relation to more modern views (e.g., Jonassen, 1991). The idea of constructing learning was present in the seminal writings of Skinner promoting teaching machines, which were in many ways the precursors to computer-based instruction. In the introductory section of *The Technology of Teaching* (1968), Skinner reviewed "three great metaphors" in use in the field of education: growth or development, acquisition, and construction. However, in Skinner's view, it was the *teacher* who constructs learning in the student. This was accomplished via the arrangement of contingencies of reinforcement. "The *behavior* of the student can in a very real sense be constructed" (p. 4, italics in original). This view is alien to the view that learners create their own meaning; but the same metaphor of construction is being employed in both cases. Modern designers should consider carefully what it is they mean when they claim to be doing "learning design." Are they claiming to control the learning, as Skinner did? Does a learning designer design the perceptions and memory-formation of the learner?

If we equate learning with meaning-making, and if we accept the premise that meaning-making, ultimately, is a deeply personal process, then we should ask ourselves whether we claim to be designing the meaning-making itself. When the question is put this way, it appears obvious to me that the answer must be no. What we design allows and encourages the meaning-making to happen; we design for learning but what we design is not a blueprint for the learner's meaning-making. We design with a view to learning outcomes, but we do not dictate specifications to which the details of the meaning-making *process* must conform. When our work is framed as designing *instruction*, we can meaningfully claim to be creating such a blueprint, since we presumably have a degree of legitimate expectation that our specifications will be followed (by developers or by instructors). The terminology works because what we are designing is external to the learner. Not so with the learning itself.

Thus there is an argument that can be made against the adoption of the title "learning designer." However, it seems likely that practitioners and scholars will not view such a microscopic deconstruction of this title as having enough weight to influence day-to-day practice, or to affect what should go on a business card. Nonetheless, regardless of one's epistemological orientation, this distinction—between "designing learning" directly and designing *for* learning—is important for our understanding of our roles as educators and should be preserved in our discourse. Wide use of "learning design," if not accompanied by clear thinking, could invite the distinction to be muddled; thus, the general intent of the title, to privilege learning, could ironically lead to a diminishing of careful regard for its nuances, for the very personal and idiosyncratic process that is learning.

Each designer must come to his or her own best understanding of learning and design. But it matters how we frame our discussions of design and learning in graduate programs. Are we helping our students to understand this distinction?

Be these issues as they may, the 2014 AECT Summer Research Symposium has produced an impressive array of chapters focusing on learning and design topics, from a group that includes some truly formidable scholars. The topics range widely, from teaching complex thinking skills, to designer-as-guarantor, to instructional design as feminist practice, to a long view of the future of learning, and 13 other intriguing pieces. Participating in the conversations that helped shape the refinements of these chapters was an enriching experience that has made important contributions to my own scholarship. I highly recommend this experience to my colleagues at all institutions.

Athens, GA, USA Gregory Clinton

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Introduction

Brad Hokanson

In the field of educational technology we have reached the point where we need to move beyond the concept of the design of *instruction* and seek to understand *how learning occurs*. Most simply, this will change our semantics; at a deeper level, it will change our orientation from instructors and information to learners and learning; it will change how we design; and it will change how we take advantage of new and old technologies. What small or grand changes can we make to focus on the learners themselves? What changes should be made, to encourage and ensure learning? And what changes should be made within the full range of learning beyond content?

This orientation also precludes a different form of instructional design as well, one which embraces constructivism as a method and as an outcome, and one which allows for exploration and engagement, one which is less about delivery and more about involvement. Designers are often driven to produce finished solutions, and not to provide opportunities for others to invent their own. How should we develop designers to create open-ended learning experiences as opposed to set pieces of structured information? How does one learn to create constructivist learning experiences? How does one design the invisible?

Two divergent yet parallel themes formed the framework of the 2014 AECT Summer Research Symposium; first was an examination of how we can design the experiences of learning, with a focus on the learner and the process of education; and second, how we learn to design educational products, processes, and experiences. These two themes and their interaction through the symposium shaped our investigation and our discussions, and the subsequent writings.

For this symposium, concepts that focused on the design of experiences for learning were solicited from the membership of AECT, the Association of Educational Communications and Technology. They were reviewed by a team of experts and the

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symposium leaders. Selected authors were asked to develop their proposal ideas into full-length chapters which were reviewed by the other symposium participants. All authors gathered for the in-person symposium held in July 2014 in Jacksonville, Florida to participate in additional discussions and development. The discussions of the writing were rich, intense, and engaging, and formed the basis for subsequent drafts and shared reviews by all authors. Divergent experiences during the symposium also enriched and balanced the discussion; the process has been described more fully in the Preface by Dr. Greg Clinton. Building from this event, the 17 authors and teams of authors have developed their best ideas and explorations, interacting with each other on a detailed and professional level, to form the chapters of this book. This experience has been essential to the development of this volume.

The in-person sessions of the symposium were structured using the methods of participatory leadership from the Art of Hosting movement; it was a significant departure from conventional academic conferences, moving from concurrent paper presentations to iterative small group discussions around each written piece. Authors worked together in a "Pro-Action Café" format of structured discussions. In our use of Pro-Action Café, each chapter author hosted three intense discussions with four or five other discussants. An initial keynote presentation was made by Daniel Cheek on the final day of the symposium, and it is included in this publication. His work begins this publication, with an examination of the future role of instructional design…and education. Challenging our own status quo, Cheek outlines the many important roles that instructional design, designers, and those in educational technology must play.

Karen Kaminsky, in a case study, examines how those training teachers for adult basic education used a constructivist model to develop instruction in critical thinking and problem solving. With a goal of helping adult learners gain the same skills as including in the Common Core standards for high school graduates.

Within that same realm of constructivist-oriented instruction, Jill Stefaniak focused on the use of a cognitive apprenticeship to help develop new college faculty, seeking more contextually relevant learning experiences.

Simon Hooper, Michael M. Rook, and Koun Choi directly examined the processes of the instructional design studio, seeking to redesign the studio for presentation as a hybrid course. Their chapter reports on two goals of their project; the development of essential computational competencies and a focus on peer collaboration for learning.

Elizabeth Boling and Colin Gray looked deeply into the process of instructional design, and how design is performed in studio. Sketching learning objects and the learning process leads to different results for our design processes; this writing describes the value of integrating visualization into instructional design.

Collaboration is an important aspect of the design and learning process, as Monica W. Tracey describes her investigation into how collaboration affects complex and ill-structured design. Working with a large scale medical educational project, this interaction between designers provided both procedural and conceptual value.

Shenghua Zha and Andrea H. Adams examine how perceived prior learning can impact involvement and engagement with instructional content; they outline strategies to increase involvement of learners.

Marisa Exter, Rich Dionne, & Christopher Lukasik have authored a case study of the implementation of a new university program with a focus on the learning experience through studio- and seminar-based experiences. A pragmatic challenge, their writing examines both pedagogy and organizational strictures.

John Baaki and Monica W. Tracey use a metaphorical approach to their investigation of the reflection-in-action of instructional designers. "Fatwood" is the incendiary metaphor that is sought from experienced teachers and designers. That concentration of learning effort is examined in Amy Grincewicz' examination of accelerated educational programs, a growing trend in professional education. Prior learning is critical for understanding in both cases, and indicates a societal benefit of lifelong learning experience.

Robert Kenny and Glenda Gunter address the topics of creativity and critical thinking through use of the STEM disciplines to benefit all students. Through their research, they illustrate the value of what they call "engineer-think" to develop these critical skills in learners. At the same time, there is also value in examining the roles of learner and context that are evident in aesthetically oriented learning experiences. Colin Gray highlights the importance of learners constructing their own understanding in the design process.

Jennifer Maddrell examines the important model of service learning, building on her own history of creating organizations to offer a broader educational experience for students. She examines the theory, design, and research of virtual service learning. Katy Campbell explores an important aspect of the field of instructional design, the nature of the designer themselves, and learning and practice within a male-dominated and -oriented field.

Also examining the learning environment from a view outside the mainstream, Angie Calton, Xun Ge, Melody Redbird-Post, & Moge Wang present research on a community-based learning model for the Kiowa language. Language inherently shapes our thoughts, and maintaining a living language is essential to human society.

Finally, as we are entering the age of data visualization and analysis, Sanghoon Park presents his examination of online learner activity and interaction, shedding light on how we learn online.

This varied endeavor, a diverse exploration of the world of learning experience, gains its value from the participants. They are the ones who have shared their findings, their efforts, and their involvement in the process. This wide ranging collection is a sample of the leadership of the field. It would not be possible without their work and participation.

Similarly, the Summer Research Symposium and this resultant publication would not exist without the backing of a great organization, the Association for Educational Communications and Technology. I would like to strongly thank Executive Director Phil Harris for his ongoing support and insights in the presentation of the symposium and for his efforts in the publication of this book, as well as the leadership of AECT for their backing. Additionally, Jason Huett, Greg Clinton, Andy Gibbons, and Monica W. Tracey have all served as the symposium advisory board, reviewed initial proposals and acted as essential voices of reason in the process. Stephen Peters has again been of great value for his editorial help and humor in his side comments.

A Panoramic View of the Future of Learning and the Role of Design(ers) in Such Experiences

Dennis W. Cheek

Design: "The conception and realization of new things."

(Parrish, 2014, p. 261)

Abstract Despite the evident success of current learning systems in Pre-K-12 education, higher education, and workforce training, it is increasingly clear that these systems have failed to keep pace with what we know about how and under what circumstances human beings learn. Learning systems are highly impervious to the kinds of systemic changes required for twenty-first century learners, including reliably learning and mastering new skills and knowledge on demand across their entire lifespans for both work and general success in life. At least five key areas must be worked on in an iterative and dynamic manner if we are going to make substantial progress in creating a sufficiently disruptive environment for learning to be substantially accelerated for ALL human learners in this new century. These five areas are: (1) the nature of learning across the human lifespan, (2) recent and emerging technologies, (3) assessment and evaluation, (4) transitions from the old systems to the new "system," and (5) sociocultural dimensions from a global perspective. I briefly outline each of these areas. Design(ers) can and must play many important roles in helping to move this agenda forward. An R & D effort of unprecedented proportions is proposed and preliminary steps outlined.

Introduction

I am not a "professional instructional designer" and my sole formal collegiate education in this general arena was a graduate course on principles of instructional design, which I took under Professor Francis (Frank) M. Dwyer at Pennsylvania State University in 1988. My biggest take-aways from his class included: (1) that

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good instructional design was very hard work requiring extensive and extended iterations, (2) work should be informed by one or more theories (but always be distrustful that such theories actually "work" in the real world), (3) there is no substitute for large data samples and well-designed experiments, and (4) even at their very best, instructional materials never work equally well for all learners. It is exactly this focus on *learners* that has guided, stimulated, challenged, disturbed, and animated my work as a teacher, educational administrator, manager, policy maker, funder, and leader.

Thinking About Learning

As I wrote in the 2009 *Kauffman Thoughtbook* (Cheek, 2008, p. 22):

> Learning is at the very core of what it means to be human. Even before we are born, our senses are already at work as we process information from the outside world. An intricate dance begins between our inner self as known through thought, emotions, and self-regulation, and our outward self as known through perception, speech, and behaviors … Before a child enters kindergarten, she has already mastered at a highly proficient level at least one language (often two or three), grasped in amazing detail fundamental aspects of the social and physical world, formed friendships and bonding relationships with others both near and far, and learned important life lessons. Above all, one is impressed by the seemingly endless curiosity of children about the world, the ways in which it seems to work, and that endless query to others—"Why?"

The crucial question is how we can exploit the innate human propensity of even young learners to question, explore, and "yearn to learn" and make these attributes pervasive across learners throughout their lifetimes? A subsidiary question is "What role should both design and designers play in advancing such efforts?" I noted in my earlier essay:

> Learning is a concept with much broader connotations and applicability than education—the latter, a word that conjures up immediately a particular set of structures and functions that are the serendipitous outcome of history, culture, political power, geography, economics, and sociology. Learning is a fundamental aspect of human life throughout our days on Earth and provides a point of linkage among our lives as citizens, employees, family members, leaders, and social creatures. There is much we do not understand about how people learn, whether at the fundamental physiological level of perception, attention, and memory or in the more sociocognitive dimensions of goal orientation, problem solving, information processing, organizing, collaboration, and decision making. (Cheek, 2008, p. 23)

Despite these shortcomings, we know far more about human learning at this point in human history than any generation that has preceded us. Yet a "walkabout" (that lovely Australian word) through the wilderness of formal "educational learning environments"—whether in K-12 systems, higher education, or the world of global corporations—reveals in a startling manner a set of practices that seem directly at variance with what we think we know about learning at this point in the twenty-first century (Blindenbacher, 2010; Duderstadt, 2000; Heiphetz & Woodill, 2010; Kirkpatrick & Kirkpatrick, 2010; Seel, 2012; Tippins & Adler, 2011). While certainly not true in every case or every locale, we can observe the following strong *system* tendencies:

- Learning is age-centered or role-centered rather than ability or capability-centered, as evidenced in various national curricula documents from around the globe.
- Knowledge and skills are introduced in a linear, chunking fashion with predefined, standardized prerequisites that produce one and only one learning "track" as seen in the recent US "Common Core" standards effort, or a series of such discrete tracks.
- Time is an important organizing principle in terms of how information is organized and presented and forms the general parameters within which acquisition by learners is measured. Much of this "learning" time fails to translate into long-term student memory, new skills, or autonomy as learners.
- The upper levels of these formal systems define in large measure all that is to be learned at lower levels with little exception; the upper levels seem narrowly focused on only a few desirable sociopolitical, economic, or societal ends.
- Many individual learners within these systems are "off-task" as much as 50 % or more of the time with little evidence of the highly motivated, exploratory behavior seen in young children or in older individuals outside of formal educational settings.
- The standard solution for dealing with a learner who has failed to attain the requisite information or skills is to repeat the same set of processes one or more additional times until either judged suitable or motivation to continue is extinguished.
- The only learning that is "recognized" by the formal systems is the learning that is acquired within them; anything the learner brings to the environment is largely ignored or viewed as irrelevant.
- Very few opportunities are presented for learners to make personal or social "meaning" of information, processes, or skills within a wider context that transcends the focus of the activity of the moment; rarely are practical applications employed as suitable contexts for learning and transfer to other contexts outside the focus of the initial experience is limited or entirely absent.
- There is an extremely large "disconnect" evident among the three major formal learning systems (prek-12, higher education, and corporate learning) in terms of desired outcomes and how knowledge and skills from one system effectively relate/translate to one of the other two systems. People often appear to be "learning" the same things all over again, just in a different setting or context.

Despite these evident shortcomings, and many more that could be mentioned, a dispassionate observer would note that all three systems achieve a reasonably high percentage of "success" at what they purport to do. The credentials granted by the three systems are widely deployed around the globe and convey distinct and measurable economic and social advantages to holders of these credentials (Cheek, Santos, & Vaillant, 2015). Despite calls over centuries for fundamental reforms and the evident success of some of these reforms (e.g., moving well beyond the classical curriculum of ancient Greece and Rome, although one suspects an ancient Greek philosopher would still recognize the historic relationship), the *basic* outlines of these systems are little changed from ancestral systems that developed in Europe and beyond in the period of the Industrial Revolution and the nascent Mass Manufacturing Age.

So Much Reform, So Little Progress

Sociopolitical systems as well as individual organizations and persons have advocated over the centuries for fundamental changes to formal educational systems. We can think of some of the great names in the history of education like Plato, Socrates, Maria Montessori, Johann Herbart, Friedrich Froebel, Marie Clay, Booker T. Washington, Horace Mann, Charlotte Mason, Edward Thorndike, Paolo Friere, Clark Kerr, John Dewey, and Russell Ackoff who put forward visions of how formal education might be different. Several of these thinkers and others like them launched or stimulated a school or networks of schools that tried to actualize their ideas (Bowen, 2013; Fullan, 2012; Hess, 2013; cf. Sahlberg, 2011). In America alone the last 50 years have witnessed a plethora of state and national reform efforts to transform pre-K-12 education including basic education, open-spaced learning, *A Nation at Risk*, *Rising Above the Gathering Storm*, charter schools, prekindergartens, bilingual education, community learning centers, small high schools, comprehensive high schools, curriculum and assessment alignment, constructivist teaching, multiculturalism, outcomes-based assessment, *No Child Left Behind* (and its two predecessors *Improving America's Schools Act*, *Elementary and Secondary Education Act*), integrated schools, free and reduced lunch, College Bound, SAT and ACT, NAEP, teacher professional development plans, IEPs, Common Core, middle schools, individualized and self-paced learning, total quality approach, online and mobile learning, 2 + 2 programmes, service learning, and standards-based instruction (e.g., consider just the arena of online and mobile learning as explored in Aspen Institute Task Force on Learning and the Internet, 2014; Bowen, Chingos, Lack, & Nygren, 2014; Honey & Hilton, 2011; Kampylis, Law, & Punie, 2013). Over the same time period, understandings about the malleability and plasticity of human intelligence have advanced exponentially (Nisbett et al., 2012; The Royal Society, 2011; Shors, 2014) and edupreneurs along with a vibrant set of education industry investors annually explore at forums such as the Education Growth Summit in New York City and SkySong—the ASU Scottsdale Innovation Center, yet further innovations that might result in desired breakthroughs in formal schooling.

A fair summary of the American scene, and one applicable in varying degrees elsewhere around the world, is that while much has changed on the surface, most things remain the same in terms of the deep overall structure and function of formal educational systems (Cuban, 2008, 2013; Payne, 2008). The late analytical philosopher of education Thomas Green (1980) in his seminal book, *Predicting the Behavior of the Educational System*, dispassionately explained why this is so in a manner that has not been equaled. Public dissatisfaction with formal education and its results has also continued unabated while at the individual family level, satisfaction or dissatisfaction with the system hinges most directly upon the extent to which fulfilling system demands has led to desired economic and social opportunities. American parents from varied socioeconomic and ethnic backgrounds when queried still rate the school their own K-12 child attends for example, as at least a "B," despite independent markers that suggest such schools run the entire continuum from "A" to "F." There is a startling predictability about formal educational systems that transcends the particularities of a single nation, state, or institution around the world and whether they are public, private, or parochial institutions. The same fundamental things can be said for corporate universities and the world of higher education, although these systems are far less transparent to outside observations and monitoring than prek-12 education. Throughout these systems there is frequently as much or more variation in quality of services and learner results within single entities than there is across entities.

Speculation about the causes of the perceived minimal progress of reforms in education—and whether such perceptions are in fact real artifacts—have been debated for decades both within and outside the academy. Little consensus exists, leading to continuous waves of new reforms designed once again, in the words of proponents, to radically transform education. Virtually all of the prior and existing approaches to transformation suffer from two serious flaws:

- They tend to accept as a given the underlying *explicit and implicit* assumptions of the current systems.
- They fail to reckon seriously enough with known properties of systems that include reinforcing feedback loops, sociopolitical realities, benefits and rewards structures, rights and contractual obligations, historically conditioned expectations of those both within and outside the system, and well-understood and predictable connections and "negotiated" relationships among various actors, levels, subjects, and objects.

As Thomas Green (1980) argued, the "system" has a way of gobbling up innovations, stripping them of their most potent transformational elements, and incorporating them into the system in a manner that allows major pathways, rights, responsibilities, work patterns, incentives, labor rules, administration, and outcomes of the system to remain intact—impervious to deep and lasting changes. There are then *structural* reasons why innovations fail to scale, fail to outlive their champions, and rarely have true transformative impacts. This is also why widely heralded recent ideas in American educational reform such as disruptive innovation (Christensen, Horn, & Johnson, 2010), charter schools (Wohlstetter, Smith, & Farrell, 2013), MOOCs (e.g., Coursera, Udacity, edX), and the recent flurry of new interest in competency-based degree programmes and badging systems (Alliance for Excellent Education, 2013; Klein-Collins, 2012) are likely to fall far short of their promoters' expectations.

At the same time that the institutional structures and formal processes of education have remained relatively stable, wider societal changes have significantly altered learning needs. The average male life expectancy in America in 1900 was 48 years so that a newly minted college graduate was almost at the halfway point of their life expectancy. Today an American male's life expectancy is 76 years of age and a male college graduate has about two-thirds of their life still ahead of them—and even more in the case of American females and their longer life expectancies (Arias, 2012). The steep erosion of retirement savings coupled with attendant rises in human life expectancy, better health care, and an anticipated demand for older workers, requires that we have adequate and powerful means for learners to continue to learn across their lifespan rather than in a few concentrated decades at the start of their lives. The pace of technological change and growing complexity within globally linked economies also means that workers will increasingly have several occupations throughout their lifespans, including some jobs that have not yet been invented (Soares & Perna, 2014). These demands are growing around the globe and require a continually upgrading workforce if economic growth is to be optimized. The age pyramids of industrialized nations in particular and the rising costs of retirement for citizens around the globe suggest that the mean age of the workforce will continue to rise along with increasing skills and knowledge demands throughout their shifting work careers (American Association for Colleges of Nursing, Association of American Medical Colleges, 2010; Dutta, Patil, & Porter, 2012; Hatum, 2013; Kluge, 2013). This will place a premium on a societal need to focus even more on adult learners who have dispositions, abilities, skills, and orientations towards learning quite distinct from those of younger learners (Knowles, Holton, & Swanson, 2005; Merriam & Bierema, 2013).

No Progress at All for Too Many Citizens

There has been a tremendous inability of human society as a whole to educate all learners despite the lofty but increasingly hollow words of Article 26 of the Universal Declaration of Human Rights, which was approved by 48 nations in 1948 and made part of international law in 1976 (www.un.org/en/documents/udhr). The Article declares:

- (1) *Everyone has the right to education. Education shall be free, at least in the elementary and fundamental stages. Elementary education shall be compulsory. Technical and professional education shall be made generally available and higher education shall be equally accessible to all on the basis of merit.*
- (2) *Education shall be directed to the full development of the human personality and to the strengthening of respect for human rights and fundamental freedoms. It shall promote understanding, tolerance and friendship among all nations, racial or religious groups, and shall further the activities of the United Nations for the maintenance of peace.*
- (3) *Parents have a prior right to choose the kind of education that shall be given to their children.*

Over one billion people entered the twenty-first century unable to read a book or sign their name and an estimated 67 million primary-age children worldwide were out of school in 2008 (UNICEF, 2012). In far too many jurisdictions, including in rural and urban America, there are still poor facilities, poorly trained teachers, and mobile students in poverty who spend large portions of an academic year learning very little. The National Assessment of Educational Progress (NAEP) in the United States in its 2013 administration of tests in mathematics and reading found 74 % of the 11 participating states' 12th grade students below proficiency in mathematics and 62 % below proficiency in reading. While better results were seen in grades four and eight across all 50 states, the overall observation of significant proportions of US students below proficiency holds at all three grade levels and overall results have held pretty constant going back to the early 70s (Institute for Education Science, 2013, 2014a, 2014b). At the international level, both the Programme for International Student Assessment (PISA, 2014a, 2014b), which measures achievement in selected subjects across 34 OECD nations and 31 partner countries and economies, as well as the OECD (2014) Education Indicators annual report and the OECD (2013) Survey of Adult Skills find similarly large proportions of learners in the assessed populations below par in performance.

Certainly the lofty goals of the UN have never been achieved at scale in regards to technical and professional education being "generally available" and in far too many places, higher education access is still based upon class, culture, ethnicity, language, and other factors instead of merit (OECD, 2014). A dispassionate observer from another planet might well conclude that the governments of the world have no intention of educating ALL learners even through the level of an elementary education, let alone a high school education and beyond. If we take *quality* of accessed learning systems into account along with people who only have marginal access, it is likely that somewhere between 1/3 and 1/2 of the world's population has been fundamentally denied their basic human rights to an admittedly "implied" quality education and its subsequent benefits.

The current economic downturn in many industrialized nations has resulted in thousands of displaced workers, including a huge number with graduate degrees across many fields of endeavor. The unemployed can talk about what they have done and what degrees they hold with what kind of major(s) and minor(s) but have no idea what microanalyses of their skills, knowledge, and capabilities would reveal—if even such analyses could be validly and reliably performed. Similarly, prospective employers are frequently unable to specify in concrete, microanalytical terms what *specific* knowledge, skills, and capabilities particular jobs *require*. Historically companies resort to using degrees as surrogate "screens" for desired employee characteristics with a frequent mismatch occurring between the *actual* demands of the job in question and the *proffered supply* of skills and knowledge presented by the employee in the form of certifications of dubious merit (Brynjoflsson & McAfee, 2014; Cheek et al., 2015). The current situation highlights the deficiencies of current formal learning systems. Additionally, it seems reasonable to believe that every learner knows and can do a variety of things which have never been formally measured, evaluated, or certified by these formal learning systems.

A Way Beyond the Current Impasse

Deeply disruptive changes within society and its institutions invariably occur from *outside* the existing order of systems. Frequently these *disruptive technologies* (used in its broadest sense here and not just signifying computers and related devices) are created for a particular purpose but turn out to have unexpected applications well beyond their original use. For example, transportation via automobiles was inadvertently accelerated by paving city streets to enable horse dung to be more easily and efficiently collected in the interests of public health and safety. The WWW was initially created by Tim Berners-Lee and colleagues to accelerate connectivity and group collaboration among thousands of literally "scattered" physicists (and "physicists of scatter") associated with projects at CERN in Switzerland. Its underlying set of technical standards turned out to allow for widespread deployment of the resulting "platform" into a global phenomenon that transformed computing, commerce, culture, social relations, politics, etc., and whose end is not yet in view. Business models in music, consumer goods, media, and many fields had to be reinvented. Sometimes a disruptive technology creates a new demand unforeseen by its creators but quickly capitalized on by entrepreneurs always on the lookout for discontinuities between emerging needs and existing goods, products, and services. Many large corporations began their journey to greatness by capturing these emerging markets with a technology that already existed but that suddenly was seen to have a new use. In order for these disruptive technologies to thrive, they often must be accompanied by a whole new infrastructure that supports the radical innovations they represent. The WWW and the various software platforms, programs, and affordances that sit upon it is perhaps the ultimate current example of this phenomenon, as entire industries and services exist solely because of the continuing work of the World Wide Web Consortium that builds and maintains the underlying infrastructure on which these applications, goods, and services "live and have their being" (Evans, Hagiu, & Schmalensee, 2006).

At least five key areas must be worked on in an iterative and dynamic manner if we are going to make substantial progress in creating a sufficiently disruptive environment for learning to be substantially accelerated for ALL human learners in this new century. These five areas are: (1) the nature of learning across the human lifespan, (2) recent and emerging technologies, (3) assessment and evaluation, (4) transitions from the old systems to the new "system," and (5) sociocultural dimensions from a global perspective. I will briefly outline each of these areas with the length of the discussion roughly paralleling the amount of work going on presently in each of these five areas. These comments should be read merely as illustrative rather than in any way comprehensive or evaluative.

Area 1: The Nature of Learning in a Lifespan Perspective

We desperately need a new infrastructure for learning worldwide that embodies the best of contemporary knowledge about the nature of learning across the human lifespan. Three notable centers for this type of work are the Max Planck Institute for

Human Development in Berlin (www.mpib-berlin.mpg.de), which has conducted pioneering research on lifespan development commenced under the late Paul Baltes; the Max Planck Institute for Cognition and Brain Sciences in Leipzig (www.cbs.mpg.de); and The Learning in Informal and Formal Environments (LIFE) Center, an NSF Science of Learning Center at the University of Washington, jointly managed with SRI International and Stanford University (www.life-slc.org). This kind of pioneering work involves interrelationships among three core research strands:

- Human learning in all its variety and manifestations, with an increasing focus on real-time or close to real-time capture of learning "moves" and application of advanced analytics tools and complexity analyses
- Insights from the developmental sciences, including lifespan studies
- Insights from neurosciences and social and behavioral sciences

For example, we know from studies in chronobiology that learners of differing ages have internal biological clocks that are functioning on different "time zones." Optimal learning times for young children as well as the elderly, for example, peak in mid-morning; optimal learning times for adolescents peak in mid-afternoon. Conversely, the most *nonoptimal* learning time for adolescents is early morning and for young children late in the afternoon. Schools are daily "fighting biology" in their attempts to focus students on their learning (Kelley & Lee, 2014; Kelley, Lockley, Foster, & Kelley, 2014). This may account for why small-scale studies that look at high school students' achievement in schools that are open in late afternoons and evenings for classes often find one or more grade-letter improvements in the students' marks.

Similarly, studies about the relationship between light and living organisms (including humans) document that all living things respond to light. ANSI/IES standards for educational facilities call for about 50 foot-candles (fc) for reading while dining areas require about 30 fc. Interior lighting in general in facilities ranges from 10 to 100 or more fc, while exterior lighting ranges from 100 to 10,000 fc or more. Optimal alertness for human beings requires about 1,000 lumens per square meter; the average school classroom has at best 537 lumens per square meter—half of what is optimal. It is likely that many schools are closer to the lower end of the scale of 30 fc = 322 lumens per square meter or one-third of what is needed (Illuminating Engineering Society of North America, 2006). Today's emphasis on environmental concerns, such as energy savings, while undoubtedly important, may be at direct odds with maximizing the chances for human learning to be optimized (Gelfand & Freed, 2010).

Human lifespan studies by the late Paul Baltes and his associates over many years have demonstrated that certain human characteristics are associated with learning peak at particular points in the lifespan, others endure with relative stability, and others decline precipitously at particular points. Successful learners compensate for these fluctuations in ways that we are just beginning to understand but that suggest that such behaviors can be learned and learning for all improved as a consequence (Bornstein & Lamb, 2011; Lerner, 2015).

Another powerful example comes from studies of peer-to-peer learning. An enormous number of studies and robust findings from systematic reviews suggest that one of the most optimal ways learners learn is from one another. A novice who has now mastered new knowledge or skills turns out to be much better positioned, on average, than an expert in teaching the knowledge or skills to another novice. Despite this reasonably robust finding across ages and cultures, one does not have to look long in current formal educational systems (pre-K-12, higher ed, or corporate) to find little sustained use of this finding from research (Hmelo-Silver, Chinn, Chan, & O'Donnell, 2013).

We are in the beginning stages of new insights into how learning to read improves brain function using functional magnetic resonance imaging and other new technologies, how testing improves memory, how values affirmation for females can increase their performance in STEM subject-matter tests, and how making a text *harder* to read might actually result in more permanent and powerful memory and mastery of the material, to cite just a few examples (Dehaene et al., 2010; Diemand-Yaumen, Oppenheimer, & Vaughn, 2011; Miyake et al., 2010; Pyc & Rawson, 2010). Such advances in improving our understanding of the *basic science* underlying human learning is due to the availability of new technologies, and recent advances in psychopharmacology, genetics, neurosciences, and a host of other disciplines. We may be entering a new "century of learning" where fundamental insights can begin to more closely and powerfully inform how we *structure* learning environments—an interesting development since there is already a line of research that suggests that much of the current focus on teacher characteristics as they relate to student learning may be largely misplaced and ephemeral when it comes to really impacting learning results. Structural contexts may be far more important (Kennedy, 2010).

Application of large-scale data collection in real-time and powerful analytics that can enable insights into actual learner "moves" in pursuit of knowledge, as well as feedback into increasingly more powerful adaptive learning systems, hold promise of bringing about a much more fine-grained "science of learning" than was possible to even contemplate in the past. No longer must we just rely on laboratory experiments under artificial conditions; we can increasingly study learners in actual learning environments in real-time or close to real-time ways (Conley, 2014). The largest application of this BIG DATA approach to formal learning environments (learning analytics) at present may be at Arizona State University in collaboration with the for-profit company Knewton, Inc., founded by José Ferreira, and the educational content giant, Pearson, Inc. that builds upon prior work like the Open Learning Initiative that was created and implemented at Carnegie Mellon University (Kolowich, 2013; Education Growth Advisors, 2013a, 2013b).

Stafford and Dewar (2014) accessed data from a large-scale, online game with 854,064 subjects in their recent study of an "informal" learning environment which required rapid decision-making and motor responses. Such a large sample with extensive performance and tracking data, enabled them to link for the first time, training (i.e., skills learning) history with performance measures, over extended periods of time where effort was expended. Mention can also be made of the National Laboratory for Education Transformation (www.nlet.org) in Salinas, CA, and its partners at UT-Austin and Los Alamos National Laboratory, which has an NSF-funded project applying high-end computing and visualization applications to improve mathematics learning in selected schools in CA and TX.

Another critical element into these types of efforts is work being done on learning progressions in science and other disciplines (e.g., Alonzo & Gotwals, 2012). This is a large-scale attempt to figure out, based on empirical evidence, what typical learning trajectories look like in specific subject areas and to build conceptual scaffolding for learners that increase the probabilities that they will master requisite skills and knowledge to advance along the desired trajectories.

It is clear that much can be learned from existing systems, especially those that employ blended learning techniques with some regularity combined with the capability to amass and analyze large amount of data related to student learning in, or close to, real time, as at ASU (cf. Berman, 2013; Marz & Warren, 2013; Singer, Nielsen, & Schweingruber, 2012). It must be noted that there are significant issues of privacy, confidentiality, and other legal matters as well as issues emanating from collegiate faculty that swirl around these types of innovations and their related research (cf. Hackett & Connolly, 2013; Loshin, 2013; Rivard, 2013). A meeting at Asilomar Conference Grounds in Pacific Grove, CA, from June 1–4, 2014, among participants drawn from MOOC coalitions, other online learning university programmes, and a sprinkling of federal and private funders articulated an initial set of principles and protocols for using digital learning data as a public good (Silbey & Stevens, 2014a). They also issued a brief document outlining six principles to guide the use of digital learning data (1) respect for the rights and dignity of learners, (2) beneficence, (3) justice, (4) openness, (5) the humanity of learning, and (6) continuous consideration (Silbey & Stevens, 2014b). We must note in passing that questions of ethics also arise within the realm of instructional design and design more broadly as new types of learning environments are created to replace those that currently exist (Moore, 2014).

A final example of more scientifically grounded approaches to learning is the creation of "spaced learning," an approach based on discoveries by R. Douglas Fields' lab at the US National Institutes of Health (Fields, 2005). Fields' work was taken up by teachers in one of England's first "trust" schools (i.e., in US parlance, "charter"). Unusually, the school was set up with a specific mandate to apply new research in science and technology to learning, working with scientists and from recent research in learning. A team led at the time by Dr. Paul Kelley (now Honorary Clinical Research Associate at Oxford's Sleep and Circadian Neuroscience Institute and CEO of Science + Technology in Learning), developed a learning approach based on discoveries in neuroscience about Late Long-Term Potentiation (LTP) and the formation of long-term memories (LTM). Specifically, laboratory studies showed that when information is presented succinctly and then followed by a 10-min period of an alternate activity, with the cycle repeated two more times, relatively permanent memory retention occurs. Working in concert with researchers at the Open University and other UK universities, this approach demonstrated that spaced learning delivered over the course of a single hour of total instructional time enabled students to perform as well as their counterparts who had taken a 4-month long course (Kelley, 2008; Kelley & Whatson, 2013). Spaced learning has been taken up in a number of different countries and is the subject of further research that seems thus far to have replicated these initial and quite promising findings.

These are but a few examples of the ways in which more attention to such matters on a large scale could begin to improve learning within *current* formal learning systems (cf. Witt & Orvis, 2010). Such approaches could also be more widely applied within the so-called informal learning world. More rigorous testing of these approaches under varied conditions would provide better information to inform the design of future learning systems that more readily and routinely incorporate such insights as part of global *learning infrastructure*.

Area 2: Recent and Emerging Technologies

The second area that we must explicitly exploit is the ubiquitous nature of recent and emerging technologies within the modern world. We have already suggested that simply inserting these technologies into existing formal learning systems will, at best, achieve only marginal results because of the underlying assumptions, enshrined practices, and mutually reinforcing behaviors of the systems as they stand. A better way forward is to build out new learning environments that sit outside of the existing systems but that are accessible by learners worldwide in evermore robust, transparent, and accessible ways. These systems must *reconceptualize* at a very deep level what it means for computers and related devices to truly become and BE social machines with substantial changes to " interfaces for social interaction" that will demand the utmost imagination, experimentation, and continuous tinkering by designers of all types (Donath, 2014). We can never predict with any confidence what this "new learning world" will look like, but here are a few starting design assumptions that might undergird its evolution[1]:

- Learning should always be as fast as a learner can proceed but as slow as needed for powerful acquisition and transfer.
- Any learning content should in general be available to any learner anytime, anywhere.
- No single modality, device, tool, process, or experience should be employed to the exclusion of other learning affordance options.
- Age, gender, race, and ethnicity, religion or creed, language, socioeconomic status (SES), or other such characteristics should never dictate the terms or manner under which a learner can learn or how they must learn.

[1] Principles similar to those enunciated here are either stated differently or implied in several recent other efforts to set principles for learning such as "A Bill of Rights and Principles for Learning in the Digital Age," by a dozen people brought together by MOOC pioneer Sebastian Thrun at Stanford and publicly released January 23, 2013 and a 2010 working draft by Diane Rhoten, Laurie Racine, and Phoenix Wang of Startl called "Design for Learning in the 21st Century." (I was a member of their Advisory Board and thank them for sharing this insightful document with me.) The rights-based movement highlights issues such as the right to: access, privacy, create public knowledge, own one's personal data and intellectual property, financial transparency, pedagogical transparency, quality and care, great teachers, and the right to be teachers of learning peers. Startl's six learning design dyads are: affinity and utility, professional and amateurs, content-creation not content-delivery, distributed but integrated, physical and virtual, and embedded and authentic assessment. A scenarios-based approach to the future of learning is that of the KnowledgeWorks 2025 document (knowledgeworks.org/learning-in-2025).

- Learning should be fully enabled across the human lifespan, with as much real-time learning acquisition, capture, evaluation, and validation as possible.
- The learner should have *primary* control over the capture, assessment, portrayal, and exposure of their own learning profile to others (perhaps in an approach modeled after the highly successful use of X-road in Estonia, cf. Ansper, Buldas, Freudenthal, & Willemson, 2013; Kalja, 2011, or new for profit applications such as WICKR or ANSA, Bourne, 2014).
- Organizations and sociopolitical entities extrinsic to the learner will always set the bounds of acceptability for credentials for particular purposes, but these knowledge and skills profiles must become more precisely defined and attuned to differentiated opportunities for learners that allows continuous learning to be acquired commensurate with attainment of the desired credentials.
- Open access to learning materials wherever they may be found, with such learning resources effectively authenticated and certified, must become the norm for learners and be curated and made accessible in ways that enable easy access and use (European Commission, 2013; Schweik & English, 2012; Suber, 2012).

It is clear that learners today can be reached directly without the need for any intermediaries other than an access device, although what they access, how well they do so, and what meaning they make of such experiences are inexorably complicated (Bruck & Rao, 2013; Miller & Doering, 2014). Games are but one limited means by which to directly reach learners. The Kauffman Foundation in the period from c. 2003 to 2009, for example, demonstrated the feasibility of directly reaching learners via three distinct projects:

- *Hot Shot Business*, a property that was launched on the Disney website, was a simulation game that enabled tweens to run their own simulated businesses in competition with other tweens in the environment. Twenty-three million users worldwide played HSB over a 5-year period with the average tween spending 43 min of engagement with each visit.
- *SportsBytes*, a learning game about STEM content as it relates to sports, was developed by the foundation. A nonprofit and a for-profit company competed against one another with the goal to get 100,000 teens in 8 weeks to play the game on a cell phone. The resultant success of this large-scale proof of concept led to the adoption of the game as a free download on the Sprint platform of cell phones, and adoption by several national STEM education organizations like JETS and US FIRST Robotics.
- A pilot programme with the government of Maine for their one-child, one-laptop initiative involved placing appropriate gaming software on each laptop. Preliminary results documented that about 25 % of kids will play an academic game without prompting if it is made more readily accessible to them (www.maine.gov/miti/giti). If a game is good, they'll play it 10–12 h per week, typically with session times of 1–2 h at a stretch. Interestingly, most kids were not playing at home but during study hall or lunch at schools.

The X Prize Foundation, as a follow-on to an exploratory effort regarding X Prizes in education in the mid-2000s funded by the Ewing Marion Kauffman

Foundation, announced in September 2014, a $15 Million Global Learning X Prize. The 5-year competition will develop scalable, open-source software to teach basic English literacy in reading, writing, and arithmetic, and teams that move forward in the competition will have to show credible results in at least 100 villages in the two-thirds world (Philanthropy News Digest, 2014).

Efforts like these indicate that there are a significant number of technological and system barriers that must be overcome for a powerful new learning infrastructure to come into being. There is an amazing lack of standardization and considerable incompatibility among existing technologies. A single large phone company in America, for example, will have a surfeit of phone options for customers with many of these phone systems being incompatible with one another in terms of games that could be placed on such a device. A detailed study funded by Kauffman in 2006–2007 that was conducted by the Federation of American Scientists in collaboration with personnel from several Department of Defense agencies and other experts examined over 250 existing 3D immersive platforms to determine their functionality for learning purposes. While all were found deficient in important aspects, some were vastly more useful than others. Among leading platforms there was no common standard that would allow users of such platforms for learning purposes to, for example, move objects between worlds. Technological barriers like these, which can be multiplied many times over in Kauffman experience alone, suggest that a large-scale and sustained global effort is needed if we are going to have learning platforms that can be rapidly and continuously evolved, can communicate with other devices and systems in a more seamless and reliable manner, and can achieve cost efficiencies of time, effort, and usefulness to be widely deployed and utilized.

Success in this arena must include getting in front of bodies that set technical standards for devices, networks, and other potential learning platforms. I took a preliminary stab at this sort of venture by speaking to the group tasked to set the 4G mobile phone network standards. I spoke to them at the 2007 Fourth Generation Mobile Forum in San Francisco about the future of learning (FOL) and suggested that perhaps there were certain tweaks they could make to the standards to increase their potential as learning tools. I was told afterwards by the Committee Chair that they did indeed take these matters under deliberation and made some decisions consistent with this purpose. In a similar manner, materials of varying properties that can be used for learning purpose must also be an area of interest, e.g., the emergence of graphene that could turn out to be the “silicon of the next century” according to *Fortune*, March 18, 2013 (p. 32) and the recent work of start-up companies like *Nanophotonics Inc*., which presents the possibility of superthin and flexible displays. Materials with these or similar kinds of properties could be a basis for highly flexible, eminently portable, and ubiquitous screens for personal learning use. The rise of these types of nanocomposites creates tantalizing possibilities in creating materials with unique combinations of desired attributes that enhance learning opportunities (Hao et al., 2013; Zhou, 2013). For example Samsung unveiled a new TV (*Youm*) at the 2013 Consumer Electronics Show in Las Vegas, LG promised a 60-in. OLED screen based on an 18-in. display it unveiled at a press conference on July 6, 2014, with 1,200×810 pixels, and in October 2013 both Samsung and LG released demonstrated flexible screens for smartphones.

A third but highly contentious and ethically murky arena in the technological materials front is at the interface of the anatomy, physiology, and neuroscience of human beings. One critical body of work focuses on the role that new pharmaceutical products might play in enhancing already existing human cognitive capabilities (Floresco & Jentsch, 2011; Paule et al., 2012; Zovkic, Guzman-Karlsson, & Sweatt, 2013). A second body of work focuses on generic direct current stimulation or point-specific neurostimulation via electromechanical means (Clark et al., 2012; Coffman, Clark, & Parasaraman, 2014; Kadosh, Dowker, Heine, Kaufmann, & Kucian, 2013; Kraus & Kadosh, 2013; Rahman, Toshev, & Bikson, 2013). A good summary of current thinking regarding how the many ethical issues raised by these quasi-therapeutic methods might be approached within a regulatory environment modeled after that of medicine is provided by Maslen, Douglas, Kadosh, Levy, and Savulescu (2014). They suggest that suitable regulations be evolved within the contexts of these various quasi-therapeutic methods following similar rules making behavior used with medicinal and medical therapeutic products to minimize both possible risks to learners and insuperable regulatory barriers to further developments.

Finally, there are the challenges facing getting robust Internet and connectivity access to a world where only about 33 % of the global population has reliable and reasonably ready access, e.g., Google's recent LOON project (www.google.com/loon) and recent work by Liquid Telecom on Internet infrastructure across eastern Africa. Suffice to say there are multitudinous challenges and plenty of opportunities for fundamental breakthroughs and further innovation in the realm of recent and emerging technologies.

Area 3: Assessment and Evaluation of Learning

A third area where a significant amount of work must be conducted relates to assessment and evaluation. Efforts such as *Knack* (which focuses on measuring attributes that are job related) and the *Open Badges 1.0 Project* of the Mozilla Foundation (www.openbadges.org) in collaboration with the MacArthur Foundation, which currently has over 600 groups that have issued more than 62,000 badges to over 23,000 learners in various areas of competency (mostly targeted to young people through groups such as National 4-H, Youtopia, Educause, Corporation for Public Broadcasting, and Workforce.io), are early examples of new ways of measuring people's capability sets. *Degreed* (degreed.com) and the Workforce Data Quality Campaign (Massie, 2014) are two ambitious newer attempts. *The Economist* teamed up with the Lumina Foundation and Innocentive in 2014 to sponsor a contest on closing the skills gap between universities and employers, identifying the following semifinalists according to its advertisement in *The Economist* in October 2014: *On Campus, Verified Resumé, and Talent Profiles.*

Work on assessment will involve some really heavy lifting about improving our capability to assess in functionally useful ways contextual learning, soft skills, and learning transfer. Admittedly, current learning systems are not very good at these kinds of functions—nor does the current system often confer much weight to their acquisition (Educause, 2014). The OECD ran a very important project over a number of years a decade ago to define and select key competencies for life and work in an informed manner. This DeSeCo programme still has many valuable insights for future efforts to delineate and measure competencies (OECD, 2003, 2005; Rychen & Salganik, 2001, 2003).

Presently it is extremely difficult and expensive, except in very narrow circumstances, to capture learning as it is occurring in real time. Kauffman funded some preliminary work in the Research Triangle area in 2007–2008 by a coalition to see if problem-solving and decision-making while in 3D worlds can be captured and analyzed in real-time as a precursor to the kinds of tools that are needed. Keystroke technology is increasingly being employed in some environments and Department of Defense and medical applications along these lines are the most robust at the present moment in time. The ability to capture large volumes of data is, of course, routinely done on a daily basis in such fields as astrophysics, astronomy, geology, climatology, physics, logistics, and traffic management. These fields have also developed automated tools that can quickly make sense of the data almost in real-time, despite its enormity. Such tools for learning purposes are still in their infancy; yet the fact that analogues exist fully deployed provides reason to believe that progress can be accelerated by sustained effort and scalable projects focused on such matters. Three-dimensional plotting and scientific data visualization is now routine as the weekly pages of *Nature* and *Science* attest. Similarly, the library and information sciences community is getting better at automated search and establishing semantic and other information-relevant criteria to produce interactive displays such as are regularly described in the pages of the *Journal of the American Society for Information Science and Technology*. The involvement of the library and information sciences community will be vital to creating new systems to catalogue, tag, find, update, and otherwise curate the informational and search aspects of the emerging system. Combining these ideas, tools, and approaches with classic complexity sciences as pioneered by the Santa Fe Institute and others, creates powerful possibilities for dramatically new and increasingly more potent approaches to delivering, capturing, profiling, validating, and certifying human learning across the lifespan. A very promising start in this direction are recent start-ups such as Kidaptive, Inc., in Palo Alto, CA, and Knowledge Platform in Singapore, and work funded by the MacArthur Foundation at Florida State University and elsewhere (e.g., Schwartz & Arena, 2013; Shute & Ventura, 2013; Ito et al., 2010).

When we come into today's formal learning circles, we are hard-pressed to find visualization beyond simple data plots, bar charts, and simple graphs. Imagine realizing the dream articulated some years ago by Dick Lesh (then at ETS and now at Indiana University) and colleagues to show in three dimensions a person's grasp of mathematics or any other subject (Lesh, Lamon, Gong, & Post, 1992; cf. two decades later, Lesh & Yoon, 2007 and Lesh, Haines, Galbraith, & Hurford, 2010).

Creating a new infrastructure for learning will require creating and demonstrating the fidelity of new ways of capturing, analyzing, and certifying learner knowledge and skills and portraying them in real-time formats meaningful to intended users. This type of work must be coupled in an iterative relationship with in-depth, rigorous evaluation of new learning tools and approaches with diverse populations that inform the continuous evolution of the tools and the wider learning endeavor and environment(s). Imagine, for example, a future learner being able to carry a small device that upon demand can portray in a three-dimensional, colored format, their personal learning profile. Upon demand they can compare it with anonymous learners just “behind” or “ahead” of them in mastery of a complex skill or compare it with prototypical “expert” profiles in that particular domain. Adaptive system capability also lets them identify a series of resources they might use to take their learning in this specific arena or skill set to a new desired level of achievement. [This latter idea is a robust version of the more rudimentary education search capability currently available in applications like Lore LMS (formerly Coursekit), acquired in 2013 by Noodle Education.]

The current unemployment crisis in the United States and elsewhere suggests that our current systems do not provide enough fine-grained assessment of skills, knowledge, and dispositions to be fruitful for persons who are seeking employment nor for employers to reliably determine what they *might be good at and how good they might be* (Qualigence International, 2014). We also need a system that is more asset-focused rather than deficit-focused. The current systems tend to define what a learner lacks and uses testing to determine that fact while casting the assessment in a very narrow gauge that only focuses on certain capabilities and talents measured in quite limited ways. A better approach will be to create a more dynamic and open assessment system that will continuously profile knowledge, skills, and dispositions as they are demonstrated in real-time (as much as possible) and as they change over time. In this sense metaphorically, we want *microcredits of learning and skills* to be continuously deposited into a learner’s learning account that can be accessed to portray ALL the things that learner has demonstrated that they know and are able to do at that distinct point in time. This will require designers to think more about *upending* the current paradigm of development which begins with specifications of what the learner is intended to know and do in a discrete set of activities or arena and starting from real-time performance data of various kinds emerging from real-life circumstances and engagement and working backwards to determine what skills and talents exist and at what level(s) they are being demonstrated.

Area 4: Transitioning from Existing Systems to a New Learning Infrastructure

A fourth area that must be undertaken for genuine progress is hard thinking about how to transition the current learning systems into a different and more productive future. Already thinkers like Kieran Egan (Canada), Mark Weston (USA) and Alan

Bain (Australia), and Allan Collins and Richard Halverson (USA) have been thinking about such transitions within formal education systems (especially at pre-K-12 levels) assuming that the future will happen (Egan, 1997, 2008; Bain, 2007; Collins & Halverson, 2009; Weston & Bain, 2010). The Lumina Foundation, as part of its current efforts to reinvent higher education in the United States, recently funded a study released in draft form in June 2014 by the University of Houston Foresight Programme that in around 200 pages explores six major transitions they believe will occur in higher education to better meet student needs in 2025 and beyond. They postulate the following six areas of change that will impact and influence changes: (1) *Living* in the "Our" economy with its collaborative consumption, (2) *Learning* that is student centric, (3) *Working* in an "ultracompetitive job market influenced by the spread of AI and automation," (4) *Playing* constantly in a world that has been "gamified" at serious scale, (5) *Connecting* in a continually fluid immersive environment, and (6) *Participating* in "nationcraft" as democracies no longer rely on a representative model of government but more to a much more direct participation model. Similar documents have also appeared thinking about changes to the workplace itself, most notably perhaps the work of Future Workplace (www.futureworkplace.com) with its most recent report (Futureworkplace, 2014) focused on how gamification will affect work in 2020 and beyond (cf. CISCO, 2014).

Conscious actions by a *coordinated* group of organizations and individuals *working within* a set of *common design and operating principles* and *constantly learning* and *fine-tuning* the system rather than allowing market forces alone to determine winners and losers would allow the system to functionally evolve in a faster and more predictable manner that ultimately begins to overwhelm existing systems by its very demonstrable successes *at scale*. Scholars and cultural critics have vital roles to play in advancing the necessary sociocultural dialogue that opens institutions and individuals within the current systems to start playing in the open playground of the new system that is arising—while at the same time not allowing the old system to pollute the emerging system by reintroducing the same stifling design principles and operating assumptions that undergird the learning systems we have today.

Area 5: Sociocultural Dimensions of Learning

The fifth area that demands some sustained work is reckoning seriously with the sociocultural dimensions of learning from a global perspective. Some innovations will quickly take hold in some cultures while facing serious barriers to adaptation and use within other cultures due to a variety of factors associated with the innovation itself, human actors, societal norms and customs, and a host of factors (Johnson & Atwater, 2014; Kanu, 2005; Wejnert, 2002). Learning itself is a sociocultural enterprise and insufficient attention is paid to these dimensions when innovators of new approaches to learning approach, implement, test, and refine their innovations. Some ideas travel well across cultures and other morph in unexpected ways or are closed down completely because they are culturally unacceptable. Much talk about the impact of “globalization” by both proponents and critics insufficiently attends to the substantial nuances that this arena embodies [cf. Jandt, 2012; Lustig & Koester, 2012; and the recent exploration of “pigmentocracies” in Latin America by Teller (2014) to see just how extraordinarily complicated cultures can become]. A further important sociocultural factor is the world’s youth cultures. It is abundantly clear that young people today can and do access, use, assimilate, and question information in ways different from older generations (CISCO, 2014; Ito et al., 2010; Ling, 2012). The manner in which sociocultural considerations should be embodied in design principles, collaborative tools, supportive learning systems, and adaptive affordances is an area with rich possibilities, many unknowns, and fraught with challenges. This fifth area may be the most important area in the long run but the one that is most challenging and least explored from a global perspective in light of the massive changes that an ever evolving “new learning system” will embody in its tradeoffs and assumptions (cf. the thoughtful look at current mobile and handheld technology practices in UK classrooms by Galloway, John, & McTaggart, 2014).

A Global Approach to the Future of Learning

There are, of course, other matters to which such a global effort must attend, but these five core areas will suffice to make clear the nature of the challenge before us. Genuine progress will only be made if an unprecedented, coordinated, global collaboration of potent R & D Centers work together in a FOL Consortium that can be created and sustained over time. No corporation, university, school system, nation, state or province, or government acting alone can create or sustain an effort of sufficient scope and duration to be fundamentally *transformational*. Corporate, university, government, and nonprofit sectors must find new ways to combine their talents and capabilities and utilize opportunistic creation of definable, time-constrained, and resource-constrained projects that address real-world issues but that fit into a larger fabric of an evolving learning environment(s) to advance the vision articulated here. Of course, we must acknowledge at the outset of this journey that no one can successfully anticipate the future but we can believe that sustained work towards creating a desirable future could result in much greater gains than simply allowing it to occur without such a sustained and deep effort as envisioned here.

Many large-scale efforts that have transformed societies (for good or ill) over time reflect such global collaboration, e.g., airline and other global logistics systems, telecommunications systems, the World Wide Web, supercomputing, and large-scale and expensive scientific investigation collaboratories such as CERN, Hubble Space Telescope, Human Genome Project, Sloan Digital Sky Survey, deep sea exploration and oceanic monitoring systems, Campbell and Cochrane Collaborations, Human Protein Atlas, and the work of multinational global educational and relief organizations such as the International Red Cross, UNESCO and the United Nations in the face of major disasters and crises. A significant number of these types of efforts have arguably failed in their ambitions and been sidelined by a series of issues including egos, apportioning of credit, funding, sociopolitical issues, etc. BIG sci-tech programmes and endeavors have, however, become quite routine in the twentieth and twenty-first centuries. A recent example is the challenge issued by Jeetz, McPherson, and Guralnick (2012) to integrate biodiversity distribution knowledge from around the globe, an effort that offers some striking parallels to the challenges posed in this essay.

Helping humans learn predictably, effectively, efficiently, and globally has yet to gain sufficient traction and interest to tackle its core problems in a coordinated, sophisticated, massive, and global R & D effort. More typical is the formation of consortia of limited scope and duration that attempt to tackle smaller problems with the rest of the "system" largely accepted as a given. A recent example is the Connected Learning Alliance (www.clalliance.org) based in Santa Monica, CA, which is a Digital Media and Learning (DML) Hub, incubated by the New Venture Fund and funded by the MacArthur Foundation. It links together various individual researchers and efforts funded by MacArthur and others into a network that is committed to spread and scale "connected learning" where a learner, according to their programme's website, "pursues knowledge and expertise around something they care deeply about, supported by friends and institutions who share and recognize this common passion or purpose." There is little doubt that this well-thought out, well-funded effort will make some progress in its core objectives (cf. the unfunded proposed FutuICT education accerator by Johnson et al., 2012).

Similarly, the One Billion Project (onebillion.org.uk) launched in early 2014 by co-founders and veteran educational software developers Andrew Ashe and Jamie Stuart has developed a set of mathematics lessons delivered via laptops directly to children in the schools of Malawi in their national language (Chichewa) as well as in British English for UK use. Preliminary evaluations by Nicola Pitchford and colleagues at the University of Nottingham both at Biwi Primary School in Lilongwe, Malawi, and Dunkirk Primary School in the UK showed remarkable and similar progress by students over a period of 8 weeks in their grasp of mathematics.

The Khan Academy has pushed the issue of access further than most other initiatives by creating short, highly-focused, English-language, topical video clips on selected learning topics and made them available via the Internet. This has led to a large and growing global audience of users. However, it remains true that a continuation of small-scale projects launched by relatively small and localized coalitions for limited durations with modest objectives will never produce the *learning infrastructure* changes that are required for a quantum leap forward in learning for all human beings across their lifespans and fulfill for the first time in human history the core rights to education articulated by the UN's Universal Declaration of Human Rights.

Are We (Including Designers) Up to the Challenge?

The US National Academy of Engineering (2008) identified *personalized learning* as one of 14 *Grand Challenges of Engineering*. NAE was well aware that "Engineers will have roles in most aspects of these complex problems, though the solutions will require contributions of people from many disciplines" (p. 47). Bruce Alberts (2013, p. 737) recently observed: "… science works best when there is a deep mutual trust and understanding between the collaborators, which is hard to develop from a distance," noting that face-to-face gatherings stimulate "a random collision of ideas and approaches. The best new science occurs when someone combines the knowledge gained by other scientists in nonobvious ways to create a new understanding of how the world works." One can point in the history of modern science and technology to a number of such scientific meetings where a different path to the future was constructed, significant barriers to progress were identified and targeted for dissipation, and where sufficient leadership resolves, and commitments were mustered to make a substantial difference. It will require a coalition of the able and willing who already share or can acquire a sufficient level of trust and working relationships to move forward a coordinated effort across continents and regional coalitions. The remaining portion of this chapter sketches out some possible coalitions and a provisional sense of how such a coalition might operate.

Roles for Designers

But before we proceed to the particulars, we need to examine the role that design and designers might play in such a massive international effort. There is little question that the kind of efforts envisioned here require tackling ill-structured and interconnected problems across a range of domains, geographies, disciplines, age groups, cultural issues, etc. If indeed, the "core challenge of design thinking is, in parallel, creating a complex object, service, or system and making it work," then this is a giant nest of problems that requires the continuous application of design thinking (Tracey & Baaki, 2014, p. 2). It bristles with uncertainties, but designers have a solid history of embracing and using "uncertainty as a tool to propel optimal design solutions" (Tracey & Baaki, 2014, p. 11). Of course, we also must take note that individual teachers down through the centuries have sometimes functioned as successful instructional designers, creating a wide variety of solutions (e.g., spaced learning, flash cards, use of mobile phones) and even entire environments (e.g., STEM and Arts-focused magnet schools).

The type of endeavor envisioned here will require acceptance of the idea that the efficiency of "signature pedagogies" must be abandoned to think anew and afresh about the relationships among learners, those who have something to share (i.e., "teachers"), and the entire world as a learning laboratory where there are no artificial separations among tool learning, learning concepts, habits of thought, and acquisition of skills and knowledge (cf. Boling & Smith, 2014). The coining of novel words that replace older ideas with fresh thinking, promote genuine dialogical pedagogy from below (Dunne & Owen, 2013; Fenwick & Nerland, 2014; Lefstein & Snell, 2014), and a new "designer language" for learning across the human lifespan cannot be overemphasized (cf. Gibbons, 2014). Like all innovations, these efforts will build on that which came before but substantially alter it in the face of the boldest challenges and boldest objectives the human race has ever had for learners worldwide.

Designers, who themselves come from various traditions, increasingly share with scientists, engineers, artists, humanists, and others the reality of a world that increasingly can only be successfully approached and understood within a multidisciplinary orientation where each can come to appreciate at a minimum, and perhaps even *learn* from the other (e.g., Parrish, 2014). Designers, as well as anthropologists, are often skilled at recognizing ways that different specialists from differing backgrounds and orientations possess different habits of mind, inclinations, preferences, and ways of both knowing and doing. The challenge will be to meld these diverse perspectives effectively into a holistic effort that results in more than the sum of its parts and leads to breakthrough thoughts, imaginative leaps, fruitful risks, and truly transformative innovations (cf. Cennamo, 2014; Nelson & Palumbo, 2014). Fluid, flowing systems must be created and organically grown in light of learner interactions in a manner that goes beyond even the best current thinking and approach to systems designs, whether from a design, engineering, or other perspective (cf. Gunter, 2015; Yamagata-Lynch, 2014; Zenke, 2014). Learning materials themselves, wherever they may exist and within whatever varied forms they exist, have to be better located, acquired, catalogued, archived, curated, and made accessible in real-time and in differing formats for the world's learners—a task far beyond that achieved by current efforts such as those found within library and information sciences, Google and similar platforms, electronic libraries, YouTube, Creative Commons, and Open Content initiatives (cf. Maron & Pickle, 2014; Maron, Yun, & Pickle, 2013). These aspirations require considerably hard thought even to decide how to more fruitfully approach such problems, and designers may have a role to play not in making the decisions but creating conditions under which such decisions can be proffered, tested, and further refined over time (with apologies for expanding beyond recognition the far more pragmatic thinking expressed by Grincewicz, 2015).

Operations and Funding

Core staff of the FOL Consortium in its earliest days should be kept small with affiliated staff, graduate students, and self-funded Visiting Scholars/Distinguished Practitioners filling out the remaining human resource needs, drawing upon Consortium partners. The Consortium will have a Steering Group/Executive Board and a much larger Governing Council that comprises the regional coalitions and selected national and international partners as well as core leadership and administrative personnel.

The central premise of the FOL Consortium will be to undertake ambitious proof of concept projects that meet or exceed existing, clearly articulated needs and that advance one or more of the FOL Consortium designated critical directions needed for ever more robust, fruitful, and personalized learning environment(s) to emerge and/or evolve. In most cases this will require an engineering-like approach to root cause analysis, formulating clear problem definition, assessing alternative development paths, prototyping, testing, and refinement, and careful monitoring in real-time whenever possible of results as they occur. The active engagement of computing, engineering, information, and science faculty as well as specialists in a host of disciplines including but not limited to psychology, sociology, economics, education, and the arts, will be necessary. Many of these human resource needs might be met by the active engagement of project partners with coalition members who are drawn from the ranks of corporate or other settings that possess skills and experience commensurate with the tasks at hand and who will self-support the engagement of their team members because of the win/win nature of the engagement. Projects that the FOL Consortium will undertake can be grouped into three distinct classes:

- Near-term projects that can be executed within a span of 1–3 years.
- Middle-term projects requiring 4–8 years.
- Long-term projects requiring 9 or more years.

Each project will have an identifiable project lead, clearly defined management team, delineated outcomes, personnel, and budget and run as a cost center. In situations where intellectual property is created and where either a for-profit or nonprofit entity could be launched to fulfill core objectives, such results will be encouraged by the Consortium—with appropriate safeguards to ensure that ownership of IP will be maintained or shared by the Consortium itself.

The Consortium will be open to use of IP created elsewhere along with a very strong bias towards open access/open source approaches. A recent development in this regard is the March 14, 2013, announcement by edX (co-founded by Harvard and MIT universities) that the full source code will be made openly available in the near future. This will place pressure upon other MOOC providers such as Coursera, Udacity, and the recently announced Open2Study (Australia) and FutureLearn (UK) to make their development platforms open source. Blackboard, the industry leader, announced at its July 16, 2014 annual meeting that a version of its platform called "Learn" will be offered in the public cloud—possibly in response to market pressures. A good example of suitable corporate IP would be selected applications from IBM's Emerging Internet Technologies Group. Promising efforts around open-source culture developing in the arena of unmanned aerial vehicles (UAVs) for commercial use drawing upon 3D printers and crowd-sourced R & D also appear promising (Raskin, 2013). Another important development area is biometric data for identification of unique learners and maintenance of their profiles and learning endeavors. Nok Nok Labs is a leading developer in this area of important technology.

Private foundations that may have an interest in initially supporting the Consortium would include national/global foundations such as Gates, Kellogg, MacArthur, Kauffman, Hewlett, Mellon, Sloan, Broad, Helmsley, Robertson, Rockefeller, Templeton, Ford, Carnegie, Joyce, Casey, Margaret B. Cargill, Walton Family, Robert Wood Johnson, Noyce, Jacobson Family, Emerson Collective (Laurene Powell Jobs), Barr Foundation (Boston), and Wallace. Some foundations outside the United States that may have an interest include Atlantic Philanthropies, Bertelsmann, Wellcome

Trust, Jacobs, Bosch, MasterCard, and selected sovereign wealth funds from nations like Singapore, China, UAE, and Saudi Arabia. Of course, interest will revolve around the ability of the Consortium to "scratch an itch" that the foundation in question has at the moment. Similarly, there are corporate foundations interested in this space and advancing the technologies and systems possibilities, but even more important will be the engagement of corporations as players themselves in the effort. These include well-known technology companies such as CISCO, Microsoft, Google, Amazon, and IBM as well as telephone companies such as SPRINT and SINGTEL, and companies across an array of other industries (e.g., Merck, Dell, Wal-Mart, UPS, Federal Express, GE, Ford, GM, Toyota, Samsung, Sony, Bosch, BMW). NSF and NIH would be core federal targets in the competitive grant arena, especially NSF's Cyber infrastructure and Research on Learning in Formal and Informal Settings divisions. Other federal agencies like Agriculture, DOD, NASA, and the various Energy labs may be suitable revenue capture/partner targets. The DOD especially stands out because of its massive ongoing training needs; the same observation holds true for the federal government, the largest employer in the United States. The Consortium can and should bid on government contracts for government learning systems in partnership with large government-contracting firms such as AIR, RTI, CSC, Northrup Grumman, Lockheed Martin, and SAIC.

An Early-Stage Sample Project

A sample, large-scale, "showcase" project would be to create an international set of mathematics museums along with a 3D virtual math museum. A good start in this arena is two existing museums: The Mathematikum in Giessen, Germany, with 150 exhibits (www.mathematikum.de) and the recently opened (national) Museum of Mathematics in New York City (www.momath.org), funded by Renaissance Technologies hedge fund manager and mathematician, James Simons. This starting point could create the possibility of bringing into existence an additional set of math museums globally, each supported by one or more high-net worth individuals within their own nation that would showcase their own nation's contributions to this important arena of human endeavor, while including mathematics undertaken elsewhere.

Two key selling points to such an effort are that mathematics is THE universal language spoken through recorded history by peoples all over the world, even those who have no written language. Every major global culture has contributed substantial ideas and techniques to the continuously evolving history of mathematics, resulting in new insights for humankind. Mathematics remains a global challenge for creating more math-capable human beings and present formal educational systems worldwide at their very best still achieve results that feature large achievement gaps, with minority populations in the respective countries scoring on average far lower than the majority population(s). To be successful and attract the kind of "buzz" that is needed to take forward this FOL effort and bring mathematics as a subject area of human concern to new levels, it will be necessary to think very "outside the box." The approach should include global competitions for various age groups ranging from lower primary to postgraduates and adult mathematicians for what should be featured within the museums, what the geometrical shapes and design of the museum facilities themselves should be, what the museums in respective countries should be called (perhaps even without the word "math" or "mathematics" in them), and ideas for how the museums could be used to engage the world in mathematics for various purposes, serious and merely and most importantly, FUN. The focus would be on real-world contexts, "acceptable experience" for learners themselves (not just professionals), and gifting math "to the people" of Planet Earth (cf. Gray, 2015; Stefaniak, 2015).

Mathematics as a discipline lends itself to working out ways to better capture, compare, validate, display, and certify a learner's growing mathematical capability set—likely using a mobile device. The theory of change is that as learners see their progress in close to real-time, they will be motivated to go further and continue to build their competencies—all without the direct intervention or mandates of others outside themselves. In this sense, it speaks to the desire of the Connected Learning Alliance mentioned earlier, that creates and enables learners' passions and interests to guide their learning environment choices. Making "math" both accessible and fun while also being able to see one's own progress, should be a unique elixir to the perennial problems encountered within formal mathematics education settings. It could well be that by creating more motivated and younger "mathematicians" who can see their learning progressions in real-time on portable display devices, that we would jumpstart "accelerated learning" of mathematics on a large scale—a phenomenon whose potential one can observe in a small way in nations like India which have a long and venerable history of making some mathematics part of the culture of the country such that people of all ages who have never even been to school demonstrate to a visitor amazing skills at common mathematical tasks (Grincewicz, 2015).

Such a global effort would command worldwide and significant media attention, provide a source of funds to pioneer new FOL applications that advance larger core objectives regarding the FOL, and involve a real mix of cultures, languages, and ideas that could be the springboard for rapid acceleration towards a different future for learners of all ages. Most importantly, it would provide a test bed for the creation and refinement of new means of assessment of mathematics learning and skills "on the fly" in real time and the creation of tools that could be widely deployed anywhere in the world in the hands of learners to capture, profile, validate, and certify their growing mathematical acumen and skills.

Regional R & D Nodes of the FOL Consortium

This effort will only succeed to the degree that it pulls ideas, involvement, human capital, and resources from corporate, nonprofit, university, and government sectors. With its focus on applying research and development to real-world problems and offering real-world solutions that are rigorously tested and refined in light of results, the Consortium should be able to attract a healthy collection of suitable local and regional coalition partners.

The United States will likely have the most regional coalition members and an emerging consortium will have to figure out how to govern itself and sort through its continuing work in a manner once again analogous to the WWW Consortium or other global enterprises such as the Cochrane and Campbell Collaborations. An informal group of thought leaders across government, corporate, university, and foundation circles has already met and discussed elements of the notational plan presented here.

It is vital to the effort's success that great care is taken in establishing which regional coalitions should become part of the effort for a prescribed period of time and rules that establish how a regional coalition is renewed as a member. Organizations like Internet2 and many other scientific and technical collaboratories can serve as models of how to approach these matters. The FOL Consortium needs to minimize conflicts, have clear ways in which disagreements (genuine or otherwise) are resolved, and how the Consortium can smoothly conduct its business both in the hardcore science, research, and development work needed but also in the evaluation, dissemination, and publicizing of its efforts (Davidson, Goldberg, & Jones, 2010; Olson, Malone, & Smith, 2012; Pepe, 2011). Some core criteria for a regional coalition might include:

- Written commitments from the senior leaders of all regional coalition members to the Coalition's overarching learning infrastructure design principles.
- Strong university–corporate–government–nonprofit partnerships and commitments.
- Minimum of $2 million per year budgets raised starting in year 2.
- Dedicated core staff.
- Number of qualified affiliated personnel across disciplines.
- Able to provide very large-scale, diverse test beds across formal and informal systems of learners in corporate, government, nonprofit, and community venues for Coalition products and approaches (e.g., those routinely found within America's land grant universities).

Key centers of current activity that could emerge as suitable FOL Consortium nodes exist across the United States in locations like Chicago, Phoenix, the Bay Area of CA, NYC, Research Triangle (NC), Boston, Central FL, Michigan, Atlanta, New Mexico, and Seattle. Cities or regions outside the United States could include: Greater London (UK), Greater Toronto, Hong Kong, Berlin, Singapore, Switzerland, India (ITTs, Tata Group, etc.). Not all nodes need be geographic if organizations have a history of working successfully together.

Conclusion

Whether the global initiative envisioned here comes to fruition as outlined is totally beside the point (Samuel, 2009). The challenge before the world is that learning for all human beings is still not within reach and that which is available could clearly be far more varied in its format, accessibility, usefulness, timeliness, comprehensiveness, cohesiveness, etc. Learners of all ages could benefit from systems that are designed and operating consistent with the best of what we currently know about how people learn and with considerable focus on doubling or exponentially increasing what we know about how people learn within the next decade. At least five key areas must be worked on in an iterative and dynamic manner if we are going to make substantial progress in creating a sufficiently disruptive environment for learning to be substantially accelerated for ALL human learners in this new century. These five areas are: (1) the nature of learning across the human lifespan, (2) recent and emerging technologies, (3) assessment and evaluation, (4) transitions from the old systems to the new "system," and (5) sociocultural dimensions from a global perspective. Personalized learning—the Holy Grail going back to the ancient Greek philosophers—absent concerted and organized design efforts, will never optimize its potential for learners everywhere, across their entire lifespans, unless more is done. Design(ers) can not only play a role, but might just hold some important insights that would greatly help such an effort move forward into a world more needy than ever for the fruits of such an endeavor.

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Designing Instruction Through Cognitive Theory, Problem Solving, and Learning Transfer: An Ethnographic Case Study

Karen Kaminski

Abstract Adult Basic Education teachers indicate they need unique tools to help their students gain critical thinking and problem-solving skills. This ethnographic study provides a view into the process of designing such instruction by a team of graduate students whose expertise is in the area of learning and teaching rather than instructional design.

Keywords Instructional design by nondesigners • Designing for learning transfer • Collaborative instructional design • Instructional design based on adult learning theory • Problem-solving instruction for adult basic education

Setting the Stage: Nondesigners as Designers

The Center for Adult Education—Training and Learning Center (ABE-TLC) at Colorado State University is funded by the Colorado Department of education. It is charged to prepare adult basic education and adult secondary education (ABE/ASE) instructors across the state to help their adult learners (noncompleters of high school) gain the same skills identified as essential to the Common Core. One of the intended outcomes of establishing the Center on the CSU campus was to increase access to research and innovation.

Two doctoral candidates, who were studying teaching and learning for nonformal learning settings, focused their efforts on the specific learning needs of underserved populations. These individuals are members of a team assembled to create an intervention to help enhance critical thinking and problem-solving skills of ABE/ASE students. Their graduate course work followed a constructivist philosophy that

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delves into methods which use learning and cognitive theory to support learning transfer, critical multiculturalism, and research-based assessment. While they are not completing formal training to become instructional designers, one of the courses in their program of study focused on explicit instruction for problem solving following Jonassen's *Learning to Solve Problems: An Instructional Design Guide* (2004).

Background

The Partnership for 21st Century was founded in 2002 to initiate a national discussion regarding essential skills for all students (http://www.p21.org/about-us/our-history). One outcome of these discussions is the Common Core State Standards (CCSS) which were launched in 2009 (http://www.corestandards.org/about-the-standards/development-process/). The CCSS were developed through the collaboration of governors and state commissioners from 48 states, two territories, and the District of Columbia. They first determined the college and career readiness standards, what students are expected to know and understand when they graduate high school, and the second developed the common core standards. Their framework states that critical thinking and problem-solving skills are essential for students to be competitive in an innovative global economy. Though members of society have repeatedly demonstrated critical thinking and problem-solving skills in their quest for survival, formalization of the processes and application to modern work/life settings have caused them to rise to critical importance in education, including programs that support underserved and challenged learners. This includes the 2014 newly designed General Education Exam (GED) which "meets the higher standards for high school completion as set by the College and Career Readiness Standards for Adult Education [and] the Common Core State Standards…." (GED Testing Services).

The Setting

The population the ABE/ASE teachers serve are those who were not able, for various reasons, to complete a high school degree. In the United States, approximately 19 % of the adult population (more than 40 million individuals), have not completed a high school diploma or equivalent (National Center for Educational Statistics, 2014). The Bureau of Labor Statistics' 2013 report indicates the unemployment rate for individuals without a high school diploma was 11 % while those with a high school diploma or equivalent was 7.5 %, decreasing to 5.4 % for those with an associate degree and 4.0 % for those with a bachelor degree. Those without a high school diploma earn $472 per week as compared to $651 for those with a high school diploma or equivalent and $777 for an associate degree. Attaining a high school diploma or equivalency certificate enables these individuals to contribute to their own economic wellbeing as well as their community and society.

Faculty, the Director of the Adult Basic Education—Training and Learning Center, and graduate students are working together with adult education providers statewide to design instructional processes that ABE/ASE teachers can use to enhance their instruction of critical thinking and problem-solving skills. Our initial prediction was that, by participating in professional development courses, these teachers would increase their ability to embed into their classes the knowledge and skills to apply the processes involved with critical thinking and problem solving.

The College and Career Readiness Standards indicate specific criteria for educational outcomes and publishers are updating their products and student workbooks to assist these students to gain the competencies reflected in the standards. However, our initial work with these teachers indicates that adult basic education professionals believe that the publishers are simply creating more of the same: traditional teaching tools that have already failed for this population. These teachers are struggling to develop their own methods to adjust their practice due to an insufficient curriculum. The instructors are in need of support and unique tools to support their instruction of critical thinking and problem-solving skills to their adult education students.

The challenge is that many teachers in the field of ABE/ASE lack adequate tools and resources to teach these skills. A constructivist/collaborative design process evolved as the students and supporting faculty worked with the ABE/ASE teachers who work in the field to develop an intervention the teachers can implement with their ABE/ASE learners.

The Process

The need for some type of intervention became clear during an annual state educators meeting in which the directors of the ABE centers from around the state openly shared their concerns with the CCSS in that those trying to earn a GED would struggle with the new standards. They were clearly concerned about their lack of skills and resources to reach these students.

As a follow-up to this statewide meeting, university faculty and the doctoral students met to determine how they might assist the ABE/ASE teachers accomplish this goal. While the advising faculty member had extensive experience in the field of instructional design and providing professional development, the doctoral students and teachers involved had little or no experience. The advisor chose to let the course development process evolve using a "barn building" approach that is common in a constructivist framework that incorporates the student's foundational understanding of cognitive theory and learning transfer rather than forcing instructional design practices based on steps in a model. The graduate students readily acknowledged the importance of including the ABE/ASE teachers to gain their perspective and buy-in and ultimately build learning communities.

The students initiated an investigation through conversations with the state program directors and three focus groups with the teachers to gain further information on their specific concerns. All three groups (a total of 12 teachers) shared similar concerns:

1. Their students did not succeed in "regular" school; therefore, they felt that providing traditional learning activities would be ineffective.
2. Their students' perceptions are that school teaches things that do not apply to their lives.
3. Their students are overwhelmed with life and are often called out of class for family emergencies.
4. The students are problem solvers, but do not know how to put it into words.
5. The students need to learn different approaches to problem solving and to think on their own.
6. Whatever we do in the partnership, it needs to provide unique tools for the students.

While the initial intention was to design an intervention for these teachers to use, the doctoral students recognized that the teachers may also be deficient in their own problem-solving skills. A search of Adult Basic Education licensure informs us that while a number of states offer a license similar to a school teaching license, many, including the State of Colorado, only require demonstration of knowledge or experience in the field to work as a full-time instructor in ABE/ASE. For example, the Colorado Department of Education requires full-time ABE/ASE teachers to hold the Adult Basic Education Authorization (http://www.cde.state.co.us/cdeadult/liaindex). This can be gained through completion of four courses at the community college or four graduate level courses offered through CSU, or a portfolio of experience. Often these teachers do not have formal training in the area of critical thinking and problem solving. Therefore, one of the first decisions resulting from the focus group meetings was the need to increase the teacher's knowledge and skills in multiple ways and not solely rely on the resources created for their ABE/ESL students. Thus, the teachers became participant learners in their own train-the-trainer sessions.

Teaching Critical Thinking and Problem Solving

From the graduate students experience in the problem-solving class and the feedback from the teachers that their learners do not know how to put their solutions into words, the graduate students determined the intervention should include explicit instruction on how to solve problems. Research shows that explicitly teaching the process of solving problems increases an individual's success with this skill (Jonassen, 2004). Understanding developed in authentic contexts is better retained and more meaningful, making transfer or use of the knowledge and skills broader and more accurate (Hung, 2013). Jonassen (2004) suggests that providing a rich narrative in which learners are required to generate the problem to be solved rather than presenting the entire problem in advance enhances their ability to transfer the skills to other environments. In this process, learners also need to determine which data embedded in the story are important for solving the problem. The final step is to teach these learners how to make the argument as to why the path they selected to follow is the most appropriate. Jonassen also recommends learners build a mental model of the problem and then visually (or in print) walk down each potential path to determine which one ultimately leads to the best outcome. The more effort learners expend while solving the problem the stronger their argument for their solution.

Brookfield (2005) suggested the goal of education is to challenge students to analyze their notion of self and the world and generate new and more developed perspectives. The development and utilization of critical thinking skills is paramount to building a strong foundation for learners to analyze new knowledge and generate multiple ways for solving problems.

Teachers explicitly learn to apply the process of problem solving to the point where they are able to transfer these skills to others. They are taught to establish authentic problems and problem-solving spaces for their learners. By explicitly modeling these processes through worked examples, teachers can help their learners build problem schemas. These consist of the kind of problem they are trying to solve, the structural elements, the situation the problem occurs in, and the processing operations (equations) to solve that problem (Jonassen, 2004). The ABE/ASE learners should learn and practice a specific process for verbalizing the steps utilized and process for making the decision they did. When using these strategies it is important to recognize that some students will require considerable instruction in the content and contexts to be able to approach a specific problem. The process implemented will take this into consideration.

In response to the faculty indicating traditional learning activities were ineffective, the original idea of modifying existing curriculum to include the application of problem-solving techniques was put aside. While this process may still remain part of the intervention, we decided that unique tools needed to be created to supplement the instruction. The team decided interactive, technology-based activities that incorporate levels of achievement and an aspect of gaming may engage the learners, leading to greater achievement. Development of this tool will take more time, but the investment will be worth it. A benefit to a technology-based intervention is that the students can access it outside of class time, potentially providing more opportunities for learning for individuals who suffer from multiple challenges outside of class.

Finally, as the ultimate goal is to increase the student's employability and contribution to society, the contexts used in the intervention will be authentic. The students will use technology to gain "access to information, people, and tools to engage in problem solving and informed and collaborative decision making" (Kaminski, 2015, p. TBD). This allows students to make informed choices about their education, employment, voting, and to be engaged members of their community. As educators, we need to promote using computers and mobile devices to access information that will inform decisions.

Throughout the design and development process, the ABE/ASE teachers were consulted. We started with member checking of the analysis of the findings from the focus groups and a brief summary of our new plan for the intervention. As pieces of the intervention are developed, we will ask the teachers to formatively evaluate each aspect. Once we have a complete intervention, we will implement the professional development.

Implementing the New Plan

It was determined to start with professional development for the ABE/ASE teachers. Graduate students will facilitate the intervention with the teachers as learners, asking them to examine their own ability to think critically and solve problems, the processes they use, and what weaknesses and personal barriers they have.

- The first phase of the professional development is designed to teach the teachers the process of problem solving and the importance of the design of the problem.
- In the second phase, the graduate students introduce the digital intervention that allows teachers to explore.
- In the third phase, these teachers practice facilitating the intervention with their peers.
- In the final stage, they facilitate the intervention in their own classrooms with support from the doctoral students who are either co-teaching with them or guiding the implementation, as needed.

Returning to the key aspects of learning transfer and creating a safe learning environment (McGinty, Radin, & Kaminski, 2013), the doctoral students indicated that they recognize their work is not completed with the facilitation of the professional development workshops. The next phase is teacher application of the new knowledge and skills within their classrooms. Therefore, the doctoral students will be present to provide support while the instructors practice implementation with their students. They will team teach when appropriate, providing scaffolding and a safe environment for the teachers (McGinty et al., 2013). Finally, the doctoral students indicate that the ultimate outcome is the success of the ABE/ASE learners in making life choices, moving through the ABE/ASE curriculum and completing the GED, and gaining employment or going on to post-secondary learning opportunities. We will track the progress of the learners who participate in the new curriculum and gather feedback from them. For the purpose of this design process, we will ask for feedback from the teachers and the designers regarding the collaborative/constructivist process of design and how effectively the intervention met the teachers' needs.

Once teachers become more confident in their abilities and master the processes involved with teaching critical analysis, they can eventually apply critical thinking and problem-solving skills to new instructional situations. This will increase their ability to help their students reach the CCSS and College and Career Readiness requirements. By explicitly teaching critical thinking and problem-solving skills to adult learners, these teachers can encourage positive social outcomes beyond classroom learning and accomplishment of attaining education.

With guidance from the advising faculty, the graduate students were tasked with designing and developing both the teacher's guide and student materials. Continuing with the team approach, as specific components are nearing completion, teachers will be asked to review and formatively evaluate and share their input and perspectives. Revisions will be made based on their feedback. In addition the graduate students will develop the train-the-trainer materials to be used in phase one of the professional development activities.

New Practice in Instructional Design

Though many traditional instructional design models are not meant to be linear, the nature of a textbook requires authors to cover steps uniquely and then remind students that they can work on the steps simultaneously and/or return to earlier steps at any point in the design. The two-dimensional nature of this process often causes novice instructional designers to believe they should complete each step in its entirety before going on to the next.

Moving away from using a print-based model and description of ID to a social constructivist approach for design brings an organic element to the process. The student-designers in this project have a depth and breadth of knowledge including:

- General information on adult learners and barriers to success.
- Motivational factors.
- A wide range of processes and methods for successful facilitation of learning.
- Cognitive theory.
- How to create a learning environment that increases the likelihood of retention and application of new knowledge and skills outside of the learning environment (transfer).
- Various methods for determining if learning occurred.
- Qualitative and quantitative data collection and analysis skills.

When we apply the problem-solving process to design, one of the first things to do is create a mental (or physically drawn) image of the problem:

What do we know about the problem and what experience do we have with it?

For this project, one graduate student and mentor attended the summer leadership conference for ABE/ASE coordinators across the state. The focus of the conference was the change in the GED to include questions focused specifically on critical thinking and problem solving and a general concern filled the room: "How are we going to do this?" We left the conference with the belief that we could help. The students studied problem solving through the work of Jonassen (2014) and felt they had a good grasp of what the teachers and their students needed. Their work in research methods kicked in and they instantly went to the literature to bolster their knowledge and skills in this area as well as to gain more background on the CCSS and curriculum available.

What do you know about this particular set of learners?

It was obvious to the student-designers that they required additional information. After conducting the first focus group, the student-designers' analysis of the transcripts revealed a number of key concerns. We started investigating biases or assumptions made from personal experiences that led them to acquire additional information. After the second focus group, we began to realize that each group had a different perspective and shared their own unique needs. The student-designers completed the remaining focus group and applied their skills in qualitative data analysis to find the common themes and the important outliers. With the data analysis complete, they shared their findings with the teachers for member checking on accuracy.

Including the teachers in the design process helped ensure that the intervention met the teachers' needs and was easy to implement. This created a back and forth dialogue between the student-designers and the participant-teachers. Not only are we meeting the teachers' needs but we gain important information on how we can help them help the ABE/ASE students with their learning needs. With confirmation they had a good grasp of the problem and the characteristics and needs of the teachers and students, the graduate students formulated a plan for the development of the intervention.

Conclusion

Our successes working with student-designers who are not trained in instructional design and in the development of an intervention that enhances critical thinking and problem-solving skills has provided us with what we believe is a compelling argument for conducting additional research in using a nontraditional approach to train and prepare graduate students as instructional designers. Rather than focusing on the design process itself, this team of student-designers focused on the learners (teachers and students). The graduate students in this case study were fluent in adult learning theory, facilitation methods, qualitative and quantitative research, and assessment/evaluation. They were very much aware of the need to meet the learners where they are, and instinctively worked in collaboration with teachers to design the professional development materials. They planned for authentic, contextual, and creative activities that encouraged knowledge transfer outside of the classroom. The graduate students analyzed their own preconceived notions and assumptions and began to understand that the teachers needed appropriate materials but also the theory and process behind problem solving to help them be successful. Their depth of knowledge and experience led them to apply all of the critical aspects of ID without being tied to an ID model or process.

If we consider the analysis of problem solving and critical thinking that Jonassen and Brookfield developed through years of study, we find a powerful way to design successful learning events with noninstructional designers. The skills of creating mental models, engaging our prior experiences to determine our own schema and analyzing our unique biases, considering the lens of other members or stakeholders, making decisions based on analysis of options and creating an articulate and well-supported argument for our decision can be applied in literature, science, math, communications, relationships, and all aspects of our work/life environment.

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Promoting Learner-Centered Instruction Through the Design of Contextually Relevant Experiences

Jill Stefaniak

Abstract Learner-centered instructional strategies provide learners with increased autonomy of the learning process and promote participatory learning through solving authentic problems that are contextually relevant to the learners' environment. Instructors must be adaptable to the needs of their learners and flexible to address the challenges associated with learner-centered instruction. A cognitive apprenticeship was used to teach undergraduate faculty how to develop more contextually relevant learning experiences for their courses. Examples of how such experiences promote principles of situated learning and enhance the design of instruction are discussed.

Keywords Cognitive apprenticeship • Learner-centered instruction • Contextually relevant experiences • Faculty development • Situated learning

Instructional design is a field requiring its practitioners to be adaptable and flexible in order to design purposeful and often complex learning solutions. Learning experiences are pushing beyond the confines of traditional face-to-face, online, and blended environments to deliver instruction in formal and informal settings. With so much information being made available to learners, there is a renewed emphasis being placed on learner-centered instruction.

Constructivist learning theorists purport the following three premises: (1) learning results from interpretations of experience; (2) learning is an active experience that occurs in realistic and relevant environments; and (3) learning results from exposure to multiple perspectives (Richey, Klein, & Tracey, 2011). Learner-centered teaching strategies provide students with increased responsibility; promote critical thinking; and support student development, peer learning, and teaching (McCombs & Whistler, 1997). Learner-centered instructional strategies shift the instructional focus to a decentralized approach as compared to traditional instructional strategies where learners take on a passive role in the learning process (Kahl & Venette, 2010).

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Learner-centered instructional strategies provide the learner with autonomy of the learning process by promoting collaboration and participation in discovery learning, solving authentic problems, critically reflecting on one's learning, and taking learning risks (Doyle, 2008). These instructional strategies are an extension of situated learning in which learners are taught knowledge and skills within contexts that reflect how they will be applied in real-life situations (Brown, Collins, & Duguid, 1989; Collins, Brown, & Newman, 1989; Lave & Wenger, 1991). Chen, Chang, Lin, and Yu (2009) assert that an environment full of activity, culture, and content has great potential to motivate students to engage in curricular activities and gain more knowledge, skills, and experience compared to traditional learning environments. The development of contextually relevant instructional activities serves as a bridge between students and their social environment (Chen et al., 2009; Duncan, 1996).

This bridge allows students to make connections between instructional material and how it can be applied to a variety of different situations that they may encounter in their everyday lives. Collins (1989) describes situated learning as "the notion of learning knowledge and skills in contexts that reflect the way the knowledge will be useful in real life" (p. 2). Research has shown that students often struggle with applying information that has been taught in formal learning environments to real-life situations because they lack practical experience (Brown et al., 1989; Lave & Wenger, 1991). Situated learning places emphasis on learning in a variety of different contexts to help students utilize their critical thinking skills to begin generalizing information and identifying how it can be applied within different contexts. Additional benefits of situated learning are that experiences provide students with opportunities to learn conditions for applying knowledge, engage in situations that foster invention, and witness the implications of the knowledge and specific contexts appropriate to its use.

Herrington and Oliver (2000) identify the following nine essential characteristics for situated learning environments that promote learner-centered instruction:

1. Provide *authentic contexts* that reflect the way the knowledge will be used in real life.
2. Provide *authentic activities*.
3. Provide access to *expert performances* and the modeling of processes.
4. Provide *multiple roles and perspectives*.
5. Support *collaborative construction* of knowledge.
6. Promote *reflection* to enable abstractions to be formed.
7. Promote *articulation* to enable tacit knowledge to be made explicit.
8. Provide *coaching and scaffolding* by the teacher at critical times.
9. Provide for authentic assessment of learning within the tasks.

Developing learner-centered instruction does not go without its challenges. Brush and Saye (2000) acknowledge that learners often experience difficulty dealing with the lack of structure and management of their metacognitive skills, and are overwhelmed by the amount of information being presented. They also recognize that instructors experience difficulty understanding their role as facilitator, creating

Table 1 The alignment between situated learning principles and learner-centered instruction

Situated learning theory (Herrington & Oliver, 2000)	Learner-centered instructional strategies (Doyle, 2008)
1. Provide *authentic contexts* that reflect the way the knowledge will be used in real life	Perform/present learning publicly
	Take part in discovery learning
2. Provide *authentic activities*	Solve authentic problems
	Take learning risks
3. Provide access to *expert performances* and the modeling of processes	Demonstrate use of teacher feedback to improve performance
4. Provide *multiple roles and perspectives*	Work in teams/groups
5. Support *collaborative construction* of knowledge	Collaborate with others
	Listen in class
6. Promote *reflection* to enable abstractions to be formed	Engage in reflection
7. Promote *articulation* to enable tacit knowledge to be made explicit	Self-teach
	Teach others
8. Provide *coaching and scaffolding* by the teacher at critical times	Demonstrate use of teacher feedback to improve performance
9. Provide for authentic assessment of learning within the tasks	Evaluate own learning
	Evaluation of other's learning

and managing groups, holding students accountable, and providing adequate feedback.

Table 1 outlines how learner-centered instructional strategies align with situated learning principles.

A cognitive apprenticeship provides the framework to promote the abovementioned situated learning principles by providing learners with guided experiences on cognitive skill processes (Collins et al., 1989). Learning within a cognitive apprenticeship occurs through modeling, coaching, fading, articulation, reflection, and exploration through situated learning activities where learning occurs by working on realistic tasks, learning from others, and setting personal goals (Collins, Hawkins, & Carver, 1991).

This project was conducted as part of a larger study (Stefaniak, 2013) that explored whether a cognitive apprenticeship framework could be used to teach undergraduate instructors how to incorporate different instructional strategies into their practice. The purpose of this ethnographic research study was to explore the relationship of contextually relevant instructional activities and students' perceptions of motivation in an undergraduate learning environment. It also attempted to identify the challenges that educators face incorporating contextually relevant examples in class. This study attempted to answer the following questions:

1. How do students experience learning in a learner-centered teaching environment?
2. What challenges do educators experience with implementing contextually relevant instructional activities within a course?

Methods

Participants

Participants included six faculty members at a Midwest urban university. The six participants were randomly assigned to either a control group or an experience group. A cognitive apprenticeship was designed to train the three faculty participants who were enrolled in the experimental group how to incorporate contextually relevant and learner-centered instructional strategies within their classrooms. Inclusion criteria required the faculty participants to teach a face-to-face section of an introductory public speaking course within the College of Communications. In addition, each participant had taught the course at least once prior to participating in the study. Faculty were excluded from participating if they possessed an advanced degree in educational technology or instructional design or had received formal instruction regarding pedagogy and instructional strategies. Table 2 provides an overview of demographic information pertaining to the faculty participants.

There were a total of 27 students enrolled in each faculty participants' class. A total of 36 students participated in interviews at the end of the study to provide feedback on the various instructional activities they experienced throughout the semester. Of the 36 students who participated in interviews, 22 were male and 14 were female. Table 3 shows basic demographic information pertaining to the students who chose to participate in an interview.

Setting

This study was conducted at a Midwest urban university in six course sections that were taught in a face-to-face learning environment over the course of a 15-week semester. The course was a freshman-level course that was a mandatory requirement for graduation, introducing students to communication theory and public speaking. All assignments and course readings are standardized for all course sections; however, instructors are provided with autonomy in deciding how they will sequence various units and deliver the content to their students.

A key challenge that was identified early in the study and revealed in multiple data sources was that the majority of students struggled with understanding the material in the textbook. The textbook appeared to be more suitable for a graduate

Table 2 Faculty participant demographics

Study ID	Gender	Age range	Approximate years of teaching experience	Approximate number of times they have taught COM 1010
EXPF1	Female	50–59	10+	11
EXPF2	Male	30–39	4	4
EXPF3	Female	30–39	7	17

Table 3 Demographic information of students who participated in an interview

	Male students interviewed				Female students interviewed				
Instructor	Freshman	Sophomore	Junior	Senior	Freshman	Sophomore	Junior	Senior	Total
CONF1		1			2		1	1	5
CONF2	2	4	3	1		2		1	13
CONF3							1		1
EXP1		2				1			3
EXP2	4		2			1			7
EXP3	2			1	1		2	1	7

level seminar course discussing philosophical views of communication. Most of the examples were political in nature and did not represent multiple views of social issues. Instructors mentioned at the beginning of the study that students struggled with understanding the readings as well as the ability to summarize and make notes. They mentioned that the book was difficult to incorporate within the classroom and a few had decided not to address any material from the textbook during class time and make it a requirement for homework. As mentioned previously, all assignments for course sections were standardized and students were responsible for completing several quizzes and a final exam that consisted of multiple-choice questions based solely on the textbook material. While the level of difficulty of the textbook was a point of contention throughout the study, the instructors, along with myself as the researcher, were unable to make any adjustments to the reading selections for the course sections as textbooks were reviewed and mandated by a departmental task force that was responsible for enforcing the use of the same textbook across all course sections.

Cognitive Apprenticeship

Faculty participants that were assigned to the control group were instructed to continue teaching as they normally would. No instructional materials or feedback were provided to them. I conducted interviews with the control group at the beginning of the study to gain a better understanding of their teaching philosophy and the types of instructional strategies that they used within the classroom. Each faculty participant was observed five times throughout the course of the project. The cognitive apprenticeship that the experimental faculty group participated in was divided into three phases through the 15-week semester. Each phase was 5 weeks in length. During Phase 1, I met with faculty individually to discuss activities in their class and designed instructional strategies that were more learner-centered and focused on providing students with contextually relevant examples of real-life experiences. The faculty participants would implement the instructional strategies that they had been provided. During this phase, I discussed with the faculty participant why certain activities were considered learner-centered and together we brainstormed how the activities might be used to overcome challenging course material. Advanced organizers were developed for students to navigate through the course readings and identify key components of each chapter. Collaborative activities were developed to allow students time to work with one another to build off examples and content provided in the textbook and develop examples that were more reflective of their lives as college students. Attention was placed on incorporating discussions into class lectures in order to create a more participatory and active learning environment.

Phase 2 required the faculty participant to identify learner-centered instructional strategies and develop examples on their own. Once the faculty participant had selected strategies and articulated why they settled on particular activities, I provided them with feedback as to whether any adjustments were necessary.

During Phase 3, the faculty participants were responsible for selecting or developing their own contextually relevant instructional activities and implementing without receiving any feedback from the instructor. The three phases were used to implement faded coaching, a technique commonly used within the cognitive apprenticeship framework. The faculty participants were provided with regular feedback and coaching during Phase 1. Faded coaching involved a reduction in feedback and participants began to design instructional activities on their own (Stefaniak, 2013). Details regarding the results of the three phases are outlined in the larger study (Stefaniak, 2013).

Data Collection Tools

Direct Observations

Observations and extensive field notes were made documenting how faculty members initially taught at the beginning of the cognitive apprenticeship and throughout to determine whether there were any changes with their teaching strategies. Interviews were conducted with faculty and students to gauge their perceptions regarding the contextually relevant instructional activities being used within the classroom. Instructors in both the control and experimental groups were observed periodically throughout the semester in order to see what instructional activities they were incorporating within their classroom. Instructors were not made aware of when these observation sessions would occur in order to avoid them making any adjustments to their teaching plans based on the knowledge that someone would be observing. Faculty participants enrolled in the control group were not provided with any instructional interventions and were instructed to continue teaching their course the way that they normally would. I did not provide any feedback as to their instructional techniques upon observing class sessions.

Faculty participants enrolled in the experimental group participated in a semester-long (15-week) cognitive apprenticeship. I worked closely with faculty participants on an individual basis following a cognitive apprenticeship framework to train them on how to incorporate more learner-centered and contextually relevant instructional strategies in their courses. Details of how the cognitive apprenticeships were structured are outlined in the larger study (Stefaniak, 2013). I worked closely with the instructors to design activities for the classes, provide the instructors with examples they could incorporate in their teaching, and brainstorm new instructional activities for their students.

During the observation sessions, I recorded attendances to see how many students were absent, how many arrived late, and how many arrived on time. I also counted the number of times the instructor asked students questions during the lecture portion as well as the types of class activities that were incorporated. In addition, the researcher also made field notes that addressed students' perceived interest by documenting how many students were paying attention to the instructor compared to those that were preoccupied with texting on their cell phones.

Interviews

Interviews were conducted with the six faculty participants (control and experimental) at the beginning of the semester. During these interviews, faculty were asked to discuss their philosophy towards teaching, contextually relevant instructional activities commonly used, and any challenges with the course they were teaching. A second round of interviews was conducted with the three faculty members who were in the experimental group. These interviews provided the instructors with an opportunity to share whether they experienced any difficulty emphasizing learner-centered instructional strategies, why they chose particular strategies over others, and their general thoughts on preparing instruction that incorporated more contextually relevant instructional activities. In addition, interviews were conducted with students of the various course sections at the end of the semester to discuss their learning experiences and perceptions of the overall learning environment. Interviews were conducted with students enrolled in both the control and experimental groups at the end of the course to discuss the types of contextually relevant instructional activities that were used throughout the semester, as well as their perceptions of motivation regarding how comfortable they felt learning the course materials.

Results

Through interviews and observation analysis, several themes emerged pertaining to the topic of developing contextually relevant instructional activities. These themes include instructor feedback, relevancy of instructional material, collaborative activities, and emphasis on learner needs.

Feedback

Instructors were encouraged to provide feedback to their students throughout the semester; however, students appeared to only recognize that they had received feedback when they received a grade on an assignment. Students did not associate their instructor walking around during class asking groups if they needed help, building off of ideas, and clarifying whether student responses were correct or applicable during class discussions as forms of feedback. The following is an example of a student's response addressing whether the instructor provided feedback to him or her throughout the semester:

> Yeah. I mean when we submit all of our analysis papers and assignments, he writes back to us and comments on it and says please see my comments. He writes a lot in our rubrics when he grades us on our speaking. He doesn't give us feedback during class. Okay, well today, he said he'd come around and help us if we had questions. (Student Response)

The goals for this study were to explore how students experience learning in a learner-centered teaching environment and the challenges that educators experience with implemented contextually relevant instructional activities within a course. While the instructors did not appear to experience any challenges providing feedback to their students, their students did not always recognize when feedback was being provided aside from formal grading procedures. Instructors were observed on several occasions answering student questions during class discussions and building off of student responses. The instructors did not communicate any challenges in providing students with feedback during either of the two interviews.

Relevancy of Instructional Material

A frequent challenge that the instructors faced during the semester was that students did not come prepared to class. This was largely because the students found the textbook material to be too advanced and difficult to read and that this was a required general education course. The instructors encountered difficulty building off of students' prior knowledge because many were not familiar with the topics being discussed in class. The instructors had to break the material down and present an overall view of the material and then elaborate by providing examples to students and having them work collaboratively in groups.

Students did report during interviews that they were more inclined to learn the material when the instructor provided examples to which they could relate. Providing examples of how the instructional content could be applied in real-life settings is an example of a contextually relevant instructional activity. The following is an example of a student describing how the instructor motivates students by incorporating different types of examples during class:

> I think that she's actually pretty motivating. She tries to use examples in the class. She is lecturing from the book and then she pulls it back kind of into our lives I guess. She does use a lot of examples. She tries to help us also with YouTube videos. (Student Response)
>
> I guess she tries to relate all the examples in the book to real world things and things happening on a week-to-week basis instead of what was written two years ago. (Student Response)

Group activities were also integrated into the course as contextually relevant instructional activities. Students found the group activities to be helpful with learning the material and making sense of the examples that were provided in the textbook. These activities also provided students with the opportunity to apply materials in the textbook to different contexts that they'd be more familiar and comfortable with as college students. Results of the student interviews revealed that students preferred a variety of learning activities during class:

> She engages with us. She uses the classroom activities to keep us involved and I think if she didn't do the activities, then it would be boring without it. (Student Response)
>
> There is a lot of group discussion. He will break up the PowerPoint and we will talk about it just briefly and then he will go into like a short video or he will bring up a daily speech and then after that he will bring up some group topics, then we will talk amongst ourselves and then we will talk overall as a class. (Student Response)

Collaborative Activities

During the collaborative group activities throughout the semester, students were observed taking a more active role in their learning. Students were working together in small groups and helping one another better understand the material before they had to present or discuss with the class. Providing opportunities for collaborative learning activities helped students communicate and articulate their thoughts as they began applying instructional material from the textbook to a variety of different contexts. The instructors encouraged students to find examples that pertained to school, work, and their personal lives. This is another example of providing students with contextually relevant instructional activities that allow them the opportunity to engage in conversation with their peers, share their individual experiences, and observe how the instructional material can be relevant to their everyday lives.

The following is an example of a student discussing the group activities that were incorporated throughout the semester:

> I found the group activities helpful. We get to work with each other and some people…a lot of people don't read the book so when she gives us 10 minutes or so to do it with our group we kind of read the book and present our information to each other, which helps us understand it. (Student Response)

The instructors did encounter some challenges with disengaged students. As previously mentioned, the majority of students did not come to class prepared and many did not attend class regularly. Faculty participants in both the control and experimental groups experienced infrequent attendance rates as outlined in Fig. 1.

The instructors reported difficulty in preparing for group exercises because they never knew how many students would attend class. The following is an excerpt from one of the faculty participants who experienced a challenge implementing an activity when several students were absent from class:

> Having only 8 students at the beginning of class was troubling. I had a group activity with six groups coming up shortly. This did unnerve me for a bit…. I conceptualized a new activity that I called group debate which leads from a small group discussion, to a large group discussion, finally with a student from each group presenting. While it did not go as planned, due to my mistake, I think by organically selecting groups, it can work to indicate the diversity of many issues we face in life. (Instructor Response)

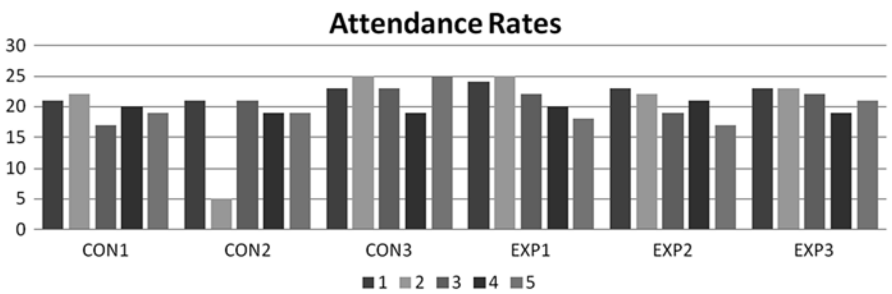

Fig. 1 Attendance records during observation sessions

Another instructor reported that she felt that she had become less learner-centered throughout the course of the study due to the amount of preparation required to implement contextually relevant activities. The instructor stated that she preferred to be a spontaneous instructor and often did not decide what she would cover during a class session until the actual day of the class:

> I'm usually more spontaneous…And I still don't always know what I'm going to do until the day before or the day of if things change on the ground. (Instructor Response)

Emphasis on Learner Needs

Having the instructors get to know the students and relate examples to their own personal and academic experiences conveyed to the students that their instructor was taking a particular interest in their learning. Students in the experimental classes were observed asking more questions during class time, answered more questions that were posed by the instructor, and built off of their peers' discussion points during class.

It was not apparent from the data gathered during the interviews with the instructors that greater emphasis should be placed on understanding their learners' individual needs. While instructors did not articulate that getting to know students as individuals assisted them in providing contextually relevant examples, this was observed during the classroom observation sessions. The following is an explanation provided by a student as to the importance of understanding your learners:

> When I think of teaching styles that really work with the student I think of like building on student ideas and actually trying to understand the students. I'm a philosophy major and with my teachers when I start talking they are like well, yeah, no and they just kind of like keep going, but I would like, really like, for them to try to understand me. (Student Response)

Two of the instructors spent time during the semester talking to their students in class and getting to know their interests outside of school. Some of the conversations that were observed included talking about sports, music, movies, what programs students were majoring in, and whether they had part-time or full-time jobs. When students were struggling to understand the material in the textbook, the instructors began calling on students and bringing up examples that related to their abovementioned interests. Students appeared to grasp the material and were able to contribute to class discussions as the instructors helped them make the connection between the material and their everyday lives.

> His style is really laid back. It's, it's like very informative, you know he always has a lot of facts, I'd say that as far as his style it's, it's engaging like when he, he doesn't just like talk at you, he talks with you and he has you participate also and like, and any feedback he wants from you, you can just give him, so he is real open. (Student Response)

Students conveyed that an optimal learning environment is one in which the instructor is interactive, knowledgeable, and passionate about the subject that he or she is teaching. Student participants believe that it is important for instructors to establish a rapport with their students. The direct observations conducted throughout this study supported this view that students are more likely to engage in an environment where they have made a connection with the instructor. When the instructors invested time in getting to know their learners, they were able to provide their students with more contextually relevant examples to which the students could relate. The following is an excerpt from a student discussing the importance for establishing a rapport with an instructor:

> Yes, she is student-centered. Well, she asks us for our opinion and she doesn't say you are right or wrong, you just give her your opinion pretty much and she never judges you on, you shouldn't say that or that, you know, that's your opinion. (Student Response)

Discussion

The purpose of this ethnographic research study was to explore the relationship of contextually relevant instructional activities and students' perceptions of motivation in an undergraduate learning environment. This study also attempted to identify the challenges that educators face incorporating contextually relevant examples in class. While challenges facing instructors have been identified bearing on the topics of dealing with unprepared students, the additional time requirements needed for preparing for instructional delivery, there are guidelines that can assist instructors while designing these types of educational experiences.

A large part of designing contextually relevant instructional activities for learners is actually gathering information about the learner in order to make the content relatable. Every instructor should conduct a learner analysis to learn more about their students beyond the basic classroom demographics. Taking the time to become more familiar with students will make it easier for instructors to develop relevant examples to incorporate in their instruction. Learner analyses should be expanded beyond the traditional learner characteristics such as program major, age, purpose for taking course to include deeper insights into who they are as people (Stefaniak & Baaki, 2013). Obtaining glimpses into students' everyday lives will help instructors with providing authentic contexts that reflect the way knowledge will be used in real life (Herrington & Oliver, 2000) because the students will be able to relate to the instruction context.

Situated learning theory and learner-centered instruction promote participatory learning environments where students are engaged and empowered to take a more active role in the learning process. Providing students with consistent opportunities to relate instructional material to their everyday lives aids in providing them with contextually relevant experiences to help them better understand the relevance of what they are learning. Establishing consistency within the learning environment where students are expected to routinely participate in authentic activities and collaborate with others will help address issues regarding student preparedness. If instructors communicate their expectations to their students and explain that students will be called on regularly to participate in class discussions, students may be more apt to come to class prepared.

Feedback should be incorporated throughout the instructional process as well as highlighted to students when it is occurring. Students should be given opportunities to articulate what they are learning and make the necessary connections to enable tacit knowledge to become explicit. These contextually relevant instructional activities should be a combination of individual and collaborative activities. Allowing students to digest instruction and articulate their own interpretations will assist them with contributing to discussions when working collaboratively with a group. Throughout these activities, instructors must be present to provide the necessary coaching and scaffolding to help students accomplish tasks, overcome challenges with material, and view contexts through multiple perspectives.

Instructors interested in designing contextually relevant experiences must be adaptable and flexible to address the challenges associated with the fluidity of learner-centered instruction. With the ever-changing needs of our learning audiences and the cadre of instructional options available to instructors, research is needed to examine what support is being provided to handle these changing instructional demands (Gibbons, 2014; Hokanson & Miller, 2009; Smith & Boling, 2009). Further research is needed that explore what strategies instructors are currently utilizing to develop contextually relevant learning environments that add value to instructional design projects. Furthermore, research is also needed to explore what necessary checkpoints must be incorporated within the design of contextually relevant instructional experiences?

As a field, we need to foster constructivist learning environments where students can develop their skills by participating in authentic learning experiences. Providing learners with the much desired contextually relevant instructional activities tasks instructors to push the limits of a traditional systems approach to instructional design and customize authentic experiences for their learning audiences.

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Reconsidering the Design of a Learning Design Studio

Simon Hooper, Michael M. Rook, and Koun Choi

Abstract In this chapter, we introduce a graduate-level Learning Design Studio (LDS) course and discuss how core practices inform a redesign of the resident course for a hybrid offering. We begin with an overview of the theoretical framework for LDS (from the course instructors' perspectives) and compare the framework with recent students' experiences of the face-to-face offering of LDS. Using a transcendental–phenomenological approach, we uncover two emergent themes related to students' experiences. Students recognize and value the (1) increased emphasis on authentic context and (2) peer interaction in LDS. The implication of these findings is established by analyzing the instructors' perspectives in relation to students' experiences. We identify two core practices as central to LDS and acknowledge that these practices should be the focus of a redesign of LDS for a hybrid offering. First, LDS involves computational competence activities that are differentiated according to students' needs. Second, LDS involves students engaging in peer collaboration. While the affordances of online environments present challenges, especially in relation to peer collaboration, we do see opportunities to build upon the strengths of online environments in relation to the first core practice of LDS. We conclude by offering suggestions and next steps in our work that could be transferred to other LDSs.

Keywords Design studio • Peer collaboration • Online environments

In recent years several educational technology academic programs have established design studios as alternatives to traditional courses. The notion of a design studio draws from common pedagogical practice in the fields of architecture (Schön, 1986), industrial design (Kelley, 2001), and interaction design (Löwgren & Stolterman, 2004). Studio courses encourage students to develop the skills, processes, and dispositions of practicing professionals by applying design theory to authentic problems, and

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generally involve students creating innovative proof-of-concept or functional prototype designs.

Likewise, at our university, we teach a graduate-level studio course in the field of learning technology titled Learning Design Studio (LDS). In LDS, students are encouraged to think and perform as learning designers, to become familiar with design processes by participating in professional design practice, and to develop the computational flexibility needed to develop their own software tools to support teaching and learning.

In response to developments in computer hardware, software, and computing technology, academic programs at universities around the world are being encouraged to accommodate students who cannot attend in person. In most cases, universities create separate course versions to account for the inherent difficulty of accommodating students who meet synchronously and asynchronously. An alternative approach involves a single hybrid course design, one that connects and supports all students regardless of time or location restrictions. With this in mind, we are attempting to redesign LDS to develop a single course that accommodates both residential (i.e., face-to-face) and online (i.e., asynchronous) students.

In this chapter we will examine a set of practices from the perspectives of both the course instructor and the students enrolled in the course to inform a redesign of LDS for a hybrid course. We will do this through a two-step process. First, we will describe the current theoretical structure of LDS. Next, we will present results from a phenomenological study to understand the experiences of students in LDS. We will compare the beliefs put forth by the instructor with the themes from the study to begin to understand how the face-to-face practice of a LDS can inform a redesign for a hybrid environment.

LDS: Current and Future Structure

LDS is a single course with four levels, each associated with different skills and experiences. Each level is completed for three semester-credits and students may repeat the course up to four times, for a maximum of 12 credits. Level 1 provides exposure to four classes of software: Web development technologies (i.e., HTML, CSS, and jQuery); graphics editing and creation; video capture, editing, and production; and database creation and modification. Level 2 is intended for novice programmers. Students learn introductory programming concepts while working with contemporary tools and programming languages for web development (i.e., JavaScript or Flash). Level 3 is intended for students to extend their web programming skills or to learn more sophisticated programming techniques needed for mobile/tablet development (e.g., Objective C or Flash Builder). The first three levels are intended to provide students with the technical skills needed to develop a functional software prototype in level 4. In level 4, students identify an authentic educational problem, design and develop a technological solution, and complete a usability analysis with representatives from the target audience. Projects designed

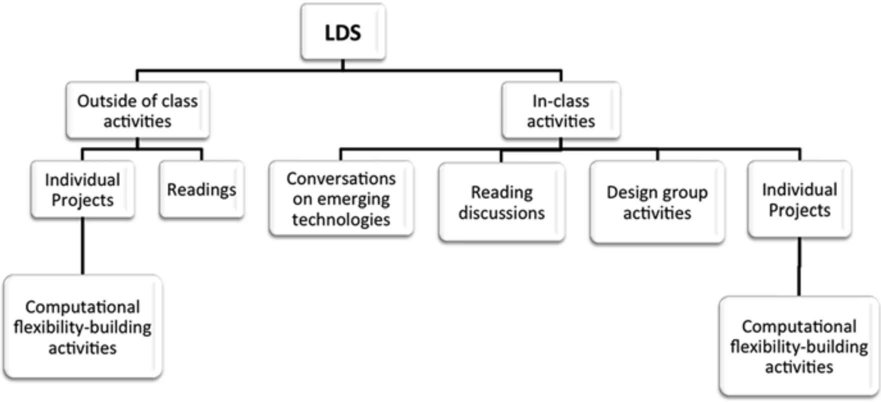

Fig. 1 Structure of learning design studio (LDS)

in level 4 are diverse. Examples include developing K-12 Flipped Classroom materials, a tool to analyze multiple choice test-reliability, augmented reality software, a tool to deliver distance learning materials by cell phone, and an iPad app to support math learning. Students are expected to have the competence to develop all aspects of their projects. For example, students program their own projects and create (or edit) their own assets (e.g., videos, audio files, images, etc.).

Students are assessed on the first day of class and assigned to a level by comparing their self-reported technological skills, backgrounds, and personal learning goals with the outcomes required at each level. Although students may work through all four levels, a linear progression is not required. For example, a student who has strong technological skills, but has not programmed before, might complete only level 2 before attempting level 4. A student who wants to develop a project for mobile or tablet computers might complete level 3 to learn the more advanced programming skills required for such development.

All four levels meet simultaneously. Although students in each level differ in experience and expertise, there is considerable evidence (Johnson, Johnson, & Smith, 2006) to support the notion that more- and less-advanced students benefit from the experiences of giving and receiving help that often occurs when students from different levels collaborate. Figure 1 illustrates the different in-class and outside of class activities that students are asked to complete.

Theoretical Framework

Although our students often possess backgrounds in education and have expressed an interest in using technology to support teaching and learning, few students possess backgrounds in multimedia development or enter LDS with the programming skills needed to develop innovative digital technologies. Hence, LDS emphasizes three beliefs concerning how students become effective learning designers. First, students should develop computational competence to be able to generate innovative technology applications. In level 1, students develop expertise with various software to develop sufficient competence to be able to communicate with working professionals. In levels 2 and 3, students are encouraged to learn the intricacies of a programming language in order to understand and explore the affordances of contemporary development tools. Second, students should develop as design thinkers. And third, students benefit cognitively and emotionally from actively building "artifacts of social relevance" (Kafai, 2006, p. 35) and from the processes of giving and receiving help to and from each other.

Computational Competence

Computational competence can be described at three levels: literacy, fluency, and flexibility (Smith, 2006). Computational literacy involves mastering software tools. Computational fluency involves adapting to current trends in software design. Fluent users understand how software tools can be used to extend current practice. Computational flexibility is the ability to recognize when existing software does not meet the demands of a particular solution and the capacity to develop custom software solutions (Smith, 2006). Many computer users (and many learning designers) may not need to grow beyond computational literacy or fluency. However, when designers wish to create custom solutions to learning design problems, computational flexibility is important.

Smith (2006) identified a common problem that limits innovation in learning design products; designers are deeply involved in project conceptualization but not in project development. Learning designers often work in teams with software engineers to produce learning software. Project workflow involves designers creating design documents that are used by programmers as blueprints to direct software development. This approach limits innovation by preventing insight that emerges during development from being incorporated into the design. Interesting solutions often emerge during development as projects evolve through iterative design cycles (Hooper, Miller, & Rose, 2013). While iterative design processes involving repeated development cycles are expensive, the design process for ill-defined projects requires rounds of design, development, reflection, and redesign to achieve innovative results.

An alternative design approach involves the learning designer being more involved in development, experimenting with different prototypes to produce diverse exemplars from which truly innovative solutions can emerge. Insight into creative problem solutions often emerges from experimentation with programmable development tools. This requires designers to develop the computational competence needed to be able to experiment with software to produce innovative and effective design solutions.

Design Thinking

While technical competence is necessary to bring innovations to life, we are aware of the dangers of favoring technology over people; most of us have seen "solutions" that are either of little use to people or are designed in such a way that the products are difficult or unsatisfying to use (Plattner, Meinel, & Leifer, 2013). Hence, we believe that learning to design new technologies should occur concurrently with learning about design thinking.

Design Thinking introduces students to design culture and how designers solve problems. Lawson (2005) found that students learning to become scientists and architects used different approaches to problem solving. Whereas the scientists applied systematic solution processes and attempted to find problem-solving rules, the architects were more likely to produce multiple potential solutions that would then be eliminated systematically until an acceptable solution was identified (i.e., a solution-focused approach). The architects generated insight into multiple design solutions that were "good enough," whereas the scientists were interested in generating the best possible solution to the process. Rather than following rules in a design process, designers develop their judgment ability (Nelson & Stolterman, 2012) and learn the appropriateness of different solutions in different contexts.

In LDS we use two approaches to help students learn design thinking. First, students read about design. Each level is associated with different readings which become progressively more complex. In level 1, students read about established design practice such as theories of human perception and their implications for layout, color use, and interface design (e.g., Johnson, 2014). Later, students read about design thinking and design philosophy (e.g., Nelson & Stolterman, 2012). In level 4, students seek out research papers or theoretical articles to support their personal design projects. Advanced students taking LDS for the first time are counseled into appropriate reading groups based on experience and interest. Second, students work in small cross-level teams to complete design activities: Students are asked to consider brief design cases or dilemmas, and each group is asked to present its design to other groups in class.

The Pedagogy of Studio-Based Courses

The pedagogy of the studio-based course involves "learning-by-doing" where theory meets practice, and participants gain hands-on experience in a professional practice (Schön, 1986, p. 89). Learning-by-doing is embedded in a learning culture with the instructor and students having nontraditional learning roles. The learning culture and learning roles of LDS are discussed in the following subsections.

Learning culture. LDS pedagogy follows the historical notions of the design studio but also draws from the theory of constructionism (Harel & Papert, 1991; Kafai, 2006; Kafai & Resnick, 1996). In contrast to instructivist approaches in which knowledge is transmitted to learners, studio courses involve collaborative efforts and iterations to understand problems, brainstorm, prototype, and evaluate solutions (Doorley & Witthoft, 2012).

Seymour Papert (1980/1993) developed a pedagogy (rooted in Jean Piaget's theory of constructivism) for computer programming and design. Papert viewed learning "as building relationships between old and new knowledge, in interaction with others, while creating artifacts of social relevance" (Kafai, 2006, p. 35). His pedagogy (building knowledge by designing, building, and discussing learning artifacts) became known as constructionism. In constructionism, teaching and learning involves "interactions between the teacher and students as they are engaging in design and discussion of learning artifacts" (Kafai, 2006, p. 36). LDS follows Papert's pedagogy of constructionism by affording opportunities for students to construct learning artifacts. The course is organized to provide interactions with software tools, peers, and the teacher.

Learning roles. In LDS, the roles of both student and teacher shift from more traditional learning and teaching orientations. Students become responsible for identifying what needs to be learned to help them achieve the course outcomes. Students are told what they are expected to produce, and are given access to a range of instructional resources, but they must determine which resources are personally useful.

Students still need access to support systems to scaffold their learning. However, that support is as likely to come from a peer or from online resources as from the course instructor. In a sense, LDS can be considered a higher-education version of the Multi-Age Classroom, an instructional approach that has been employed in K-12 education for more than a 100 years, but is unusual in higher education. University classrooms are generally separated by expertise rather than by age; course enrollment often is limited to students with relatively homogenous backgrounds, and instructional needs and expertise. In the Multi-Age Classroom, students of different ages and ability work in parallel, but more able students become partially responsible for tutoring their less able peers. This reciprocal relationship benefits both parties: Less able students receive more help than typically is available from the classroom teacher, and the more able experience the cognitive benefits of teaching that occur when students explain content (Veenman, 1995).

The studio instructor's role shifts from knowledge disseminator to learning coach and facilitator, reflecting both practical and pedagogical factors. Keeping up with contemporary technologies is beyond the scope of most people. Moreover, the growth of online learning resources (e.g., MOOCS, wikis, social media, online video tutorials, etc.) reduces the need for instructors to teach many technological skills and processes needed to develop computational flexibility. When necessary, instructors can develop additional resources to supplement online content instructional materials.

LDS also differs in assessment practice, using a performance approach (Jones, Voorhees, & Paulson, 2002) in which competence rather than knowledge is assessed. In performance assessment, students work at their own pace to acquire competencies that are then assessed for mastery. Moreover, assessment is closely integrated with a badging system. Badges provide a mechanism for students to transfer evidence of their learning between educational institutions or between traditional and nontraditional learning organizations. Badges also provide a mechanism to standardize competencies so they have similar meanings across diverse contexts. It should be noted, however, that LDS does not fit the strict definition of performance-based education as it still adheres to (and remains constrained by) a traditional university registration schedule.

Summary of Theoretical Framework

The content of LDS builds on the beliefs that students should engage in practices that build computational competence and promote design thinking. The pedagogy of LDS extends the notion of the studio-based course with the theory of constructionism, where students engage in interactions with software tools, peers, and the teacher to construct learning artifacts, and with the theory of the multi-age classroom, where students are organized according to four hierarchical performance levels.

The theoretical framework described how LDS is structured and understood from a teacher's perspective. To address the goal of this chapter, that is, to present a set of practices for a LDS that can inform a redesign for a hybrid environment, we present findings from a phenomenological study of students' experiences of LDS. The research question that guides the study is: What are students' experiences with building computational competence in a face-to-face (synchronous) LDS?

Method

We implemented a transcendental-phenomenological approach (Moustakas, 1994) focusing on removing researcher bias from data collection and analysis. This was important because of the inherent bias present among the researchers: The first two authors are the current course co-instructors, and the third author was a previous student of LDS.

Participant Selection and Data Collection

Transcendental phenomenology relies upon participants as the unit of analysis and participants' interpretations of experience as primary data sources. Consequently, we asked current course participants to participate in the study. Four of seven students during the Spring 2014 offering of LDS volunteered to participate. Of the four participants, two were enrolled in LDS Level 1 and two were enrolled in LDS

Level 2 during the Spring 2014 offering. Participation involved responding to semi-structured interview questions. The questions included: What is the learning design studio experience? What frustrates you about the learning design studio? If you were to redesign the learning design studio, what would you include, what would you add, and what would you get rid of?

Analysis Procedures

After transcribing the interviews, we used transcendental-phenomenological methods and techniques to code and analyze data. These included bracketing (i.e., removing bias by applying equal weight to all thoughts), thought-by-thought coding (i.e., coding based on thoughts as opposed to lines or entire paragraphs of data), abstraction (i.e., relating the thought-by-thought codes to the research question), horizontalization (i.e., finding the unique meaning from thought-by-thought codes), and finally thematizing (i.e., grouping abstracted horizons according to emergent themes) (Moustakas, 1994). Table 1 provides an example of the coding process.

Results and Discussion

Data analysis produced 55 initial codes, four horizons, and the following two emergent themes: (1) Increased emphasis on authentic context; and (2) Peer Interaction. The horizons and themes are presented in Fig. 2.

Theme 1: Increased Emphasis on Authentic Context

Students recognized that LDS is distinct from other courses in that it is less structured. In particular, students valued setting their own project goals within each of the course levels. The following narrative from Participant 2 shows how exposure both to professional practice (i.e., the first author's research) and real-world issues is appreciated by the students.

> It really was a pretty well rounded. You get exposure to research—(the first author's) research. You get real issues that are being dealt with. You get the topical knowledge from the readings. You have the hands-on (activities). It's a really nice variety and I think it's been really helpful. (Participant 2, 4/24/2014)

The variety of curricular activities including readings on design thinking and group-based design activities enriched students' experiences of learning and applying technological skills. In anticipating a redesign of LDS, students expressed interest in more flexibility with the structure of LDS, as evidenced in the following excerpt.

Table 1 An example of the coding process

Participant Transcript	Thought-by-thought code	Abstraction	Horizon	Theme
Author 2: How often do you see (support) happening in practice?	Often offers assistance to others because of web designer job	LDS environment enables students with distributed expertise to assist others	Distributed expertise among peers	Peer interaction
Participant 4: A lot actually… just yesterday it was in Design Studio, and (participant 2) was doing her level 2 project and she was working (on) her responsive design. And I have that as my job (i.e. web designer), so I was able to talk to her about it. Another student was working on his database project and trying to finish it up, and he was like 'Hey who has done this project before? Can you look at my code and see if you can kind of point me in the right direction, like what am I missing?' So, I mean that happens a lot				

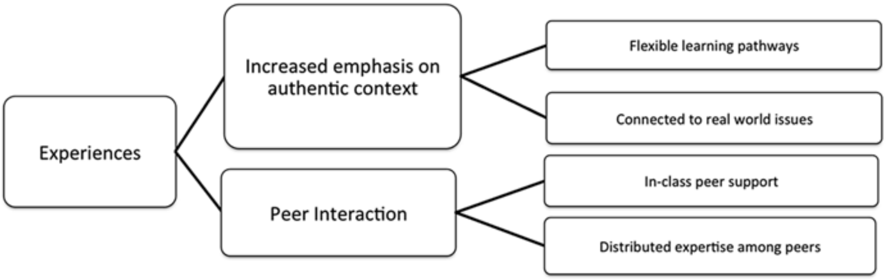

Fig. 2 Students' experiences in LDS

> I like the direction with the badging. I think that's going to be really good. And the modules—I think that's definitely going to be a big improvement as well. Both will make the flexibility (in the course) more apparent to students. (Participant 2, 4/24/2014)

Students valued selecting personal "learning pathways" from the different modules rather than a predetermined course sequence. However, students also recommended differentiating modules according to students' professional interests. Although students found value in the flexibility of the course, they suggested differentiating the outcomes of the modules so K-12 teachers, learning designers, and future higher education faculty can create course artifacts that support their professional practice.

Theme 2: Peer Interaction

Peer interactions included in-class discussions and giving and receiving help on individual projects. Peer interactions across levels in LDS were often limited however. Although some LDS students possessed considerable technological expertise, their peers were unable to identify that expertise until after they completed a project. For example, Participant 4, who was the only student working at the highest level of the course, expressed difficulty in making connections with other students in the class because Participant 4 was unaware of their expertise and did not know if any students could help.

> …you just have to work a little bit harder to actually talk to people. Be like, "Hey, I know I'm not working on this project with you, but… you know… we can still have these conversations, and I can help you." So it just takes a little bit more effort to sort of make these connections… Everybody knows sort of what projects are in (each) level. It would be nice maybe (to) say, "Okay, I'm not a programmer at all, but I know Adobe Photoshop like nobody's business. So, if anybody is working on the Adobe Photoshop module, you are free to use me as a resource." So, offer some way to scaffold those relationships. However, they do tend to happen organically eventually. (Participant 4, 4/25/2014)

In this excerpt, Participant 4 identified the value of using peers as a resource during LDS modules. If someone were an expert in Photoshop, the expert could offer assistance to her/his peers before the beginning of the Photoshop module.

To facilitate peer assistance, a review of the information economy could be conducted to determine the go-to people for assistance with specific technologies (Rook, 2014). This suggestion, to identify and state LDS students' expertise with technologies and modules before students begin the modules, is something we will incorporate in future versions of LDS.

Implications

We found two emergent core practices for LDS by comparing the teacher's perspective with the students' experiences, and present them in this section. Differences in how the core practices were planned (by the instructor) and enacted (by the students) are described to suggest improvements for the face-to-face LDS, offer recommendations for a redesign for a hybrid environment, and offer implications that could be transferred to other LDSs.

Core Practice 1: Computational Competence Activities

The first core practice of LDS extends the notion of developing computational competence. As stated previously, the instructor focused on students developing computational competence to be able to generate innovative technology applications. Students stated that computational competence should be differentiated according to students' needs. In one section of LDS, students might include classroom teachers, instructional designers, informal-learning designers, and university staff and faculty who design and develop their own software tools to support teaching and learning.

In future offerings, the curriculum will be differentiated to meet various professional interests. For example, a module is planned on implementing a Flipped Classroom to make the content more relevant for K-12 teachers. Likewise, students will be encouraged to develop custom modules in which they identify instructional resources and pathways needed to achieve a negotiated outcome. Upon completion, the students will formalize their learning processes by developing instructional modules to be added to the course content.

Core Practice 2: Engaging in Peer Interaction/Assistance

Interaction among peers is considered a core practice of LDS for students to experience the cognitive benefits of giving and receiving help, but also to promote students' sense of membership in the course and the larger design community. However, students indicated that collaboration often did not occur among students working in different levels, and students in higher levels found it especially difficult to locate help.

Such lack of collaboration is likely to be exaggerated when online students are included in the course and students experience both physical and emotional distances that limit their ability to participate fully in a learning community. A new generation of video-based tools is emerging that will allow face-to-face communication and bridge the physical and emotional distances that exist in online courses. Collaborative learning tools will impact the ability to locate and receive help in LDS, and engage students in social interactions among peers, which is a key component of community building (Crowther, 2013).

Next Steps

As we move forward in the course redesign, we will be guided by the findings in this paper in relation to design studio research and the notion that different forms of collaboration are needed in residential and online learning (Brindley & Walti, 2009). Cennamo and Brandt (2012) developed several recommendations to help design studio participants grow as design professionals:

- Course assignments should encourage students to develop dissimilar projects (similar to the recommendations discussed in Core Practice 1) that encourage learning from each other by discussing idiosyncratic design differences while concurrently demonstrating achievement of core competencies.
- Students should be encouraged to display their work publicly, to describe their design processes, and to learn to give and receive constructive feedback to and from their peers.
- Instructors should seek-out opportunities to discuss students' work to identify important design principles.
- Students should be encouraged to iterate their work in response to feedback from peers and instructors—design is never done!

As discussed in Core Practice 2, collaboration is an important consideration in the development of a combined face-to-face and online LDS course offering because it reduces students' feelings of isolation and increases their sense of belonging to the course and the learning designer community (Brouns & Hsiao, 2012). To support online collaboration, instructors can try two approaches.

First, peer support systems can be established that operate independently from the course instructors (Brouns & Hsiao, 2012). Also described as self-organizing systems (Mitra & Dangwal, 2010) or online self-organizing social systems (Wiley & Edwards, 2002), peer support systems become avenues for collaboration and learning when they are facilitated by a "friendly mediator who provides supervision but exercises minimal intervention (encouraging rather than teaching)" (Mitra & Dangwal, 2010, p. 685). The instructor could act as the mediator but a previous student, teaching assistant, or better yet, an expert in the field could also assume this role.

A second approach emphasizes building on the affordances of each learning environment. The qualities of face-to-face interaction (i.e., synchronous, high bandwidth, hands-on design activities) differ from online interaction (i.e., asynchronous or anywhere/anytime, varying bandwidth or contact, time to reflect before responding). Rather than implementing the same forms of collaboration in each setting, we will differentiate by implementing activities that work best in different learning settings. Our goal is to optimize interaction while recognizing the affordance limitations of each setting.

Conclusion

When redesigning LDS, we will build upon the core practices that emerged from the instructors' and students' descriptions of LDS in this chapter. In particular, we will emphasize developing computational competence and facilitating peer interaction and assistance at different course levels. However, we recognize that redesign will create unforeseen challenges. For example, community building and peer interaction, which are afforded in face-to-face settings, will be difficult to replicate online. Fostering productive peer interactions between synchronous and asynchronous students should provide meaning for all students. To foster peer interactions, we will build on the recommendation from Participant 4 that we identify and publicize the asynchronous students' technological expertise and experience before students begin modules. We also recognize that any design change will be part of a cyclical course redesign process. This chapter establishes a foundation for that conversation to continue.

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The Multifaceted Endeavor of Online Teaching: The Need for a New Lens

Lisa C. Kidder

Abstract With the consistent demand and increase in online courses offered in higher education, more faculty are teaching online. In order to design and develop faculty development, research has employed several common frameworks: the technological, pedagogical, and content knowledge (TPACK) framework (The Teachers College Record, 108(6), 1017–1054, 2006), the community of inquiry (CoI) (Journal of Asynchronous Learning Networks, 5(2), 1–17, 2001), and Chickering and Gamson's (American Association for Higher Education Bulletin, 8, 1987) seven principles for good practice in undergraduate education. The needs for technology training and changes in pedagogy/andragogy have been highlighted using these three frameworks. This chapter recommends the use of flow theory, from positive psychology, as a framework to guide future research in online teaching, especially with a focus on the experience of the online instructor. Flow theory encompasses both the cognitive and affective domains and can provide a more complete picture of the faculty experience. The broader, integrated picture of online teaching provided by flow theory will inform the design of more effective and focused professional development to support faculty as they transition from a novice to an expert online instructor.

Keywords Online teaching • Flow theory • CoI • TPACK • Faculty development

Rebecca is an instructional designer at a 4-year university tasked with designing new professional development for faculty who are teaching online. Her institution is at the end of a major initiative to create at least one online program in each college and offer at least one section of the general education courses online. More faculty than ever are using the learning management system (LMS), participating in the more advanced workshops, and other professional development opportunities. In fact, the numbers in the introductory workshops are dwindling. It was time to take to the next step.

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Throughout the initiative, data was collected in the form of LMS usage of both students and faculty; faculty workshop attendance; workshop feedback from the faculty; standard course evaluations from students; student achievement; and the online course evaluation from students. It was clear to Rebecca, looking at the various reports in front of her, that some of the faculty members were consistently successful while others struggled. One question came to mind, "What are the successful faculty doing differently?"

She knew each of the faculty who were successful. These were the ones that had jumped in early and had been teaching online for longer than most. But was it just time? Perhaps they had more skills in the areas outlined by the technological, pedagogical, and content knowledge (TPACK) framework (Mishra & Koehler, 2006). Perhaps they were better at creating the various presences described in the community of inquiry (CoI) model (Anderson, Rourke, Garrison, & Archer, 2001). Or maybe it was related to the training done in previous years based on Chickering and Gamson's seven principles for good practice in undergraduate education (1987). Most likely it was all of the above, but there was something more in these faculty who had taken "the next step;" who had, according to the data become experts. Now all she had to do was figure out what was unique for these instructors and how to help all faculty become like these experts.

Introduction

Online learning has experienced a fairly consistent growth over the last decade, with 66 % of higher education institutions recently reporting that online education remains critical to their long-term strategy (Allen & Seaman, 2014). In addition, 74 % of chief academic officers consider the learning outcomes for online courses to be "as good as or better" than traditional face-to-face courses (Allen & Seaman, 2014). Despite this apparent confidence in online education, researchers continue to report "compromised quality in online courses" as one of the top concerns of faculty, administration, and the general public (Hopewell, 2012; Verene, 2013; Windes & Lesht, 2014).

In higher education, faculty bring with them a variety of teaching experience and training (LoBasso, 2013), resulting in teaching practices generally based on how they were taught (Lane, 2013). In teaching their first online course, faculty report a need to change some of their practices (Crawley, Fewell, & Sugar, 2009; Kukulska-Hulme, 2012; McQuiggan, 2007). With online education relying so heavily on technology, the most commonly requested topic for faculty development is technology skills (Arinto, 2013; Barczyk, Buckenmeyer, & Feldman, 2010; Betts, 2014; Lane, 2013; Windes & Lesht, 2014). Faculty development can be designed to improve technology skills; however, if it only disseminates information or focuses on specific skills, it will not challenge prior "attitudes, beliefs, and assumptions" (McQuiggan, 2007). In order to design professional development that encourages a transformational change, it "must focus on how technology applications, new pedagogies, and content knowledge are interwoven" (Benson & Ward, 2013, p. 488).

Online teaching is a complex endeavor at the intersection of technology, content, and pedagogy/andragogy (Ward & Benson, 2010). In addition to the complex integration of these various areas, there is a constant change in technology, and an inherent iterative process that should be considered, not just an ill-structured problem, but a "wicked problem." As with other "wicked problems," there is no exact right or wrong answer or solution; and the process of exploring the problem is likely to significantly transform the problem through the iterative design stages and processes (Seitamaa-Hakkarainen, 2011).

In designing faculty development, both the perceived needs and the actual needs of the faculty ought to be considered (Betts, 2014). In addition to the request for technology training (Davis, 2009; Lazarevic, Bentz, & Scepanovic, 2010; Lee & Tsai, 2010), faculty consistently report concerns about the time required to teach online (Betts, 2014; Mandernach, Hudson, & Wise, 2013; Windes & Lesht, 2014). With research indicating the need to transition from a teacher-centered classroom to a student-centered one (Palloff & Pratt, 2011), there is a need for greater transformational change in knowledge, skills, attitude, and beliefs about teaching online (Conceição, 2006; Lane, 2013; McQuiggan, 2007).

Theoretical Frameworks

Theoretical frameworks provide a way to "systematically study the phenomena under question" and "allows us to make predictions" (Punya, 2014). A number of theoretical frameworks are used to guide the research in online teaching. In terms of online teaching, three frameworks stand out; they are the technological, pedagogical, and content knowledge (TPACK) framework (Mishra & Koehler, 2006) for its multidimensional view of the overlapping skills required to teach online; the community of inquiry (CoI) (Anderson et al., 2001) for its focus on overcoming the lack of physical presence in the online environment; and Chickering and Gamson's (1987) seven principles for good practice in undergraduate education for its continued longevity and focus on teacher interactions.

Technological, Pedagogical, and Content Knowledge Framework

The technological, pedagogical, and content knowledge (TPACK) framework attempts to address the complex relationships evident in educational technology across all learning environments (Mishra & Koehler, 2006). "The TPACK framework…suggests that content, pedagogy, and technology play unique and interactive roles in the teaching and learning process" (Ward & Benson, 2010, p. 484). TPACK is a model that focuses developing expertise in six specific areas: technological knowledge, technological content knowledge, content knowledge, pedagogical content knowledge, pedagogical knowledge, and technological pedagogical knowledge (Fig. 1).

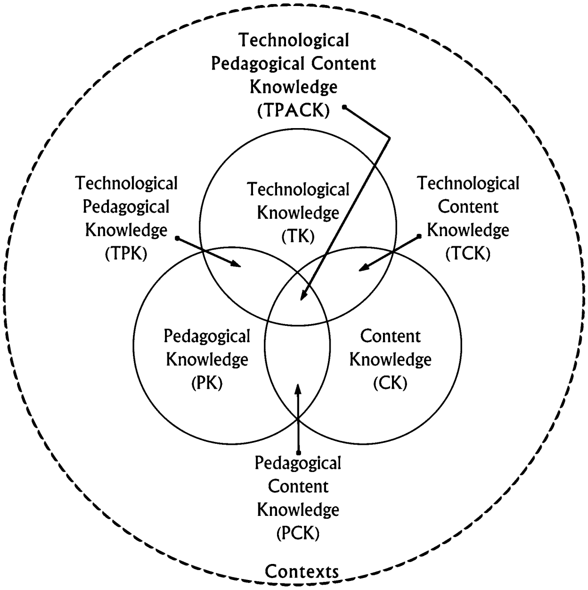


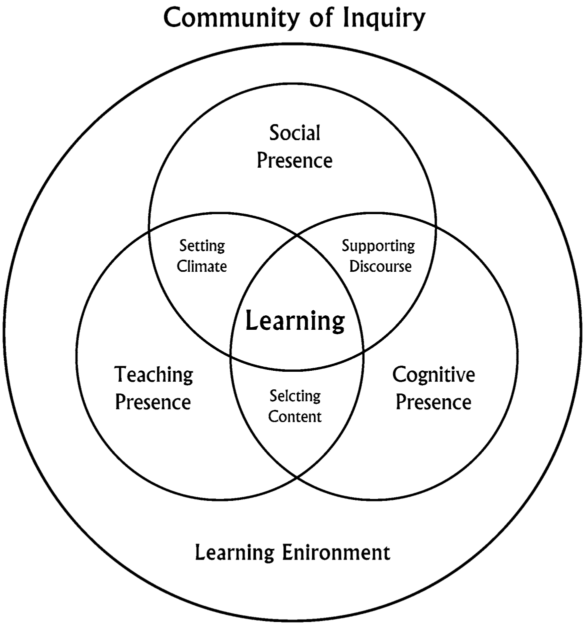
Fig. 1 TPACK Model illustrating the intersection of the three areas of knowledge needed to teach online. Reproduced by permission of the publisher, © 2012 by tpack.org

The focus of the TPACK model is in the cognitive domain, specifically building knowledge in the six areas. This focus on knowledge does not include attitudes, beliefs, motivation, or other aspects of the affective domain. Kinchin (2013) states that there is a depth in the model, which is often missed when the focus is on the individual areas. This depth is one of the strengths of the TPACK model, encouraging critical thinking about the intersection of these three domains and how they can work together in an online course (Ward & Benson, 2010). As stated by Ward and Benson (2010) "changes in learning online are not just *about the technology* but about a much more complex and 'wicked problem'" (p. 483). The TPACK framework integrates technological skills with pedagogical and content knowledge to reframe traditional thinking about teaching and learning.

Community of Inquiry

According to Rubin, Fernandes, and Avgerinou (2013), "Successful online courses create a community of inquiry (CoI) where students interact with one another, the instructor, and the learning materials to develop new knowledge and skills" (p. 49). The CoI framework was developed to guide research in online courses and suggests that a community of inquiry occurs at the intersection of three types of presences—social, teaching, and cognitive (Anderson et al., 2001). Eskey and Schulte (2012) state that "the perception of faculty presence has been cited by many research studies as one of the most important determinants of student satisfaction with online learning" (p. 4), supporting the use of the CoI framework. In alignment with the

Fig. 2 The Community of Inquiry Model illustrating the intersection of the three presences within a learning environment described by the model. Adapted from Garrison, Anderson, and Archer (2010)



recommendation that online courses have a student-centered, constructivist approach to learning (Palloff & Pratt, 2011), the three areas of presence can be found in either the instructor or student (Fig. 2).

Social presence. A large amount of the initial research using the CoI framework focused on social presence (Garrison & Arbaugh, 2007). In the early years of online education, the limitations of technology emphasized the distance created when faculty and students are not located in the same place at the same time (Hoskins, 2013). As Vygotsky (1978) observed, learning is a social activity, with interaction between faculty and students vital to the learning process. Concerns about student interaction in online learning continue to be reported (Shachar & Neumann, 2010).

Teaching presence. Teaching presence has historically been divided into the following three components: (1) instructional design and organization, (2) facilitating discourse, and (3) direct instruction (Anderson et al., 2001).

Instructional design and organization. A number of institutions have created a team-based course development process based on adopted standards or guidelines in order to support faculty and ensure the quality design of online courses (Hawkes & Coldeway, 2002). As such, faculty may or may not have control or influence on the design of their course (Hawkes & Coldeway, 2002).

Facilitating discourse. The majority of research on teaching presence has thus focused on the discussion board (Shea, Hayes, & Vickers, 2010). The discussion board was a key technological tool that made student–student interaction possible and moved distance courses based on CD-ROMs and television to an asynchronous online setting (Hoskins, 2013). Using two undergraduate courses based on the same instructional design template, with different instructor approaches to direct instruction, facilitation and social presence, Shea et al. (2010) looked for evidence of teaching presence of two sections of an upper-level online business management course taught by two different instructors in all areas of the courses, such as email, instructional materials, discussion forums, and private feedback. The authors reported that 80–90 % of their subjects' teaching presence occurred outside the discussion boards, indicating that previous research may underrepresent teaching presence.

Direct instruction. While obvious in a traditional classroom setting, online "direct instruction" is when an instructor guides, focuses, and redirects students in the subject matter of the course (Anderson et al., 2001). Shea, Pickett, and Pelz (2003) found that there was no real distinction between facilitating discourse and direct instruction. The authors surmised that students may not perceive a difference and recommended the two components be combined into *facilitated instruction*. Garrison (2007) indicated that the difficulty may be due to the high correlation between the factors or reflective of the design and individual instructor's approach to the course (Garrison et al., 2010).

Cognitive presence. According to Garrison (2007) the process of inquiry that exemplifies the cognitive presence is the student moving from exploration, to integration, and concluding with application. Spiro (2012) reports that very seldom does the student move past the exploration stage. Possible solutions, both suggested and hypothesized, tend to fall into the area of teaching presence (Redmond, 2011; Rienties, Giesbers, Tempelaar, & Lygo-Baker, 2013).

Cognitive presence has been the least researched and one of the more difficult areas to examine (Akyol & Garrison, 2008; Garrison, 2007). Rourke and Kanuka (2009) suggest that the lack of evidence may indicate a problem with the CoI framework. However, other suggestions point to issues with course design or facilitation (Akyol & Garrison, 2008; Rourke & Kanuka, 2009).

Chickering and Gamson's Seven Principles

One set of principles consistently used in undergraduate education is Chickering and Gamson's (1987) seven principles for good practice in undergraduate education (Bigatel, Ragan, Kennan, May, & Redmond, 2012; Cakiroglu, 2014; Calsolaro Smulsky, 2012). When incorporating technology, Chickering and Ehrmann (1996) suggest that technologies can be employed in line with the seven principles to fully realize their potential.

The seven principles state that good practice in undergraduate education (Chickering & Gamson, 1987)

1. Encourages contact between students and faculty.
2. Develops reciprocity and cooperation among students.

3. Encourages active learning.
4. Gives prompt feedback.
5. Emphasizes time on task.
6. Communicates high expectations.
7. Respects diverse talents and ways of learning.

These seven principles center on communication and interaction of faculty with their students. Calsolaro Smulsky (2012) described two different instruments used to evaluate student–faculty interaction based on the seven principles—the National Survey of Student Engagement (NSSE) and the Student Evaluation of Online Teaching Effectiveness (SEOTE). In reviewing the results, it became clear that even though both instruments were based on the seven principles, one instrument measured student satisfaction while the other measured students perceptions of frequency of interaction (Calsolaro Smulsky, 2012).

Arbaugh and Hornik (2006), in looking at online MBA students' experience, stated that the seven principles "provide additional support for the idea that the interpersonal and behavioral aspects of conducting business courses online may be more important than technological prowess for producing a positive learning environment" (pp. 13–14). However, the researchers struggled to empirically connect "Chickering and Gamson's seven principles of effective undergraduate instruction to graduate-level web-based courses" (p. 14).

The seven principles have also been used in the development of an online faculty peer review instrument (Taylor, 2010). In modeling the common practice of faculty peer review in traditional courses, the instrument provided guidelines to find evidence of each of the principles in reviewing an online course; this is limited to only the evidence found within the LMS.

The seven principles for good undergraduate education are good guidelines that focus on the communication between faculty and students. The variety of instruments illustrates the difficulty in measuring these principles. In addition, the focus on communication excludes other factors involved in online teaching, such as the course design.

Summary of the Strengths of the Frameworks

Each of the frameworks discussed adds to our understanding of online teaching. However, no single framework can provide all the answers (Mishra & Koehler, 2006). The TPACK framework provides solid descriptions of content areas and the need for each to integrate and inform each other. The CoI framework identifies three essential elements of presence in an online educational exhibited by both instructors and students. The seven principles focus on the interaction and engagement, bringing a focus to the delivery of a course.

Online teaching is multifaceted, and as the CoI and TPACK frameworks attempt to illustrate, the intersection of pedagogy/andragogy, technology, content, cognitive, social and instruction components is a significant aspect to consider. There is a

Table 1 Comparing Three Frameworks for Online Teaching: TPACK, CoI, and the Seven Principles

TPACK	CoI	Seven Principles
CK—Content Knowledge	(Selecting Content)[a]	
PCK—Pedagogical Content Knowledge	Cognitive Presence (Supporting Discourse)	(3) Encourages active learning.
		(7) Respects diverse talents and ways of learning.
PK—Pedagogical Knowledge	Teaching Presence (Setting Climate)	(1) Encourages contact between students and faculty
	Social Presence	(2) Develops reciprocity and cooperation among students.
		(4) Gives prompt feedback.
		(5) Emphasizes time on task.
		(6) Communicates high expectations.
TK—Technological Knowledge		
TPK—Technological Pedagogical Knowledge		
TCK—Technological Content Knowledge		

[a]The items listed in parentheses are the intersections of the three presences identified by the CoI model

need to step back, embrace the "wicked problem" (Ward & Benson, 2010) of online teaching and seek out additional perspectives to provide a better understanding of the whole picture. In addition, Eskey and Schulte (2012) reaffirm that "online instructors are an extremely important component of online student success" (p. 9), and, as such, their experience should be central in creating faculty development. As McQuiggan (2007) and Anderson (2012) recommend, in addition to developing skills and expertise, research needs to also address beliefs, attitudes, and assumptions about online.

Table 1 aligns the components of these three frameworks beginning with the knowledge identified by the TPACK framework. The majority of the aspects of all three frameworks fall within the pedagogical knowledge areas, with technological knowledge only represented by the TPACK framework. Despite the fact that technology is the most requested topic for faculty development (Arinto, 2013), only one of the three frameworks explored addresses this area. In addition, amidst the skills, knowledge, and strategies these frameworks focus on, attitudes, beliefs, motivations, and other emotional factors are missing.

Rebecca looked at the data sitting in front of her, the mix of quantitative and qualitative data focused on student perceptions and faculty behaviors. The attitudes, beliefs, assumptions, and motivational factors of the faculty were missing. How could she better capture this information in order to design professional development to create the transformational changes needed to help faculty move to the next step?

Flow Theory

Flow theory provides a framework for the optimal experience, one which equally integrates the cognitive and the affective domains (Schweinle, Turner, & Meyer, 2008). The focus of education has traditionally been on the cognitive domain, with tasks and objectives centered on learning facts, developing skills, and hopefully thinking critically (Csikszentmihalyi, 1995). In addition to the foundation of the cognitive domain, research has shown that the affective domain (Hartnett, George, & Dron, 2011; Keller, 2011; Vansteenkiste, Lens, & Deci, 2006) is equally important in education.

Csikszentmihalyi's Flow Theory is the result of years of research exploring the optimal experience across people of all ages, cultures, economic status, and gender (1990). The data identified nine criteria that were consistently reported as common characteristics of the optimal experience (Csikszentmihalyi, 1990). These moments become worth doing, simply for the sake of the activity, in a word—autotelic (Csikszentmihalyi, 1997a).

The following criteria describe the feeling of flow, or the optimal experience (Csikszentmihalyi, 1997b):

1. Goals are clear.
2. Feedback is immediate.
3. A balance of skill and challenge.
4. Deep concentration.
5. Problems are forgotten.
6. Control is possible.
7. A sense of transcendence.
8. Awareness of time is altered.
9. The experience becomes autotelic, or worth having for its own sake.

Flow theory is at the heart of positive psychology (Seligman & Csikszentmihalyi, 2000). Historically, psychology research has focused on the "disease model," wherein a solution is sought to solve a problem (Seligman & Csikszentmihalyi, 2000). Positive psychology seeks to draw upon the strengths of individuals (Seligman & Csikszentmihalyi, 2000). Scholarship in teaching and in faculty development has struggled with the general research approach to find a "problem" (Potter, 2010). It is a professional risk to focus on "problems" in teaching (Potter, 2010). This perspective of positive psychology identifies optimal experiences and can help to identify the characteristics, contexts, and emotions evident in a quality online teaching moment from the faculty perspective.

The optimal experience or flow has been used to study many areas including education students (Min, 2013; Mustafa, Elias, Roslan, & Noah, 2011; Shernoff & Csikszentmihalyi, 2009; Shernoff, Csikszentmihalyi, Shneider, & Shernoff, 2003; Shernoff & Schmidt, 2008; Stephanou, 2011). In addition, flow is very apparent in computer, gaming, and internet use (Chen, 2006; Coller, Shernoff, & Strati, 2011; Procci, Singer, Levy, & Bowers, 2012; Reese & Tabachnick, 2010; Voiskounsky, 2008).

In addition flow has been studied in various computerized learning environments (Bachvarova, Bocconi, van der Pols, Popescu, & Roceanu, 2012; Beylefeld & Struwig, 2007; Burgess & Ice, 2011; Cooper, 2009; Scoresby & Shelton, 2011). However, there is little research using flow theory in online learning within an LMS specifically addressing the experience of the instructor.

In the educational context, flow has been shown to be a positive influence on learning (Liao, 2006; Sun, Tsai, Finger, Chen, & Yeh, 2008; Weibel, Stricker, & Wissmath, 2012). Gunderson (2003) reported that an instructor in flow promotes students in flow, in alignment with what Csikszentmihalyi (1997b) described as an ideal learning environment. In studying online students, Shin (2006) reported that flow significantly predicted student satisfaction. Meyer and Jones (2013) also reported online students experienced flow; however, flow was reported more often in the non-class setting than when they were "in class." Min (2013) in researching traditional undergraduate students' experience in their course work found that the type of activity (analytical, intuitive and repetitive, or creative) influenced their flow experiences, with repetitive and creative tasks promoting more occasions of flow.

Flow has traditionally been studied using experience sampling method (ESM) to measure three key conditions of flow—skill, challenge, and either interest, enjoyment, or the desire to be doing the activity (Hektner, Schmidt, & Csikszentmihalyi, 2007). Measurements can either be taken randomly when signaled, or after specific events. ESM captures data closest to the moment of occurrence, without the intrusion of an observer and minimizes the loss of information due to global recall (Hektner et al., 2007). While not intrusive due to an observer, ESM is an intense method of data collection that requires the participants to stop when signaled and respond to a questionnaire about the current situation. This type of interruption would be harmful if participants were truck drivers or heart surgeons, due to the nature of their work. While large studies (Csikszentmihalyi, 1990, 1997a; Delle Fave & Massimini, 2003; Nakamura & Csikszentmihalyi, 2002) have used ESM in educational settings, the focus has been mainly on the students. While not harmful in the same sense as with the surgeon, teaching moments are easily lost and ESM surveys interrupt teaching to the detriment of the students. Previous studies which have explored the experience of flow in instructors have relied on general surveys, videotapes, and interviews, moving the moment of data collection away from the moment of flow (Gunderson, 2003; Hektner et al., 2007; Livingston, 2011). The asynchronous nature of online teaching minimizes the concerns of using ESM in the traditional classroom, making it an ideal methodology to capture data closest to the moment of occurrence.

Hektner et al. (2007) reported that one condition of the flow experience, the balance of skill and challenge, has shown to consistently predict the other characteristics of flow. Flow is at the intersection just above a perfect balance of skill and challenge. This is similar to the zone of proximal development (ZPD) described by Vygotsky (1978). According to Vygotsky (1978) learning happens when the situation is located just outside an individual's ability to function on their own, thus requiring another to enable their learning and forward progress. Csikszentmihalyi (1997a) describes this zone as a "magnet for learning" (p. 33). It is in this area where faculty workshops and training need to focus in increasing both skills and challenges to improve the development of the online instructor.

The use of flow theory and ESM to study the experience of online teaching from the perspective of the faculty will provide additional information for an integrated picture of online teaching to include the affective aspects of attitude, beliefs, motivation, and emotional engagement. This new lens and methodology will also capture moments related to online teaching outside normal working hours and outside of the LMS. It will also focus on the faculty experience, including both the cognitive and affective factors involved in online teaching. Research using flow theory and ESM methodology will help to identify expert online instructors in flow. By studying these optimal experiences, professional development can then be created to support all faculty in "taking the next step" and becoming experts.

Conclusion

Online learning has become a permanent part of higher education. With the demand for online courses increasing and online learning becoming a more integral part of institutions' long-term strategic goals (Allen & Seaman, 2014), more faculty will need to teach online. Flow theory is recommended as a guide for future research, to add the affective components of online teaching to the current body of research using other frameworks. Flow theory provides an integrated framework to identify the optimal experience, across the domains of the cognitive and the affective, from the faculty perspective in teaching online. With a better, broader, and integrated picture, more effective and focused professional development can be designed to support quality online teaching for novice and experienced faculty.

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Design Team Collaboration with a Complex Design Problem

Monica W. Tracey

Abstract To what extent does collaboration impact complex ill-structured design? This research project focused on design meetings held during the first year of a 5-year, grant-supported effort to develop an innovative, 6-day course that integrates cutting-edge radiation physics and radiobiology content aimed at physicians and researchers working in the field of radiation oncology. The data set included over 568 pages, 208,842 words of written transcripts of a total of 15 two-hour meetings held over 6 months. Results indicate that designers use collaboration to manage constraints throughout the design process, inclusive leadership and decisive leadership are both used to keep the design process moving forward and designers use collaboration to build and rebuild prototypes in order to envision and refine solutions.

Keywords Design • Design thinking • Design constraints • Collaboration • Design prototypes • Ill-structured problems

Setting the Stage

The following is the story of Avery, an 8-year-old boy with cancer. This text represents a simplified example of the dense material the design team in this study was charged to work with; a small portion of content for one activity out of over 20 designed for the 6-day course. Reading this small excerpt will give you an opportunity to put yourself in the shoes of the design team, providing you a sense of the content and context of the design space. As you review the following paragraphs, my hope is you will think about the layers of content, the design of the "virtual hospital" activity, in which this content was embedded and the learners, M.D., Ph.D.'s in physics, biology, and radiology.

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Avery is an 8-year-old prepubescent Caucasian male who plays contact sports (pee-wee football). He begins complaining of a headache that gets worse over 1 week, accompanied by nausea/vomiting, and “clumsiness” (occasionally stumbling and losing balance). His mom takes him to the Emergency Room, suspecting that he may have a concussion resulting from football practice. On fundoscopic exam (visual examination of fundus of the eye) the emergency physician notes papilledema (swelling of the optic disks), indicative of increased intracranial pressure. A stat CT scan of the head reveals hydrocephalus (enlargement of the ventricles) in the fourth ventricle, and a contrast-enhancing midline mass, blocking cerebrospinal fluid (CSF) outflow. A malignant tumor is strongly suspected. An MRI of the brain better delineates a 4×4 cm mass. An MRI of the spine shows no other tumors in the central nervous system. He is then referred to a pediatric neurosurgeon. The pediatric neurosurgeon removes the mass the next day, and is confident that he did not leave any residual tumor. The tumor is sent to pathology. Because surgical estimates of the extent of resection may not be reliable, a postoperative MRI evaluation for residual disease is required within several days of the procedure. Three days post-surgery a postoperative MRI shows no residual enhancement in the fourth ventricle suspicious for residual tumor. An MRI of the spine and lumbar puncture (LP) is performed to test for metastasis and returns negative; therefore, his condition is identified as “standard risk.” The pathologist’s final diagnosis is medulloblastoma. Avery is then referred to a pediatric oncologist and radiation oncologist. The pediatric oncologist discusses standard of care treatment, which includes craniospinal radiation with concurrent chemotherapy (this allows for a lower radiation dose). Weekly vincristine chemotherapy is administered intravenously. Additional chemotherapy is given after radiation treatments are complete. The radiation oncologist discusses treatment. Radiation must be done to the whole brain and spine in order to sterilize any microscopic disease that’s left behind in the brain or anywhere in the cerebral spinal fluid. Based on experience, if this treatment isn’t done, this cancer is likely to return in the brain or spine.

Daily radiation (usual dose fractions of 180 cGy/day) is performed for approximately 6 weeks. The first half of treatment will be to the spine and whole brain. The second half will be a focused treatment to the area where the tumor was located (posterior fossa or tumor bed treatment). The short-term side effects for Avery can include cell counts going very low and a combination of radiation and vincristine can cause severe GI toxicity. Avery may face long-term complications including: radiation to growing bones can cause them to grow more slowly, head size and length of spine may be stunted, can affect brain development, mild learning or memory problems down the road, new skills may be more difficult to acquire, secondary malignancies: substantially increased lifetime risk of developing cancer in all areas of the body that received radiation.

Avery is treated by numerous radiotherapy professionals, most of whom operate in the silo of their profession and do not, generally as professions, collaborate with each other. Avery is receiving radiation, an area where research and education is also declining in the United States. What can be done to improve the chances of

Avery and others diagnosed with cancer to provide them with the best clinical care? How can we improve the clinical practice of radiotherapy for cancer?

Attempting to address this problem, The National Cancer Institute, a division of the National Institute of Health, awarded a 5-year research grant to an interdisciplinary team to design an innovative and advanced 6-day course that integrates cutting-edge radiation physics and radiobiology content aimed at physicians and researchers working in the field of radiation oncology. Requirements of the educational intervention include the demonstration of how to apply state-of-the-art knowledge in successfully delivering modern high-quality image-guided radiotherapy, planning relevant and productive research, and assuring the future availability of highly qualified teachers. The ultimate goal of this intervention is to improve cancer patient care and cure in the United States: no small task for an instructional design team.

The purpose of this study, part of a larger 5-year interdisciplinary grant-supported research study on the design and implementation of this medical program, was to study design team collaboration to see if and how it impacts design. The research question that guided this study was:

1. To what extent does collaboration impact a complex, ill-structured design problem?

Designing in Context

Design is described as a process of *meaning making*, engaged in creation from a holistic systems perspective (Nelson & Stolterman, 2012). In other words, things make sense when they are connected and interrelated or presented through relationships in context. Looking at design through this lens provides designers with a systems perspective. Nelson and Stolterman (2012) describe a process of creating a “design palette” (p. 89) in an attempt to predetermine the consequences of various choices in a particular situation. They suggest that designers and stakeholders must realize that not only are these choices inevitable as a part of achieving a design, they will be made whether or not the designers are aware that they are making them. Therefore, better choices are those made consciously, based on the designer’s judgment. To make the best design choices, the designer must view the design in the context of the whole system. “As every design is part of an environmental system, formed by a systemic context that carries systemic consequences with its implementation, the best design is one that is a whole-systems design” (Nelson & Stolterman, 2012, p. 91). Design is rooted in a context framed in time, place, and culture and designers must understand the context of the design situation as quickly and as well as possible.

Nelson and Stolterman (2012) state, “Design is about how to best integrate a particular design into a specific context and fit it into its environment” (p. 161). The context of this new design project included a national threat of a reduced knowledge base in providing modern high-quality image-guided radiotherapy, the lack of cross pollination in biologists and physicists who are planning and conducting relevant productive research, and the national reduction of highly qualified teachers in this field due to numerous researcher retirements. This problem escalated to a point where time became integral in the context of this design. The NIH demanded a complete program within 6 months. The design process had to be responsive to our context. Taking a holistic systems perspective provided us with the opportunity to look at the relationship of each part of this project. This perspective supported the impetus for the team, how we assembled it, how often we met and the goals that had to be accomplished by the end of each meeting.

Design Constraints

When a team begins to design, a first step is to gather information. It is during this time that initial constraints are often unearthed, and solution generation begins. Because the design problem and constraints are not clearly defined, the deeper the team delves into the design, constraints can provide an opportunity for the team to redefine the problem and the solution. Constraints can actually bring possibilities to innovate, refine, and improve the design (Cross, 2011). Constraints can force a design team to radically redesign initial ideas and are an important tool in supporting quality design. Because constraints are almost always synonymous with problem solving, researchers have attempted to design problem-solving models addressing the issue of constraints.

Models of design problem solving and dealing with constraints (Biskjaer & Halskov, 2014; Elster, 2000; Lawson, 2006; Stokes, 2006) are prolific, as researchers are attempting to support designers' need to solve problems while embracing constraints. Lawson (2006) categorizes constraints along three dimensions. The first dimension considers who generates the constraints; this could be the designer, the stakeholder, the end users, etc. His second dimension addresses constraints and context, i.e., are they internal to the design or are they within the context of the design problem. The final dimension focuses on the type of material for the design, the function, and practical application. Lawson's model illustrates the numerous constraints designers must not only deal with but embrace during design. He maintains that design problems are significantly composed of external constraints, over which the designer has little or no control.

Problem solving and constraints have been addressed while studying artists. For example, psychologist Patricia Stokes (2006) designed a problem-solving model addressing artistic creation. She suggests that artistic creation is about solving a creative problem, and following a constraint-based creative process model can intentionally generate the artist's ability to create real innovations. Jon Elster (2000), a social and political theorist, states that constraints serve art by focusing the artist's attention, maximizing the artist's goal to make aesthetic value under the given constraints.

Elster defines a constraint as one that is imposed by the material, requirements, and demands from the context including outside end users, stakeholders, budget, time, and artist self-imposed constraints which stem from the artist's own choices.

Biskjaer and Halskov (2014), researchers in interaction CAI, suggest that constraints can be a creative resource in interaction design and found that experienced practitioners view constraints as complex, at once restraining, impeding, enabling, and advancing a creative course such as a design process. They coined the term *skillfully balancing constraints* (p. 28), which they define as the ability to realize, define, and act upon circumstances and conditions in a creative process. They argue that these constraints share (at least) two key characteristics: they are grounded in *radical decision-making* by going against easy and common creative choices as solution alternatives, and they *accelerate the design process* by pushing it forward in the form of an unexpected leap. They maintain that constraints are always a part of a creative activity regardless of their origin whether they are external requirements of the design, design materials, or chosen by the designer himself. There are also various strategies for the designer to approach these constraints. The early-identified constraints of the brand new design project described here included internal and external constraints. Heavy time constraints on the design team combined with the looming final delivery date; a complexity of the overall task and final product, dense content, and numerous stakeholders all impeded and improved the design.

Design Collaboration

Collaboration while designing is not a new concept although instructional design activities are often done individually. Some question whether this is the best way to design (Brown, 2009) and if a "radical form of collaboration where designers migrate toward ever-deeper collaboration not just among members of a design team but between the team and the audience it is trying to reach" is needed (p. 58). Brown states that we must look at design as an opportunity to work *with* the stakeholders and end users, not *for* them. Business and industry, he contends, should think about how more time could be spent doing collaborative, procreative work in face-to-face time. Brown argues that this will produce a solid outcome because face-to-face time nurtures relationships and inspires teams and is one of the most precious resources an organization possesses. In terms of design, Brown states that time collaborating in teams should be as productive and creative as possible where each person builds on the ideas of others. When design is happening in real time and among people who know and trust one another, he believes this makes design easier (Brown, 2009).

Design collaboration, however, is not always an easy or intuitive activity. Studying designing in teams Brereton, Cannon, Mabogunje, and Leifer (1996) noted that each individual designer should possess behaviors of collaboration that include expressing ideas, listening, and negotiating. A design team's process is quite complex and controlled, with numerous levels of activity occurring at the same time even if it appears to be free flowing to those outside of the team (Cross, 2011). Brereton et al. (1996) discovered that designers working in collaborative teams are constantly engaged in numerous activities at different levels and continuously look at alternatives while reflecting, monitoring, and modifying their process and course of action. Solutions are created based on the requirements and a constant review of various solution alternatives. The design team on this project attended mandatory 2-h meetings in one room, around a circular table where an initial idea was introduced to begin the creative design process. There were no breaks, cell phones were turned off, and the only goal was to design, by identifying constraints, creating ideas, and building on them. Each team member chosen because of their developed professional identity (Tracey & Hutchinson, 2013) possessed the ability and desire to create an innovative design, and also had a stake in the realization of the final product.

Designer Judgment and Identity

Fundamental to the design thinking approach, as outlined by Boling (2008), Cross (2011), Lawson (2006), and Nelson and Stolterman (2012) among others, is the idea that designers are the dynamic drivers of the design process who use their knowledge, experience, and intuition to navigate the design space and recursively refine both problem and solution until an innovative outcome is reached. Design relies on designers' judgment, or the ability to balance elements of the design problem against their own storehouse of design knowledge, which is highly personal and can't be separated from the knower, in order to reach decisions (Nelson & Stolterman, 2012). Design knowledge emerges from the accumulated episodes in an individual's history of design choices and consequences, both directly experienced and observed; these episodes have been conceptualized as design precedents (Tracey & Boling, 2013). Reflective thinking, another concept foundational to design thinking (Cross, 2011; Schon, 1987), provides the designer with a pathway to consider and reconsider design precedents in the face of complex and novel design problems (Tracey & Baaki, 2014), leveraging them in service of design judgment, decisions, and action (Tracey, Hutchinson, & Gryzbyk, 2014).

Design thinking highlights the central role that designers play in developing novel, functional solutions to ill-defined problems (Siegel & Stolterman, 2008). Designers recognize that problems and solutions are entwined concepts, but that the relationship between the two is complex, evolving, and often oblique. And as designers move through the design space between problem and solution, they must rely on their design intelligence and intuition or their designer identity. Within instructional design, professional identity development is intimately linked to the concept of design precedents (Tracey & Hutchinson, 2013). Designers on this project were chosen not because of the number of years of experience (although it accumulated to over 60 years of design experience and 50 years of biology and physics experience), but because they were grounded in their professional identity (Tracey &

Hutchinson, 2013) and believed in the skills of their design judgment. This was a concentrated, constantly changing design, and each member possessed the ability to immerse him or herself in the project and bring relentless energy to the team.

The Design Team

Design teams are made up of individual designers, each bringing their own knowledge, experience, and intuition to navigate the design space and recursively refine both problem and solution until an innovative outcome is reached (Tracey et al., 2014). Assembling the appropriate team was critical to the success of this project. Nelson and Stolterman (2012) state that "an appreciative judgment, appreciating what is important to consider and what is not; whose interests need to be taken into account and whose do not; and what level of complexity must be maintained as a substitute for never-ending comprehensiveness. It is within this context, and against this environment, that the design process unfolds," (p. 115). The two grant Co-PI's, me as the researcher in Instructional Design (ID), and the other a researcher in Biology were key leaders on the team, each bringing their expertise in choosing the remainder of the team. Two additional Co-Investigators on the grant, a researcher in ID specifically in assessment and evaluation and a researcher in Physics were also critical to the team. These four members, in part due to their roles on the funded grant, brought biology and physics content expertise in addition to the needed instructional design expertise.

The two designers interviewed and hired four additional designers to work on the team. Each designer had worked with the designer Co-PI and/or were current graduate students in the Instructional Technology program at the host university. Knowing the depth of the content, the compressed design and development time and the overall complexity of the design project, we hired designers who had a minimum of 6 years experience specifically with complex projects. These, however, were initial selection criteria. A conscious effort was made to select designers who possessed the ability to be flexible, reflective, and self-confident in their design judgment and had the ability to have their ideas analyzed, changed, and built upon. Although this may appear to be logical, realizing this project was too complex for individual design efforts, we had to ensure that the designers were able to join and help cultivate a quickly functioning team. The importance of this cannot be underestimated and this conscious decision played a significant role in the success of the design space and the end product. The biologist and the physicist served as the content subject matter experts, but, more importantly, provided access to additional biology and physics researchers and physicians and clinicians to support our design efforts along with a window into the end users. As the design team proposed ideas, these SMEs provided instant critical feedback on the viability of the design. Figure 1 illustrates the project team with a brief description of their roles. Additional team members included consultants in graphic design, desktop publishing, computer programming, and web site development. We brought these individuals in on an as-needed basis and worked with the designers to develop products.

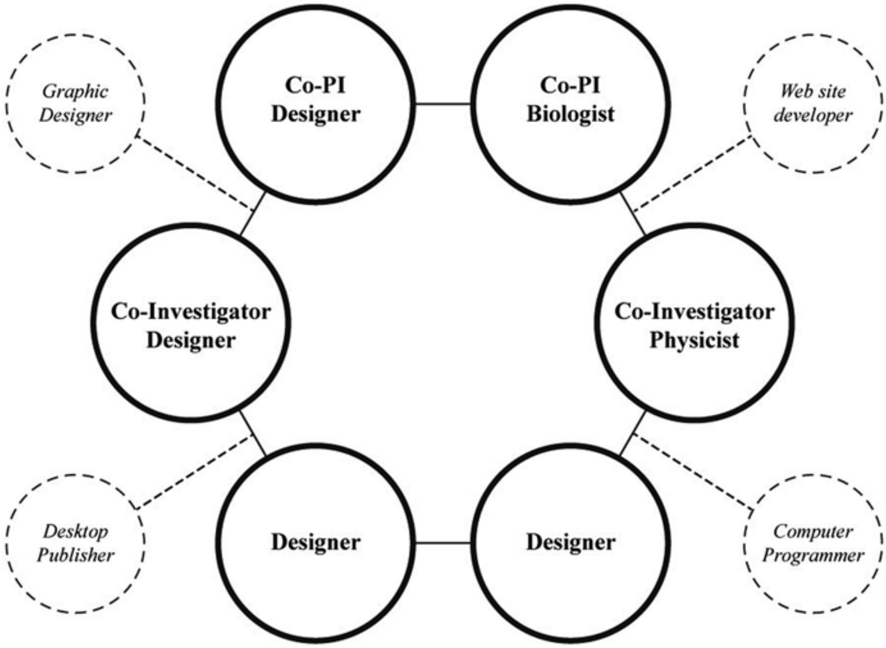

Fig. 1 The design team

Methodology

This research followed a protocol analysis methodology. Described as the ideal method to "bring out into the open the somewhat mysterious cognitive abilities of designers" (Cross, Christiaans, & Dorst, 1996, p. 1), this method follows a research-through-design approach (Basballe & Halskov, 2012; Dalsgaard, 2010; Halskov, 2011). Using protocol analysis, which relies on the designers' verbal accounts of their activities, we documented the verbal exchanges of members of the design team engaged in the shared task of designing the 6-day medical course. Cross et al. (1996) argue that protocol analysis appears to provide data revealing the cognitive activities assumed by the design team members.

We focused on design meetings held to develop our innovative, 6-day course, integrating cutting-edge radiation physics and radiobiology content aimed at physicians and researchers working in the field of radiation oncology. The data set included written transcripts of a total of 15 meetings held over 6 months. Participants, described above, included the two Co-PIs, two co-investigators, four additional instructional designers, and pertinent outside consultants such as a web developer, desktop publisher, and a graphic designer. The number of participants at a given meeting ranged by meeting (and within meeting, as consultants would typically only attend for portions of a meeting) from a high of seven to a low of four, with an average meeting duration of 2 h. Transcripts of audiotaped meetings, 568 pages

(208,842 words of text), were prepared from audiotapes by a graduate research assistant familiar with the grant, who also attended some of the initial meetings to garner an understanding of the project scope. Each designer had advanced degrees in Instructional Design and Technology, three held master's degrees, one was a doctoral candidate and two held doctoral degrees. Each designer had no less than 6 years design experience, with the most senior designer working in the field for 27 years. The designers worked in numerous areas of design before joining this team, although none had professional experience in designing in the medical field.

Data Analysis

For the data analysis, two doctoral students in instructional technology (who were not involved with the grant) served as the initial reviewers, while the primary investigator on the grant, and I as a professor of instructional design, served as the final reviewer. During initial data analysis, the reviewers read through the transcripts to understand the events and trajectory of the design process, taking notes and rereading as necessary to develop a deep knowledge of the content and to identify preliminary themes related to collaboration. The goal of this reiterative process was to gain a picture of the issues and actions that seemed most important to understanding how collaboration shaped the design process and influenced the design solution. Once the reviewers completed this process, they formalized their findings by identifying three themes that most clearly demonstrated how collaboration contributed to a refined ID product and supporting their conclusions by referencing specific events from the design meeting transcripts that illustrated these themes. At all times during this initial data analysis period, the reviewers worked independently to develop their own sets of themes and corresponding notes, with no knowledge of the other's findings.

Once the initial reviewers had completed their inductive content analysis, their findings were submitted to the third reviewer, who reviewed their findings for validity, integrated identified themes where possible, and made final decisions on the identification of the final themes based on the evidence presented by the two initial reviewers as well as her own experience on the design team. As needed, the third reviewer consulted with the two initial reviewers to gain clarity on their findings, gather suggestions for integration, and gain consensus for the final results of the data analysis.

The Results

Design requirements included designing a 6-day course integrating cutting-edge radiation physics and radiobiology course aimed at physicians and researchers working in the field of radiation oncology. Three themes emerged under the research question, to what extent does collaboration impact a complex ill-structured design problem?

Designers use collaboration to manage constraints throughout the design process. The constraints presented in this study support research conducted by Cross (2011) in that they initiated innovation, refinement, and improvement in the design. Collaboration supported us in identifying the constraints, elaborating on those constraints, revising the constraints when needed, and ultimately recasting the constraints as opportunities. Design meetings provided the opportunity for the team to identify and/or reiterate individually or as a group the immediate constraints depending on where we were in the design space. The keynote presenters, experts in physics and biology ($N=24$), the keepers of this inordinately difficult content were a monumental constraint, identified in the data analysis as the second most challenging constraint behind time. Efforts to contact these chosen keynote presenters were unsuccessful and the learning curve of what they do and how we needed to design for this content is almost insurmountable. Discussions on how to manage this constraint via technology by attempting to email questions to garner information ensued, although unsuccessful. Ultimately, several collaborative discussions describing each designer's experiences attempting to work with the keynote presenters resulted in the design of a consistent process incorporating numerous audiotaped meetings, visits to their workplace if possible, and/or scheduled conference calls.

As indicated, time was the number one constraint and, although the data indicates it could actually be its own theme, it is included as one of the constraints for this chapter. Time constraints included the design schedule, the keynote presenter's schedule and availability, and how future iterations of the design could be impacted by current design decisions due to the scarcity of time this first year. The data indicated that the shortness of time forced the design team to brainstorm and innovate in a productive manner. Design meetings were productive from beginning to end, as time was not a luxury the team had to complete this project. During design decisions, the team indicated which design ideas had to wait to be included in future design iterations, but smaller scale options were often created for this first year. For example, an idea surfaced to have participant teams develop a clinical trial. This activity required in-depth research and design, and first year time constraints prevented it from coming to fruition. As an alternative, the team researched existing clinical trials and designed questions and concerns for the participant teams to debate. This activity was well received and is the foundation for the design of the clinical trial activity planned for year 2.

One unknown was the physical layout possibilities of the conference room housing the 6-day course. This challenged the design team while we attempted to design participant activities to meet one of the overarching course goals, to provide instructional activities focusing on interdisciplinary participant collaboration. One team member resolved this constraint by uncovering pictures of the room illustrating various meetings and trainings on the Internet and sent them to the rest of the team. After viewing the online photos, the team discussed the physical room constraints and made decisions on room set up to accommodate the participant group numbers: where the projector needed to be for keynote presentation slides to allow participants the optimum viewing opportunity and how the white board activities would work. In this instance, the physical constraints were better-understood and overcome with visual reference and discussion.

The 6-day course opened to biologists, physicists, and clinicians provided the opportunity for the design team to identify, collaborate, and attempt to resolve the participant knowledge constraint. After meeting with a keynote presenter, one designer confirmed that biologists and physicists don't communicate with each other and are unfamiliar with the literature outside of their professional area. We realized that we were dealing with two totally different languages along with a lack of current professional practice integration. Discussion of this constraint resulted in agreement that this was a complex issue and would substantially affect the design. This constraint was preliminarily resolved by the grant leaders, the Co-PI designer who served as the team leader working with the Co-PI biologist and the Co-Investigator physicist, to assist the design team with the content. In this instance, the leaders of the grant had to resolve the issue by coming to consensus on the content that best educated both professional groups. Most of the identified constraints were elaborated on, revised, and resolved in the team: however, leadership was needed at times to make decisions and move the design forward.

Inclusive leadership and decisive leadership are both used to keep the design process moving forward. Design team leaders need numerous skills, but the most essential character trait is that they are designers (Nelson & Stolterman, 2012). When defining leaders, we tend to think of someone appointed to a specific position or possessing a particular role. In a collaborative design situation, leaders are those who propose the vision of the design along with an enthusiastic judgment of what is possible.

Roles were identified, naturally emerging, and at times changing in this collaborative design team. The team was well balanced in their roles and managed their negotiation well (Cross, 2011). The Co-PI designer served as the team leader and facilitator during design meetings. She used facilitation promoting inclusive leadership at the beginning of each design session through the initial idea generation process. Statements such as *What do you all think*? and *I am wondering* prompted the team to contribute to and refine ideas. While inclusive leadership seemed to be linked with eliciting ideas, decisive leadership was more associated with choosing discussion topics and making decisions. The Co-PI designer used her position as leader to open one meeting stating, "I want us to walk away today with a picture of how we see each day will look, and what we need to ask the keynote presenters to do, and how we are going to start creating those activities." This sets the agenda for the design meeting, and also linked to the third theme, using collaboration to build and rebuild prototyping (discussed below). Cross (2011) states that a design teams' need for explicit planning of activities is evident in their collaborative work. This was demonstrated repeatedly during team meeting initiation. Both inclusive and decisive leadership were used to set the agenda either in the beginning of the meeting or at the end of the previous meeting, with the team coming to consensus.

Ideas emerging from agenda items were further refined via a facilitated discussion: "Let's talk about some of their (keynote presenters) feedback so we all know that we are incorporating it into our design." Inclusive leadership in the form of facilitation is demonstrated on how the Co-PI designer directed the flow of the discussion: "We have to flush this out. Okay, now we're starting to get down to some specifics," followed by discussion which eventually led to the identification of additional constraints (theme 1, discussed above). After these constraints were discussed and resolved, the Co-PI designer kept the conversation moving forward: "Alright now, what else, what are the other issues?"

Questions, including probing questions like, "Tell me more, how would that look?" and clarifying questions, "I thought there were going to be two videos… but what makes sense," and refining questions, "What about if we come up with the guided questions and have the keynote presenters edit them?" are examples of inclusive leadership that fostered collaboration while continuing to move the design forward. While inclusive leadership led to discussion to gain consensus, there were times when decisive leadership was enforced, including once the need to reassert the role of the designers with the keynote presenters in the process emerged: "We have to make some decisions and make mistakes on our own," and "That's a design decision we are going to have to make." Decisive leadership in these moments was necessary to preserve deadlines and manage communication with the keynote presenters. Decisive leadership in these instances also provided the opportunity for the designers to reestablish their roles as designers rebalancing the entire research team.

Designers use collaboration to build and rebuild prototypes in order to envision and refine solutions. Visual lists, phrases, and words on large posted flip chart paper used during design team meetings stimulated idea generation and evolution (Fig. 2). Decisions were summarized and reinforced while new ideas were simultaneously generated. These visuals were combined with verbal prototypes, design ideas articulated verbally, encouraging rapid dialogue/questioning to build on the initial idea and create instructional strategies. Accuracy/understanding of the verbal prototypes was an issue that kept coming up (via designer questions or misconceptions of what the prototype consisted of, particularly related to the schedule and the morning activities), but this appeared to be an opportunity to gain consensus/clarity *or* to further refine the prototype based on the verbally described confusion. A team member asked a question "So wait a minute, let me just back up and ask a question. This is just the morning segment? We have 3½ h of the morning. Is that what you said? So basically you get two themes a day…" This prompted a discussion on how the day's schedule would be framed. Verbal prototyping was used to better understand the problem (How many lectures will we have?) and tentative solution (how time will be allotted). "What I'm hearing is that where we give an hour for a talk, we have two sections of question and answering, and maybe what are we thinking. Forty-five minutes for those two pieces?" This example of verbal prototyping of the day's schedule (rebuild) resulted in clarifying and refining the schedule.

These design ideas articulated verbally, or through verbal prototyping, and sketching drove the design. The introduction of ideas, "OK let me, before I show you, let me draw it. Is that ok? Let me draw what I was thinking and uhh…" The designer used a graphic as the impetus for a discussion of the pathways to treatment/virtual hospital activity, while other designers clarified via questions and added their own ideas. Prototyping the design led to design refinement: "Ok, so we have to now spend the rest of our time working on the workshop. They have gone through an opening activity and two lectures. They've gone through a patient, two guided questions with

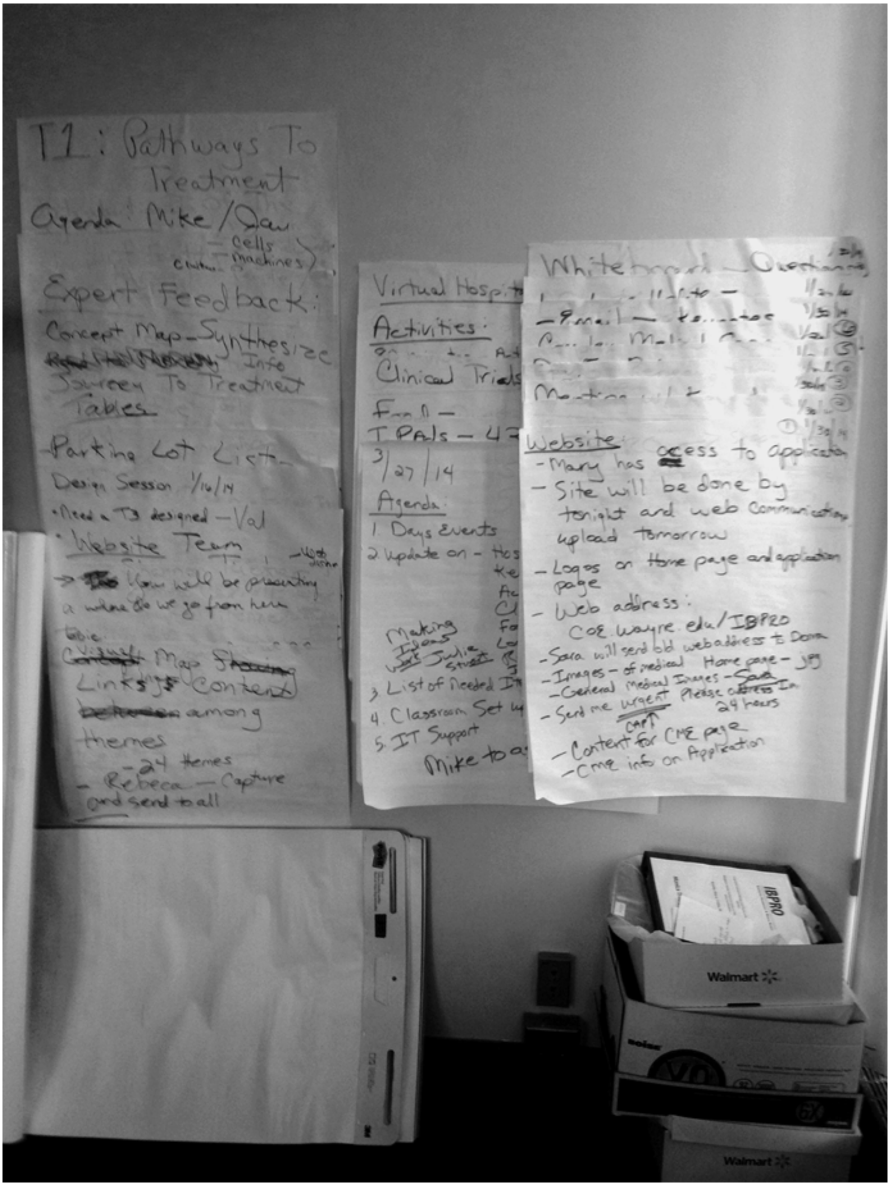

Fig. 2 Prototype example

a patient. They learned two themes, am I right?" The verbal description of the morning activity led to discussion of terminology to modify the design idea. Tentative ideas were introduced which also led to verbal prototyping, "We may have talked about this already, but Dr. D. asked if there was an opportunity for something like office hours?" Discussion followed where the team verbally constructed how the office hours might be implemented (timing, sign up) with multiple inputs to refine the idea. Office hours were ultimately implemented as a design strategy.

Because design meetings included the Co-PI biologist and Co-Investigator physicist, we had the opportunity for multiple revisits of the prototypes to ensure all group members understood and endorsed it. When the initial design idea of complex medical cases introducing each morning's themes was presented, it was purposefully revisited at a subsequent meeting with the Co-PI biologist. "Ok so let's blow this out. To create one prototype so that then we know what we're dealing with and we know all of the components that need to be in it. We have to start with one. Can we start with this one [points to one from a list on the wall]? And if we do, who do we need to work on it?" Discussion of the complex medical case ensued, including defining what it means, what doesn't need to be included, what should be included, and its overall goal for each morning. The Co-PI designer refocused the complex question that introduced the case to the participants and used input from the three other designers to clarify the question for the Co-PI biologist, but he came back with a need to clarify three more times. In each instance the prototype was repeated and refined until consensus was gained.

One design meeting with the Co-PI biologist and Co-Investigator physicist resulted in prototyping of what the main focus of keynote presenter lectures should include. The physicist began, "I was hoping that we will brainstorm some ideas, too, like you guys have some ideas about how to reach all three audiences, or all three participant types with one lecture." The biologist and physicist dominated discussion at this point because both were the content experts. Three designers, however, contributed to the discussion and ultimately a prototype of what keynote presenters should be doing was focused from broadly reaching three audiences to having keynote presenters specifically focusing on how to do research, how to get from where we are to where we want to be, which was also determined to be integrated into activities.

Collaboration with prototyping resolved questions regarding the feasibility of existing ideas in the design. Initial design connected the morning and afternoon daily themes through a patient activity. The designer who led the design of this activity described her idea; "Yeah, sorry. The opening activity after lunch, *the results are in role play consultation*. This is how it looks. Additional tests results are now in on Avery that deal specifically with or that have to do with imaging." The designer reviewed the current prototype of the afternoon activity. The CO-PI biologist asked clarifying questions that the designers answered, then the CO-investigator physicist pointed out that, based on this version, the keynote presenters would be interacting with someone on video (a constraint), which triggered an idea for removing the video and instead use another medium such as email, etc. The team came to consensus on the removal of the video consultation and used another form of communication. Through prototyping, a constraint was identified, resolved with an opportunity; the group came to consensus and the design moved forward.

Collaboration to build prototypes was used to gain consensus (inclusive leadership, theme two), but at certain times a decision to go with a particular prototype (or revisions to an existing prototype) was made by the research team leadership (Co-PIs) without polling the team. This action of decisive leadership (theme two) usually resulted from time constraints (theme one).

Discussion

Writing about collaboration and design, Lawson and Dorst (2009) suggest, "design on a substantial scale is essentially a collaborative effort… the ideas in a design firm often emerge from a collaborative creative process, rather than from a single contribution" (p. 187). There are numerous insights we now have because of this research project. We observed immediately that any known form of linear design process was not going to work on this design. Collaboration occurred at several levels that rarely happen in a design situation. If the careful selection of each team member did not happen, the collaboration would not have emerged in the manner in which it did and the final design product would not have been successful as it was. The Co-PI biologist's and Co-PI physicist's initial and ongoing presence on the design team was critical to the success of the final product. Having each of these content experts in all of the design meetings assisted the instructional designers in managing the complex content. Not only did we produce a viable product in spite of this complex problem and the numerous ongoing constraints, the final product was enhanced due to the ongoing intense collaboration of the design team. Rarely was a task assigned to one person and one person was never solely responsible for a design decision. Collaboration in this case shaped the design process and products through idea generation, discussion, refining, and consensus. Collaborative discussions on how to handle constraints resulted in solutions that would not have been possible with a single designer.

The final design product was not a random solution. Distinct design decisions were made largely because of the inclusive and decisive leadership used to keep the process moving forward. The Co-PI designer led the team consistently, opening meetings with probing questions leading to idea generation and discussion, traits of an inclusive leader, while at the same time being cognizant of time and the need to keep the design process moving forward. Decisive leadership appeared to be necessary to keep the deadlines, manage communication with keynote presenters, and reassert the designers' roles in the process as needed. Upon reflection of the end product, it is difficult to remember which team member initiated which design idea due to the rapid collective discussions and building and rebuilding of the prototypes creating and refining the design.

This research indicates that collaboration was a necessary skill in design when working with an ill-structured problem, while illustrating how designers need to be able to collaborate not only with fellow designers but also with others outside of our field (Buchanan et al., 2013). The research team on this project was comprised of disciplined, effective experts in their professions. This seasoned group of people created this innovative end product. This is an example of designing much in the manner other design fields. We maintain that this design was successful because of the expertise of the players, the decision to design in context, the ability for all to manage and embrace constraints, the designer's judgment and identity, and the conscious selection of the team. We anticipate that the results of this research will not only assist us in improving our design over the next 4 years of this project but may also aid other design teams working on complex ill-structured design problems.

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Designerly Tools, Sketching, and Instructional Designers and the Guarantors of Design

Elizabeth Boling and Colin M. Gray

Abstract Sketching can be a means to visualize learning objects and experiences differently than is possible in text-based representations. In particular, the experiential qualities of designed experiences can be explored using sketching as a tool and may not be accessible to designers via other means. If designers are to assume appropriate responsibility for our designs, to be the *guarantors of design*, our toolkit must expand. Examples are given of the ways in which sketching, as a flexible skill, may be used to represent designs for learning, together with discussion of how instructional designers would need to be able to think about these sketches in order to use them as tools.

Keywords Instructional design • Sketching • Visualization • Design representation • Guarantor of design

Introduction

Whether we have active awareness of it or not, as instructional designers we create, or specify, learning experiences—not simply the materials, reports, scripts, blueprints, storyboards, or any of the other objects whereby those experiences are enacted. These learning experiences are not equivalent to the "learning objectives" guiding them, just as they are not equivalent to the materials supporting them. These experiences are felt by the learners (and by instructors when they are present) as complex, situated events, with both learners and instructors taking an active role in shaping them—whether the experience appears outwardly to be heavily constrained by the instructional design or not (Parrish, 2008). The designer has to be aware, therefore, of the concrete reality of experiences that will result from the abstract

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specifications of a design (e.g., written objectives, content sequences, verbal descriptions of activities) and the real-time use of materials. Parrish (2008) and Hokanson (2008) have argued respectively, and convincingly, that our tools do not reflect concern for the experiential qualities of learning experiences and that the open-ended ability to sketch would be a useful tool for instructional designers. In this chapter we bring these positions together to demonstrate, via examples, that sketching may be used effectively by instructional designers as a tool to consider the experiential qualities of their designs. We argue further that the ability to visualize learning objects and experiences in the form of sketching is an important step in viewing the instructional designer as a *guarantor of design* (Nelson & Stolterman, 2012).

Learning Experiences

A traditional conception of the experiential dimension of instruction may be understood to be based on the level to which students become active agents in the learning process (Ertmer & Newby, 1993). While active agency is, no doubt, important, it does not encompass the hedonic qualities of a learner having an aesthetic learning experience (Parrish, 2005, 2009) or the utility of aesthetics in promoting transformational learning experiences (Parrish, 2014; Parrish, Wilson, & Dunlap, 2011). Likewise, the learning experience seems to be considered something that we expect to create, or determine in advance, and not a potential for experience that we hope to shape using naturally occurring and not entirely manageable phenomenon. Our models and theories do not address how to provide for learners' experiences outside of the roles we envision for them (Gray, this book). Some paradigms of instruction, such as constructivism and problem/project-based learning, attempt to engage in this space, but there are still numerous challenges in learning how to design adequately for open-ended situations in which learners—and instructors—shape their experiences actively, making the experiential dimension of the instruction inescapably important (e.g., Ertmer & Simons, 2006; Tobias & Duffy, 2009).

Guarantor of Design

Nelson and Stolterman (2012) discuss the idea that the point of responsibility for the appropriateness of a design and for its consequences—the *guarantor of design*—cannot be located in, or limited to, the design process, but must actually be taken on by the designer. If this responsibility *is* viewed incorrectly as being located in the design process, the assumption is made—implicitly or explicitly—that designers should use the "right" process and carry out all the steps of it conscientiously, and further that the resulting design will be as it should be. When there are problems with the design, those who view the process as the guarantor of design will assume that some step of the process was carried out incorrectly, was skimped on, or was overlooked. In our observation, and strongly implied in the foundational literature of our field (Smith, 2008), these are, in fact, the assumptions of many who practice and teach instructional design. In other words, many in the field view the responsibility for appropriate design as residing *outside* the designer. To illustrate, we offer the following story:

> Several years ago the first author was teaching a project-based course in basic instructional design. While the course did not rely exclusively on one model of instructional design, student teams did work through a structure of traditional deliverables: needs and learner analysis reports; a design document covering learning objectives; content sequencing, instructional strategies, activities, and materials; a formative evaluation plan and an evaluation report.
>
> One group spent the semester designing, developing, and implementing a training module intended to support non-native speakers in buying a second-hand vehicle in the United States. They finished the module, an epitome preceded by the introduction of prerequisite concepts and followed by increasingly difficult examples and non-examples, with realistic activities engaging the learners with one another to discuss how they would carry out the process of purchasing a second-hand car.
>
> When the team tested the module with students from the target learner population, however, they realized that something was wrong. Even though they had followed all of the required steps correctly to design the module, observed no confusion or technical problems to report from the trial run, and noted a learning gain, they also perceived that the instruction as experienced was repetitive, boring, and unpleasant for the learners—who were simply, and quite evidently, too polite to complain about it. They had done a good job according to the view of design, which places the guarantor of design within the process of designing; a view which holds that if you follow the process correctly, the result will be acceptable and effective. But they had not produced an acceptable experience, and they questioned whether it would have been effective under real world conditions if the learners had been less compliant.

For those who see the process as responsible for appropriate design outcomes, it is tempting to conclude, as seems to be the norm communicated by our casebooks (Ertmer & Quinn, 2007; Ertmer, Quinn, & Glazewski, 2014), or at least the typical uses of them, that the students did not follow prescribed processes, and that this accounted for the problems they observed in the resulting experience they had designed. But they *did* carry out the process well; their deliverables were thoughtful, and they created a learning intervention that was, on paper, aligned with existing instructional design (ID) theory. Even so, the learners' experience of this internally coherent and consistent content was still boring, onerous, and distinctly nonaesthetic.

It is further tempting to look only at the evidence of learning and choose to overlook the experiential qualities of what was designed—how the event felt and what its meaning was for the participants (Parrish et al., 2011). After all, if the intended learning did occur, the process may be presumed to have done its work and so, one might ask, why does this story even matter? As designers, we may assume that we understand those who will participate in the experiences we design after we have carried out prescribed analyses. However, we really do not have tools to envision the experiential dimensions of our designs early in the process, arguably necessary in order to understand learners in the context we are designing for them. This lack of appropriate tools can result in generic instruction that ignores the lived experience of the humans who participate in the designed intervention. Without a well-established understanding among IDs of the emotional and aesthetic aspects of learning, we may not know the true cost of that design in the experiential dimension (Damasio, 2005; Dewey, 1938; Greenspan & Benderly, 1997; Parrish et al., 2011). In the context of the story above, for example, what is the future effect on an international learner who has received the message that her time is not considered important? What learning will a student skip or avoid because of a previous negative experience? How will a learner who passes a post-test in the moment use his knowledge later, or perhaps forget it, when it is attached—as it may be—to a negative affective state in his memory?

While the student team in our story simply asked a few of their peers to suffer through a couple of boring hours of instruction, as a field of practice we can use their example to ask some important questions. Are all learning gains worth some form of human cost? Which are, or are not? What level of cost is appropriate? Necessary? Are we looking, as we should, beyond individual learning experiences to consider the long-term costs of instruction which is designed without regard for the experiential dimension? Where and how can the human experience of intentional instruction be considered in ID? These questions bring into focus the concept of the *guarantor of design* and how it may apply to our form and contexts of designing—to whether or not process and principles can actually serve as guarantor for the experiential qualities of design.

Tools

For the purpose of this discussion, we use the term *tools* in a broad sense to include "methods, tools, techniques, and approaches" (Stolterman, McAtee, Royer, & Thandapani, 2008, p. 116), as well as models, theories, and principles. We see tools as multiple and complementary, rather than as all-in-one templates or hierarchical sets of prescriptions (Gray, Stolterman, & Siegel, 2014; Harrison, Back, & Tatar, 2006). We recognize that within the field many tools do exist in addition to ID models, and that they are not necessarily dictated to be used in a predetermined order. However, often when our textbooks and definitions explain that our models are not linear, or that our tools may be used in multiple contexts, either no guidance is given on how to decide when designers should do what (Smith, 2008), or the guidance given is so fully prescriptive (Reigeluth & Carr-Chellman, 2009) that, in effect, it places the responsibility for appropriate design incorrectly within an instructional theory and not within the designer, where it should be.

Instructional design tools, mainly process models and instructional design theories, attempt—at least implicitly—to encompass all of designing, or all designing of a certain class (Gibbons, Boling, & Smith, 2014). And perhaps the problem in our earlier story did lie in the student designers' lack of experience. After all, experience, and the judgment it engenders, are acknowledged to be required in order to use ID models appropriately (Merrill, Drake, Lacy, Pratt, & The ID2 Research Group, 1996). This may be so, but is the students' lack of experience in this case actually different in kind from that of professional designers in the field? For those who specify designs and hand them off to developers, the distance between the idea of the resulting experience and the actual experience can be wide indeed. For any designer who is directly involved in producing the materials of instruction, but who does not take part in the resulting learning experience (even when formative trials are conducted), a significant distance still exists between conception and reality. While the materials of instruction are immediately present to these designers, the lived experiences they support are not. And as many usability specialists can attest, the time and money required to carry out large-scale, immersive implementation trials—which might provide such experience to these detached designers—are hard to come by (Bias & Mayhew, 2005). Could a different, or extended, set of tools help us connect with the experiential qualities of instructional designs, shifting the responsibility for those qualities out of ID models and into designers' hands?

Designerly Tools

Instructional design tools are by and large *not* what is termed *designerly* by Stolterman et al. (2008). Starting with the premise that tools reflect the context out of which they are developed (e.g., research context versus practice context), these scholars argue that tools most supportive of designers as guarantors of design are those that "do not guide the actions of the designer" but require skill, and are actually difficult to master (p. 116). By implication, such tools are open-ended and do not attempt to simplify designing so that responsibility is shifted to the tool.

Discussions addressing tools and views of designs in the field of ID that are not based on process models have begun to expand the view of how instructional design can happen and can be taught (Botturi, 2006; Gibbons, 2013; Boling & Smith, 2008). Tools have been explored that offer alternative ways of thinking about experience; these depict experience indeterminately rather than in deterministic or closed ways (Goel, 1995), and a number of these involve the designer's use of visual representations. Waters and Gibbons (2004) have drawn from work outside of ID to explore the ways that a design language might emerge, investigating visual notation systems from other fields such as musicology, choreography, and chemistry. Gibbons' (2013) conception of a designer moving through various layers in a design situation, with each layer involving the designer foregrounding certain concerns and backgrounding others is an example of an approach that is not explicitly visual, but rooted in a visualization of designing. Yamagata-Lynch (2014) has explored Cultural-Historical Activity Theory (CHAT) theory, imported into and applied to ID, as a tool producing visual diagrams for understanding the complexity of human behavior, intended to allow designers greater insight into a learning situation than traditional analysis tools can do.

Botturi and Stubbs (2008) offer perhaps the most extensive examination of visual methods for instructional design to date. Theory and methods are both addressed in this edited volume; much of the focus is on explaining, sometimes proposing, the methods themselves. While some are oriented toward envisioning experience, others are intended to assist designers in analyzing data, understanding the design process, and modeling entire designs. One author in that text advocates sketching in general as a designer-controlled means of supporting design thinking (Hokanson, 2008), while two others conclude that design sketching is used productively *outside* this field and that design sketching is not much practiced *inside* the field (Stubbs & Gibbons, 2008).

Attempts to explain users' interactions with a designed artifact also exist outside the field. For example, a method for task deconstruction like GOMS (goals, operators, methods, and selection rules) used with the concept of a "model human processor" in Human–Computer Interaction (HCI) (Card, Moran, & Newell, 1983). Such tools and concepts have utility, but they focus on the design as a specification rather than on the experiential dimension of designs coming into existence only during use. Similarly, there have been attempts to create a more holistic understanding of how a designer moves through the experience of designing, with varying levels of support and levels of flexibility. Holistically in experience design, Young (2008) has proposed the use of mental models as a way of understanding user needs, discovering those needs through sustained interaction with users and data analysis, with insights then being drawn that relate back to the user's experience. Reaching back even further in HCI, Beyer and Holtzblatt (1998) proposed an end-to-end method of contextual inquiry for designers to stay engaged in the interests of users and their individual lived experience. From the emerging field of user experience (UX) design, "experience maps," springing from a service design perspective, offer an example of how designers conceive of a large-scale system of experiences (Hanington & Martin, 2012; Risdon, 2011). We can see the utility not only for the individual designer in articulating complex "journey moments" that a user might go through, but also the importance of an artifact like an experience map as a boundary object (Bergman, Lyytinen, & Mark, 2007) with which to facilitate client and stakeholder communication.

Sketching as a designerly tool. Hokanson (2008) argues that sketching, the ability to create visual representations, affords methods that support designers in thinking iteratively and fluidly through an experience they are designing. Such methods may help designers move outside of their own subjective positions, and to move them away from the supposedly objective position of traditional methods, into that of the instructor and learner across multiple dimensions: temporal, physical, emotional, curricular. The visual mode of representation allows designers to exploit the ambiguity of images and related analogical mode of thought for qualitatively different understandings than allowed by text (Goel, 1995). In turn, ambiguity allows designers to appreciate factors within an image that were not specified or anticipated during production of the image, a quality also labeled as "indeterminancy" (Fish & Scrivener, 1990).

Sketching produces artifacts that are not the final products of designing, but that serve as bridges between modes of thought (Goldschmidt, 1991) and are therefore supportive of open-ended action—making the ability to sketch a designerly tool (Stolterman et al., 2008). A design situation cannot be fully deconstructed, but it must be represented in some way; in fact, in more than one way if the design is to address multiple aspects of a situation (Goel, 1995). It must also be represented with flexibility in methods for the situation at hand, versus a templated tool that does not meet any specific conditions perfectly. Also required is an awareness that the representation is not the design, but a tool for considering aspects of the design. Laseau (1986) provides a useful illustration of how such representations facilitate designing, demonstrating the analogic function of images and their bridging function from abstract thought to concrete experience. He also points out an important aspect of representations as a design tool; forms of representation need to be respected for their unique roles and not confused with each other (p. 28). In his example, students of architecture are prone to designing spaces directly from the boxes they have drawn to represent the functions of those spaces. In our field, those of us who teach have probably seen a similar phenomenon—the student who organizes a course directly from the content outline created during analysis; objective A becomes module A, objective B becomes module B, and so on. Obviously, tools for representation are no more the guarantors of design than are models and theories. The guarantor is the designer who uses the tools—and creates the tools—out of her flexible capability to do so.

Examples of Sketching as a Flexible Capability

We are proposing that sketching, as a unique means of reasoning and communicating in design (Goel, 1995; Hokanson, 2008; Laseau, 1986), affords a unique embodied experience on the part of the designer. In the process of sketching, the designer enters a reflective and iterative space where the act of sketching introduces a reflection-in-action (Schön, 1983), where the physicality of sketching speaks back to the designer in a way that textual descriptions of designs or computer-based drawing tools cannot (Goel, 1995; Verstijnen, van Leeuwen, Goldschmidt, Hamel, & Hennessey, 1998).

Three sketches are offered here (one presented as a series) as examples of using *the flexible ability to sketch* as a designerly tool that allows a designer to explore potential experiences during the process of designing. The sketches do not represent fixed templates, or implied processes that are intended to be used under prescribed circumstances. They are the outcome of using a developed visual sensibility together with basic skill in freehand sketching to think through design situations. In this case, we chose examples that emphasize the experiential qualities of the instructional designs involved—emotional qualities of a learning experience, the physical use of space for learning, and the workload imposed on students across multiple courses through curriculum design.

Emotion (Expressed as Energy)

Parrish et al. (2011) discuss immediacy and compellingness as situational qualities contributing to *aesthetic learning experiences*; experiences with the potential to rise above the everyday and influence transformational learning. In the small studio class forming the basis of Figs. 1, 2, and 3, these qualities might be termed "energy." They include students' active, ongoing attention to their own work and to the talk surrounding them, their willingness to stand, move, and talk during critique, and the degree to which they allow themselves to be drawn into discussion of their work on the spur of the moment. Class sessions are long, while the duration of the course (8 weeks) is short and the demands it makes on most students in terms of developing complex abilities are heavy. Therefore, keeping energy strong over the course of several hours, while providing some relief to avoid fatigue, is a clear imperative for the instructor creating this diagram. It is intended to explore the ebb and flow of energy over the typical class period by representing it as a fluctuating line running parallel to a timeline. The line is not precise and not tied to actual data; rather, it represents the felt experience of the instructor and the holistic observation of students as observed repeatedly in the past. The designer/instructor in this situation is, of course, bearing the timeline of a typical class session in mind—not capturing a stream-of-consciousness description of sensation, like drawing in response to music, for example. But there is also no intention to link each fluctuation of the line to an exact point in time.

As a second step (Fig. 2), the designer/instructor annotates the line, identifying the waxing and waning flow of energy as they are linked to key activities, or to phases of activities, as they play out during each class session. This use of line and text brings the original curvy line into a more precise focus, still without requiring a one-to-one correspondence with some form of precise data—which would not be available anyway until after the designer had considered the class in this visual way.

Layered over the original line is a second one in gray, depicting what may change about the energy profile of the class period when planned changes are made to the design of the course. In particular, this instructor has decided to replace "wall critique," or posting work from all the students in one place and addressing as much of it as possible, during the final hour of each session. As the original line shows, this has been a point in the class where the students lose momentum, lapsing into a kind

Fig. 1 First stage of a free-form sketch depicting holistic impression of student energy levels during a typical session of a studio class

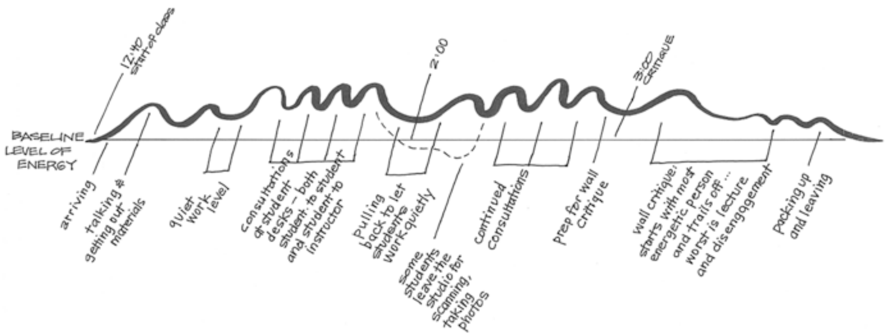

Fig. 2 Second stage of free-form sketch with annotation making the phases of class activity more specific in relation to energy level ebb and flow

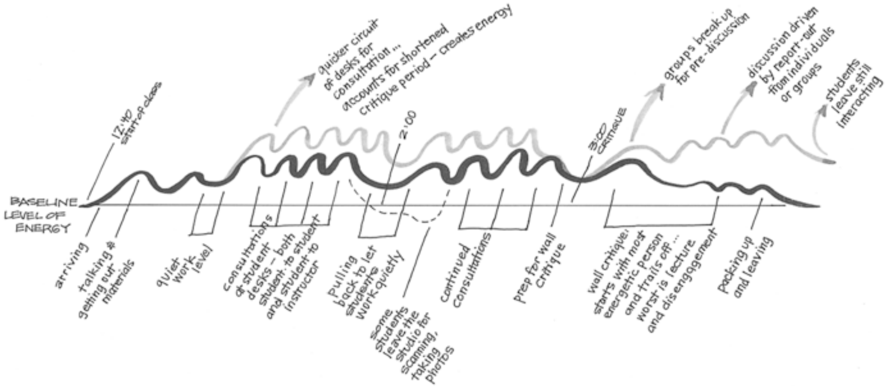

Fig. 3 Third phase of sketch using a gray line and additional annotation to speculate on energy changes that might result from revisions to the design of the course

of passive or desultory commentary on each other's work, or staying silent until the instructor ends up taking the lead—even carrying on a monologue. Knowing the class is not actually part of a strong studio culture, this instructor has decided to replace it with a format that has been effective in other courses: break-out peer-to-peer discussions followed by a full group debrief or expansion of that discussion.

In order to find time for the break-outs in the last hour of class and not cut down the students' work time, this view of the course naturally suggests that it will be necessary to carry out desk consultations with individual students on a slightly faster cycle than had been the case previously. This will require a behavioral change on her part, and she realizes that in fact there has been a problem previously when these individual consultations at the students' desks have dragged on—sometimes resulting in students not getting a consultation every class period. While the students did keep working at those times, there was a palpable lessening of the energy in the room when the consultations ran on too long for one or another student. We can see the gray line showing the planned revision rising above the black line showing the class as it is now—an expression of designerly optimism regarding how the revision may result in a higher level of energy overall during that middle period of each class sessions. The same optimism accompanies the planned revision from the previous group critique at the end of each period to break out discussions during that time; the peer-to-peer engagement and the chance for everyone to participate are expected to increase the energy level for that phase of the class period as well.

What this sketch is doing. The informal diagram in Fig. 2 exhibits two qualities that text alone would lack when describing fluctuating energy levels in a classroom. The first is simultaneity. It is possible to look across the span of the whole class session and compare all parts at one time; for example, the anticipated energy level of starting class, holding group critique, and holding individual consultations, which cannot be done as quickly with a linear description of these activities. The second quality is immediacy. Once it has been grasped, the relationship between form (the path of a line) and concept (energy ebbing and flowing) does not require continuous abstract translation as does a verbal or textual description of that same relationship, so interpretation of a sketch like this one is more direct than interpreting a textual description of the same thing.

Another visual element in play with this example is one already familiar to those in the field who have studied traditional message design; the gestalt principle of proximity (Ellis, 1938), which states that items grouped in visual proximity are understood to be related. Instructional designers who use this principle in producing instructional materials can turn this understanding to their advantage in annotating this kind of visual during designing. We do not understand these text segments to refer to parts of the undulating line only because there are lines connecting the text and the squiggles, but because the text segments appear spread out along the timeline.

Physicality

The physicality of the space in which instruction takes place has not been sufficiently addressed in the literature—particularly in ID. Some attempts to look at the physical features of a space and how they relate to pedagogical activities and content have been addressed in the context of design and studio education (Brandt et al., 2013; Shaffer, 2003, 2007), and as an indication of the kind of work that is produced in that educational environment (Vyas & Nijholt, 2012). Designers of the spaces in which learning takes place understand that there is a relationship between physical surroundings and the lived experience of learning (see the 2013 special issue of *International Journal of Designs for Learning*). Recent research has also brought some of the physical spaces of the classroom into greater focus, but is still largely centered on effects (or potential effects) of specific objects or classes of objects in a physical space, rather than the holistic, felt experience of a space.

This sketch (Fig. 4) example was created to support a reconception of a small studio class that had been required to move from a large space (for which it was designed) into a smaller one. Each period of this class includes 2 h of individual work time during which students each occupy a table while the instructor circulates, discussing their projects with them. During the final hour of class, group critique takes place; this requires space to tape sheets of paper to the wall and place or hold laptops, and enough room for ten people to stand looking at the item under discussion. The options are limited by the location of the classroom and the available spaces near it.

What this sketch is doing. Small diagram sketches like the ones shown allow a designer to interrogate the physical side of an instructional design actively, visualizing placement of classroom furniture, possible locations of students and instructor (the dots), and how the various relationships may afford (or not) the experiential qualities desired. In this case, space is tightly integrated with learning activities. This is not always true for every design, but may be true for more situations than is usually assumed.

This kind of visualization also stimulates thinking around different kinds of instructional strategies, and how these might affect the learning environment—both when the students and teacher are engaged in those strategies, and how one strategy might transition into the next. Creating a range of such visualizations of space promotes an active discussion of the affordances of each, and how these physical affordances relate to the overall goals of the educational encounter. Without the common

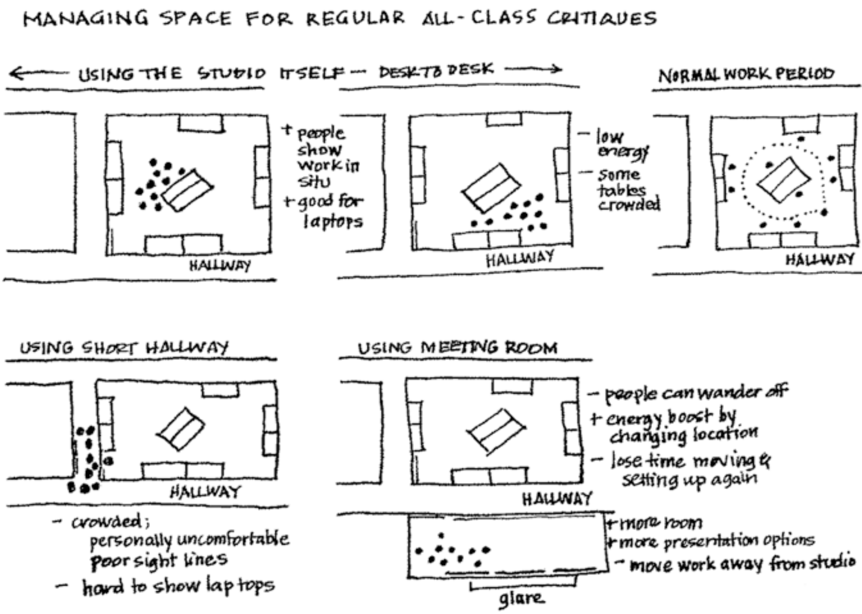

Fig. 4 Sketch diagram showing small multiples of a classroom and hallways with desks, doors, and students indicated

use of such tools, we may not actually realize how often physical space is an important factor in enacting an instructional design.

The affordances of a given physical space—alongside the kinds of interactions that those affordances might promote or discourage—also stimulates thoughts about how it might feel to be engaged in that environment, promoting empathy on the part of the instructional designer. This heightened empathy may allow for greater care to be taken in visualizing how the "flat" instructional design (understood as a specification) might play out in the real world, where the location of instruction, physical features of that location, and students with agency all vary in real time.

What a designer would have to be able to do/what way of thinking. For this kind of visualization to be useful, instructional designers need to master rudimentary skills in representing physical space as basic two-dimensional shapes. Most will find this no more difficult than sketching a simple map to give driving directions, but will need to extend those everyday skills so that they can innovate to meet the requirements of multiple contexts where this kind of tool may be used. The principle to be grasped is the inherent ambiguity (indeterminism) of visual shapes (Klee & Spiller, 1992). A rectangle may represent a table, a room, or a hallway. A circle in this case represents the top view of a person; in another circumstance, it might represent a chair, a whiteboard marker, or a pushpin.

Curriculum Planning

Shifting focus from the content of a curriculum to the experience of students moving through that curriculum requires the capability to look across courses taking an experiential view. In the example here (Fig. 3), two required courses in Master's level program both call for team-based project work supported with multiple readings and both individual and team deliverables. A simple sketch helps the curriculum designers see what the workload would be for students who are required to take these courses in parallel during their first program semester. Each square in Fig. 5 represents a week of the semester, while the visual principles of shape differentiation and visual dominance (White, 2011) allow this representation to reveal points during the semester when work load will be heavy in both classes.

What this sketch is doing. The diagram serves as a tool to shift the designers' perspective from the instructional strategies planned for each course to the impact these strategies will have on the students taking the classes in terms of effort. As most instructors know, the impact of effort can influence the effectiveness of instructional strategies; students struggling with the demands of a heavy workload and group dynamics may not realize the anticipated benefits of, for example, complex, team-based, realistic projects in which both continuous action and serious reflection are required of them.

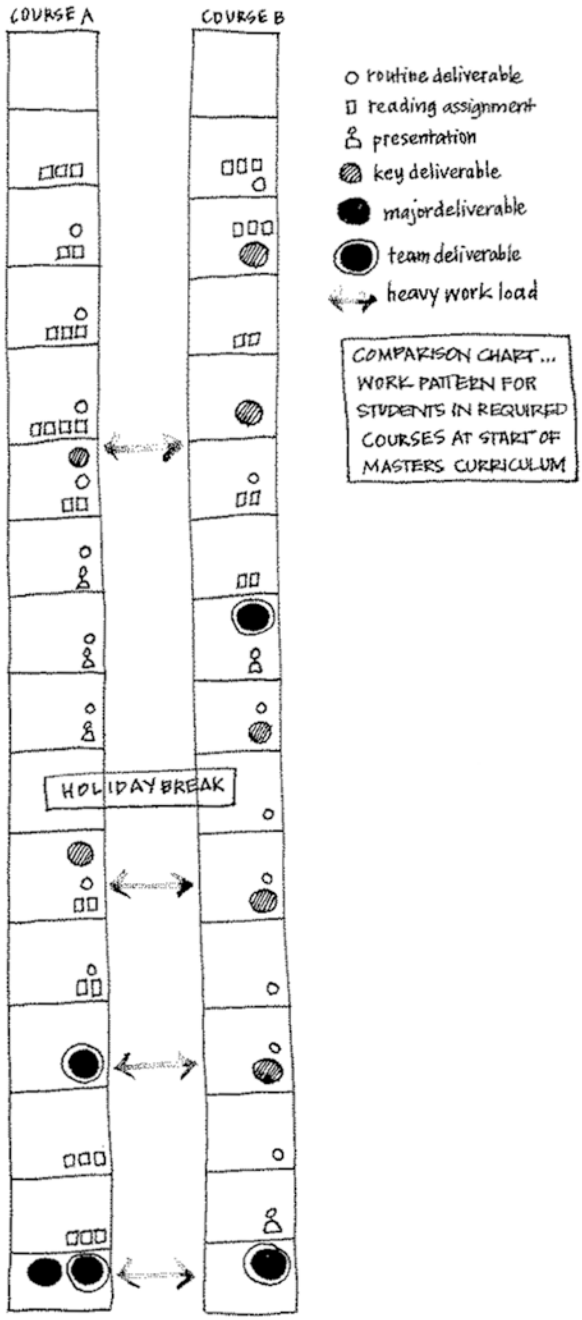

Fig. 5 Sketched visual table showing two classes side by side with deliverables indicated in relevant weeks and the effort required by those deliverables depicted symbolically

What a designer would have to be able to do/what way of thinking. For this kind of visualization to be useful, designers must master analogic, or "stands for," thought with respect to shapes and relationships. Such thinking may be familiar to IDs who are used to reading, and sometimes creating, conceptual models. Those models rely almost entirely on the understanding that a shape may stand for anything as long as it is designated "as" that thing—a rectangle may stand for "design," for example, or for a week of class. The relationship is not indeterminate; it is arbitrary (Easterby, 1970). Skill in creating this kind of sketch can be refined; judgment can be developed regarding whether to lay out visual structures vertically or horizontally in a given situation, what shape might prove more evocative for an arbitrarily assigned meaning, and sustaining consistency in the meanings applied to shapes. Its basic utility may be realized at a low level of skill, however, when it is used as a vehicle for the designer to interrogate her own design decisions privately or internally to a team during discussions where confusions and meanings can be verified in real time.

Discussion

The student team in our story intuited a different position for the guarantor of their design than had been taught or implied by their education so far. At the trial run they had the confidence to conclude that they had carried out the process faithfully, but it had not guaranteed an outcome that was engaging to, and therefore respectful of, the learners. The team realized they had set aside their collective relevant experience in favor of following the process. One member of the team had significant experience teaching outside the United States, and three others were themselves students from outside the United States, but they based their learner analysis on a short survey of potential learners in the department—using data, as specified in so many of our textbooks (Smith & Boling, 2009). They had also failed to appreciate the repetitive nature of the designed instruction because they were focused on the fact that it conformed to theory. Until they saw it play out in experiential form, they did not realize what they had required—by design—their learners to go through. At that point they took responsibility for the outcome of their designing, not in the sense that they had missed a process step, or carried it out incorrectly, but in the sense that the process—even carried out as specified—could not guarantee a fully positive outcome. Their human concern for the quality of experience they had created, and practical concern that a less polite or invested group of learners would probably not have met the target objectives, turned their focus to themselves as the source of judgment and invention required to guarantee a positive outcome of their design activities. What if they had been aware of tools that would help them do this in advance, or at least to ask themselves key questions that would have led them beyond the model they were following and into a speculative consideration of the experience they were creating for other human beings?

And how would we teach students to conceptualize and explain the experiences they are designing in a compelling way? The ability to do so in visual terms does not arise naturally; it needs to be taught and may best be introduced during formal education in instructional design. What should we focus on when looking for and teaching representational methods to ID students that enable them to grapple with the human dimensions of the experiences they are learning to design? Is the simple ability to sketch enough? How would an ID student be taught to recognize the moment when a visual tool would be useful? What appreciative capacity is required in order to invent necessary visualizations for previously unknown contexts, and how is that capacity to be developed? How is it to be integrated into the larger program of preparation for ID practice, particularly when it is not likely to be successfully taught as concept, principle, process, heuristic (Reigeluth, 1999), or even complex problem solving (Jonassen, 2011).

A central question to be addressed in tandem with those above has to do with the viewpoint generating those questions. Designs, including experiences created intentionally—by design, that is—embody ethical positions (Verbeek, 2006). An instructional design, for example, as conceived today, is itself an implicit promise that people will learn, or, at minimum, that they will learn more efficiently and effectively than they would without this experience. It is, further, an experience affording certain relationships and actions while making others difficult. These affordances embody value positions and ethical frameworks. Instructional designs created without particular regard to the human dimension of their final form take the implicit ethical position that efficient and effective learning is more important than aesthetic and engaged experiences. These two factors together raise troubling questions. How strongly can we guarantee that we can support people in learning, and in what areas is this really possible? What ethical responsibility do we assume for the learners taking part in the designs we create? What if we offer only the guarantee of process regarding the learning that may take place, and the design causes some degree of suffering on the part of learners as well? Perhaps suffering—for example, anxiety in the face of legitimately challenging content or physical pain during acquisition of athletic skill—is necessary in some cases, but we need to acknowledge, and understand, when such suffering is appropriate, how it relates to the guarantee of learning, and how we know that is the case. In other words, we need to move beyond the easy mapping of everything to learning goals, while also taking the implicit promise of learning more seriously. A feature of a design does not have to prevent learning in order to be wrong, and in tandem, suffering should not exceed what is required to produce the level of learning that is promised.

Conclusion

As do design theorists outside this field (Nelson & Stolterman, 2012; Verbeek, 2006), we propose foregrounding the designer's role in creating an infrastructure for providing learning experiences that respect and engage the human participants taking part in them. This includes placing the burden of understanding the complexity of a learning experience—both in its intrinsic properties, and in the situational and individual qualities (Parrish et al., 2011) that are context- and learner-dependent—directly onto the designer. Our own theorists have situated the guarantor of design inside our models and theories (e.g., Merrill et al., 1996; Reigeluth & Carr-Chellman, 2009; Seels & Richey, 1994), the idea being that a model followed correctly, backed up with appropriate theories and principles, will produce an effective design. But we argue that rigor should be placed in the enactment of those models and theories by individual designers or by design teams exercising disciplined judgment and designerly tools (Stolterman, 2008; Stolterman et al., 2008), and propose that a fuller understanding of the implications of where the guarantor of design (Nelson & Stolterman, 2012) is placed is an important issue for the field to address. Unless this shift takes place, the ability to reflect on human experience within intentionally designed learning experiences, to establish value for it in relationship to learning gains, and to consider it in the process of designing, will be difficult or impossible to undertake.

Furthermore, if we view the guarantor of design as centered within designers instead of within their tools, then we must be able to teach instructional design students to take such responsibility—and our models don't generally include (and probably cannot include) sufficient guidance on how to do so (Smith & Boling, 2009). This is not the kind of knowledge that can be decomposed into rational form, then taught propositionally to students or novice designers, consequently producing effective practice (Dunne, 1997). While we have some resources in the ID literature that explain the infrastructure of aesthetic experiences (e.g., Dewey, 2005; Parrish, 2009; Parrish et al., 2011), these resources have not adequately operationalized how designers would create, or would learn to create, such experiences. Acquiring the ability to sketch, to recognize when sketching may be useful, and to employ sketching as a flexible, designerly tool in the process of instructional design makes the idea that instructional designers—not their models and theories—can be the guarantors of design more probable than it may have seemed in the past.

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Designing a Nonformal Open Online Learning Program That Encourages Participant-to-Content Interaction

Shenghua Zha and Andrea H. Adams

Abstract Previous studies have focused on the scarcity of interactions between human beings in nonformal online learning. This design research study examined how individual factors, such as prior knowledge and learning goals impacted participant-to-content interaction in a nonformal open online learning program. Results of this study showed that participants' self-perceived proficiency of prior knowledge significantly affected their interaction with the learning content. Strategies that may enhance the interaction in similar nonformal learning are also discussed.

Keywords Nonformal learning • Online learning • Participant-to-content interaction

Online learning has been skyrocketing with the development of Massive Open Online Courses (MOOCs) and Little Open Online Courses (LOOCs) worldwide (Brinton, Jain, Lam, Liu, & Wong, 2013). This development gives open access to the public or a specific community of people and frees them from time and physical boundaries. However, most of the open online learning under research is formal learning where learners are typically required to pass systematic assessments to complete a course or receive a certificate (Schwier & Seaton, 2013). Nonformal learning, on the contrary, is characterized by learners' voluntary participation without summative assessment (Dodds, 1993; Romi, 2000; Schwier & Seaton, 2013). It is usually organized, but not a part of school curricula. Although the practice of nonformal online learning has been widely implemented, there is a lack of research methodologies and theories in this area (Romi & Mirjam, 2009).

In an online learning environment, participation has been considered a key indicator of performance and achievement and is typically represented by online discussions and interactions that occur on an asynchronous discussion board or in a synchronous chat room (Davies & Graff, 2005; Hrastinski, 2009; Michinov, Brunot, Le Bohec, Juhel, & Delaval, 2011). Schwier and Seaton (2013) found from their

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comparison study that participant-to-participant interaction in the nonformal online learning was much weaker compared to that in the formal online learning environment. Conversations in the nonformal online learning were so rare that they could not even be considered as a discussion. These findings were echoed by results from another study in nonformal learning where a small number of participants posted and interacted in online discussions (Schwier, Morrison, Daniel, & Koroluk, 2009). On the other hand, studies in online formal learning suggested that participants' interaction with content not only affected learners' performance but also was ranked by students as a critical factor in learning satisfaction and retention (Muilenburg & Berge, 2005; Zhang, 2005). Learners could engage in active cognitive processing and knowledge construction even when they just interacted with content in the nonverbal mode (Hirumi, 2006).

Results of these studies proposed several suggestions for the design of nonformal open online learning programs. First, they should foster participants' deep and meaningful interaction with content. Deep interaction with content here refers to a type of interaction that leads participants to learn, apply, and reflect on learning for themselves (Sims, 2006). Second, as discussions between participants may be limited or not occur in nonformal online learning, facilitators need to bond with the participants to provide personalized support in learning.

The Nonformal Open Online Learning Program

Based on evidence from the literature review, a nonformal open online learning program was developed and deployed in fall 2013 at a mid-Atlantic public university, where a new Learning Management System (LMS) was being adopted. This self-paced online learning program aimed to teach instructors about the new LMS and was open to all of the instructors and teaching assistants at the university. First, an email with the registration link was sent to the faculty listserv at the university. In the registration form, participants were asked to fill out their background information such as their learning goals and prior experiences with other LMSs. Upon completion of the registration, participants were provided with a link to self-enroll themselves into the learning site.

In addition to the literature reviewed on nonformal and online learning, this open online learning program was also built in accordance with Kolb's experiential learning theory and its relevant studies, which found that learners had better academic achievement when they learned by implementing and reflecting (Kolb, Boyatzis, & Mainemelis, 2001; Konak, Clark, & Nasereddin, 2014). All of the learning activities were delivered in five modules and occurred in a secure course site in the new LMS. The first module, the orientation module, included an introduction to technology, as well as the design principles and philosophy of the new LMS. In this module, participants posted a self-introduction in a discussion board to gain access to the remaining modules. The remaining four modules were the core components and participants would learn how to use a variety of tools in the new LMS for course customization, content management, communication, and assessment. Each of the four modules was divided into two parts. In the first part, participants were presented with video and paper tutorials, tips, and examples of using the tools. To trigger participant-to-content interaction, all of the content in the first part was packaged into small and meaningful units and embedded in discussion boards so as to encourage participants to post their instantaneous questions when watching or reading the tutorials. In the second part, participants were asked to practice suggested activities in their own draft courses and join asynchronous reflective discussions. These reflective discussions were designed to encourage participants to share their course design plans with the tools discussed in a module and pose questions or challenges that they experienced. Although not required, participants had to join the reflective discussions if they wanted to get a certificate for this online program. The learning facilitator supported individual participants' learning by providing orientations, notifying participants about changes and updates in the program, communicating with participants about their course design plans, and replying to participants' problems and questions.

Design Research Activities

While prior research underpinned the development and implementation of this nonformal open online learning program, it posed new questions for further studies. For example, a spectrum of participant-to-content interaction from no action at all to proactive contribution in reflective discussion may be observed in nonformal learning. What measure(s) could we use to cover this wide spectrum? If different measures were used to address different dimensions of interaction, could they be aligned and represented by one measure? What individual factors affected participant-to-content interaction in nonformal learning where no obligations or incentives were present?

Participant-to-content interaction, also called learner-content interaction, was first proposed by Moore (1989) and referred to as a type of intellectual interaction that learners had with learning materials or resources that could lead to changes in their understanding. Positive effects of participant-to-content interaction have been identified in studies of formal learning. Learners who had continuous and extended contact with content gained more enthusiasm towards learning and received better course grades (Leasure, Davis, & Thievon, 2000; Zimmerman, 2012). Dunlap, Sobel, and Sands (2007) assembled a participant-to-content interaction strategies taxonomy that was aligned with Bloom's taxonomy on cognitive processing and classified different levels of learners' engagement with content into ten categories. These ten categories spanned from interaction that enabled learners to access information to interaction that encouraged them to ask reflective questions. However, not many studies have examined participant-to-content interaction in a systematic way as Dunlap et al. (2007) have stated. In addition, studies in learning interaction have focused more on computer-mediated human communication and interaction, such as participant-to-instructor interaction and participant-to-participant interaction, than participant-to-content interaction (Anderson & Garrison, 1998; Tsang, 2010).

In formal learning, researchers from a large body of studies have confirmed the impact of learners' prior knowledge on their online interaction and performance, though the results have been inconclusive (Azis, 2013; Huang, Lin, & Huang, 2012; Roschelle, 1995; Yang & Hsu, 2013). For example, Huang et al.'s study (2012) in an undergraduate information science course found that students' prior knowledge in the subject area had a significantly moderating effect on the relationship between their learning performance and the time duration they spent in a course. But it did not significantly affect the relationship between students' learning performance and the frequency of their discussion posts or active views of course files. In our study, participants' prior knowledge not only included what they had known about the content, such as LMS, but also their existing knowledge of using technologies in effective and constructive ways to teach their subject-matter content, also referred to as technological pedagogical content knowledge (TPCK or TPACK) (Mishra & Koehler, 2006; Schmidt et al., 2009). TPCK highlights the integration of content, pedagogy, and technology in curriculum and instructional design and is deemed important for designing and teaching a quality technology-mediated class (Angeli & Valanides, 2005). Besides prior knowledge, participants' common interests and goal-setting have been demonstrated as critical components for motivation and increasing their online interaction and collaboration (Curtis & Lawson, 2001; Kim, Hong, Bonk, & Lim, 2011). In a nonformal learning program where participation was voluntary, how did these factors influence participants-to-content interaction? Did they carry the same effect as what was reported in other studies in formal and online learning?

Bearing these questions in mind, we conducted a preliminary study to first identify an appropriate measure that included different levels of participant-to-content interaction and second reveal potential individual factors that influenced participant-to-content interaction in a nonformal open learning program. In particular, we were interested in how learners' prior knowledge and learning goals impacted participant-to-content interaction. Our research questions included:

1. What measure represented the spectrum of participants' interaction with content?
2. Did learners' prior knowledge and learning goals determine their levels of interaction with the learning content in this nonformal open online learning program?

Methodology

Thirty-four participants were recruited in this study. Among them, 91.2 % were teaching faculty from 20 academic departments. Eighty-nine percent ($N=30$) of the participants responded that they had either no knowledge or very basic knowledge of the new LMS before participating in this program.

Q1. What Measure Represented the Spectrum of Participants' Interaction with Content?

A three-tier participation scale was utilized to measure different levels of participant-to-content interaction. The first threshold was the self-introduction after participants self-enrolled themselves into the program site. Those who did not join the self-introduction made zero participation as they could not access the content in the following four modules. The second threshold was the reflective discussions. Participants who posted in the self-introduction discussion but did not generate any messages in the reflective discussion were considered silent participants. They had access to all of the learning materials and might have been active in navigating around the learning site, watching instructions, and reading others' questions and answers; however, they did not make any contributions in the reflective discussion. Participants who contributed in at least one of the four reflective discussions were considered active participants because they had to engage with the content, and create and apply their plans for using the new LMS before posting their reflection of use, which required deeper interaction with the content (Dunlap et al., 2007; Sims, 2006).

A Mann–Whitney test was applied to determine whether the tiered participation scale aligned verbal interaction with nonverbal interaction between participants and the learning content. We focused on the tiers of silent participation and active participation and investigated their relationship with the nonverbal interaction between participants and the learning content. This nonverbal interaction, measured by the number of active clicks participants made on a page, a link, or an attachment in the four core modules, was the dependent variable in this test. The independent variable was silent and active participation.

Q2. Did Learners' Prior Knowledge and Learning Goals Determine Their Levels of Interaction with the Learning Content in This Nonformal Open Online Learning Program?

An ordered logistic regression analysis was conducted in this test, where the outcome variable was the probability that participants would have no silent or active participation. The predictors in this model were vectors of participants' prior knowledge and learning goals.

$$\text{logit}(Y) = \alpha_1 + \beta_{\text{LMS}} X_{\text{LMS}} + \beta_{\text{TPCK}} X_{\text{TPCK}} + \beta_{\text{goal}} X_{\text{goal}} \tag{1}$$

The three-tier participation (Y in (1)) was coded in three levels as no participation (0), silent participation (1), and active participation (2). Three types of individual differences were investigated in this study, consisting of two kinds of participants' prior knowledge plus learning goals. Participants' prior knowledge was divided into two variables. One was their existing proficiency of using other LMSs (X_{LMS} in (1)) and was dummy coded with "proficient" as 1 and "not proficient" as 0. The other variable was the self-assessment of participants' knowledge of using technologies to teach (X_{TPCK} in (1)). It was measured by five 5-point likert scale questions adapted from the Technological Pedagogical Content Knowledge (TPACK) survey validated in Schmidt et al.'s (2009) study. The participants' goal of learning was dummy coded by whether they planned to complete the program or not (X_{goal} in (1)). Since the data of the predictors were collected from participants' response in the online registration form, the three predictors were also called self-perceived proficiency of other LMSs, self-perceived knowledge of using technologies to teach, and stated learning goals.

Results and Interpretation

The online program started in early November. By the end of the year, 50 % ($N=17$) registered participants had zero participation, 26.5 % ($N=9$) had silent participation, and only 23.5 % ($N=8$) were active participants.

Q1. What Measure Represented the Spectrum of Participants' Interaction with Content?

Although the four core learning modules were not named in alphabetical or numerical order and participants could choose any page that they would like to learn, 82.3 % ($N=14$) of the participants who had access to the four core modules followed the order of modules given on the module index page. Only three skipped a prior module to learn a subsequent module. While findings from Brinton et al.'s study (2013) in MOOCs showed that participant-to-participant interaction in discussion forum declined over time, results of this study demonstrated a decrease in participants' nonverbal interaction with content. This interaction decreased in the first three core modules and then increased slightly in the last module (Fig. 1).

The result of the Mann–Whitney test showed that active participants who joined reflective discussions had significantly higher number of clicks with the content than silent participants who had access to the learning content but did not join reflective discussions (Table 1). In other words, active participants were more engaged with the content than silent participants. This can be explained by experiential learning theory and its associated studies that participants need to be engaged with the content and practice on their own before they are able to reflect in the reflective discussions and create course design plans using the new LMS (Kolb et al., 2001; Konak et al., 2014). This finding indicates that the tiered participation scale aligned well with participants' nonverbal interaction with the content and therefore was effective in measuring different levels of participants' interaction with the content.

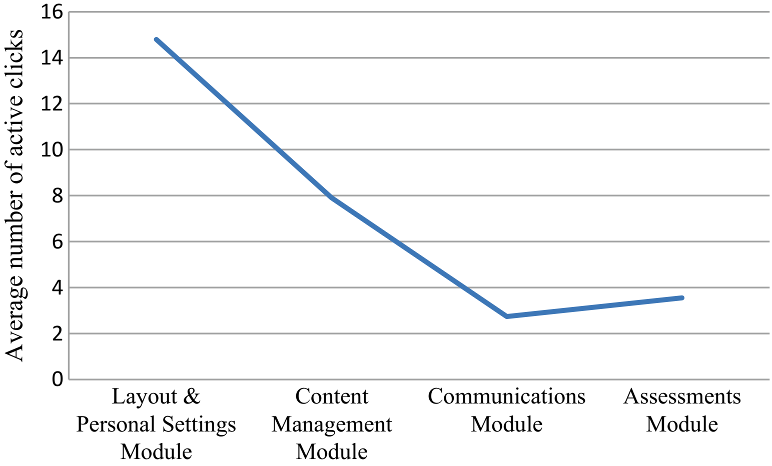

Fig. 1 Average number of active clicks in the four core learning modules

Table 1 Result of Mann–Whitney test on the relationship between participants' nonverbal interaction with the content and two tiers of online participation

Tiers of participation	*N*	Rank average	Sum of ranks	*U*	*Z*	*p*
Silent	9	6.61	59.5	14.5	−2.07	0.038
Active	8	11.69	93.5			

Q2. Did Learners' Prior Knowledge and Learning Goals Determine Their Levels of Interaction with the Learning Content in This Nonformal Open Online Learning Program?

An ordinal logistic regression analysis was carried out by the SAS® program version 9.3 in Windows 7 environment. The result showed that participants' proficiency of using other LMSs was the only factor that significantly affected the levels of their online interaction with the content (Table 2). The odds of participants who thought they were proficient in other LMSs joining reflective discussions were 9.574 times greater than the odds of those who considered themselves as nonproficient users of other LMSs, such as Blackboard and Sakai. Likewise, participants who thought they were proficient in other LMSs were more likely to interact with the content than those who considered themselves as nonproficient users of other LMSs. This can probably be explained by two considerations. First, participants' proficiency in other LMSs may make them feel the need to master the new LMS and use it the same way as they did with other LMSs. Similar to what has been found in So's (2009) case study, participants who did not consider themselves as proficient users of other LMSs may not have used them vigorously and hence did not see a need to learn the new LMS in depth or become proficient LMS users. Second, participants' self-perceived proficiency in other LMSs built their confidence of learning and

Table 2 Results of ordinal logistic regression analysis

Predictor	β	SE β	Wald's χ^2	*df*	*p*	Odds ratio
Constant 2 (active vs. inactive and no participation)	0.8019	3.0175	0.0706	1	0.7904	NA
Constant 1 (active and inactive vs. no participation)	2.4063	3.0447	0.6246	1	0.4293	NA
TPCK, β_{TPCK}	−0.1974	0.1529	1.6672	1	0.1966	0.821
Learning goals, β_{goal} (0 = partial, 1 = all)	0.9703	1.0431	0.8654	1	0.3522	2.639
Proficiency in other LMS, β_{LMS} (0 = no, 1 = yes)	2.2591	0.8222	7.5490	1	0.0060	9.574
Test			χ^2	*df*	*p*	
Overall model evaluation						
Likelihood ratio test			10.2219	3	0.0168	
Score test			9.1292	3	0.0276	
Wald test			8.7428	3	0.0329	
Goodness-of-fit test						
Pearson			23.5366	25	0.5463	

using new LMS. As a result, this confidence strengthened their comfort in joining reflective discussions and sharing their course design plan with others.

The other two predictors, namely participants' knowledge of using technologies to teach and stated learning goals, were not found to be significant factors in determining the levels of their interaction with the content. Participants rated their knowledge of using technologies to teach between 17 and 25, with the maximum being 25. The result of the regression analysis indicated that this score had a slightly negative effect on the levels of participants' interaction with the content, though the effect was insignificant.

Participants' stated learning goals did not significantly drive their interaction with the learning content. Among 34 participants who were recruited in this study, 82.3 % (N = 28) indicated at the beginning of the learning that they would like to complete this online learning program. However, only 7 % (N = 2) reached their initial goal and 21 % (N = 6) of them completed one to three learning modules. In a nonformal learning environment where there were no external incentives or obligations, internal motivation like learning goals could possibly encourage participants to take the first step, such as registering for the program, but did not have a sustaining effect on their interaction with the content.

Implication

Results of this study were similar to findings from other studies about MOOCs and nonformal learning (Brinton et al., 2013; Romi, 2000). Only 23.5 % of participants in this nonformal online learning program joined reflective discussions and the overall nonverbal interaction between participants and the learning content declined over time. While the flexibility of time, place, and learning pace attracted a number of registrants, it was outweighed by other factors in retaining participants and engaging them in deep-level interaction with the content.

Among the several factors examined in this study, only participants' perceived proficiency of other LMSs showed a significant effect on their interaction with the content. In other words, participants who did not think they were proficient in a similar LMS were unlikely to have an active interaction with the learning content. In future design of this and other similar learning programs, facilitators may consider inviting participants who didn't think they were proficient in using other LMSs but completed the learning to share their learning progress with potential participants. This may hopefully build the confidence of participants with similar backgrounds in learning and using a new LMS and inspire them to explore features that they haven't used before.

Learning goals can be measured from multiple perspectives such as depth and breadth. This study only examined the breadth perspective, which was whether or not participants wanted to complete the program. It was possible that other perspectives of learning goals, such as whether participants wanted to learn the new LMS in-depth or just on the basic level may impact the level of their interaction with the content. Therefore, we recommend measuring learning goals based on personal needs and in multiple dimensions in future nonformal learning studies.

Limitations

One limitation in this study was the small sample size. Only 34 participants in this online learning program gave their consent, which may limit the generalizability of this study. We suggest conducting future studies that use a larger sample and include more related variables so as to present a holistic and powerful picture on the effect of personal factors on participants' interaction in nonformal online learning.

Conclusion

Characteristics of nonformal open online learning have highlighted the importance of participant-to-content interaction in affecting participants' performance (Hirumi, 2006; Schwier et al., 2009). In this design research study, we posited a tiered online participation scale and aligned it with different levels of participant-to-content interaction. We then used this scale to investigate the potential impact of individual factors on participant-to-content interaction in an open nonformal online learning program. Our study rendered similar results as those in MOOCs and nonformal learning research that only a small percentage of participants joined online discussions and interactions declined over time. Among three individual factors, only participants' perceived proficiency of other LMSs was found to significantly affect their participant-to-content interaction. Those who thought they were not proficient in other LMSs were less likely to interact with the content or join reflective discussions than participants who thought they were proficient in other LMSs. Since participants' perceived proficiency may be associated with their prior knowledge and experiences of using other LMSs, we suggested inviting participants who had similar perceptions in LMSs proficiency but completed the online program to share their experiences with incoming participants in future design of similar programs so as to enrich participants' experiences and strengthen their confidence in learning and using the new LMS. The other two individual factors, participants' knowledge of using technologies to teach and their learning goals did not have significant impact on participant-to-content interaction. We recommend future studies using a large sample and examining participants' learning goals and their impact on interaction in a personalized and comprehensive way.

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Design of a Learner-Centered Seminar-/ Studio-Based Polytechnic Institute

Marisa Exter, Rich Dionne, and Christopher Lukasik

Abstract This design case describes an early design of a new, learner-centered university program for Technology students that combines Seminar and Studio experiences. The design is based on a set of values and understandings about how contemporary students learn best and how to address the needs of a twenty-first century workforce. Challenges encountered by the cross-disciplinary group of faculty designing the curriculum and pedagogical aspects of the program will be discussed.

Introduction

This design case describes the development of a new university program that was piloted with 33 students in fall 2014. A leadership team identified a set of core values, assumptions, and goals to guide the design of the learning experience, and gathered a cross-disciplinary team of faculty to develop the curriculum and pedagogy. This paper focuses on the first-year design, which integrated deep exposure to liberal arts with hands-on technical project-based learning, and the experiences of the faculty who worked together to create this design.

Our design is built on two sets of assumptions. The first relates to our understanding of how learners learn best: all learning is legitimate; learners are intrinsically motivated; learners learn best within a context and for a purpose; learning must be practiced to be mastered; learners need to be encouraged to ask big questions; and

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collaboration is essential (Mili, 2014). The second relates to our understanding of the specific needs of today's learners. Millennial students are learners who prefer group/collaborative activity; are fascinated by new technologies; prefer experiential activities; prefer structured coursework; and may not be well prepared by formal schooling for complex learning and self-guided abstraction (Levine & Dean, 2012; McGlynn, 2005, 2008; Oblinger, 2003; Wilson, 2004).

Context

Our design came out of the Purdue Polytechnic Initiative (PPI), which is a "Big Move" (Zink, 2013) sponsored by the President's Office at Purdue University and administered through the College of Technology (COT). The COT has existed for nearly 50 years and encompasses six domains: Aviation Technology, Building Construction Management, Computer & Information Technology, Computer Graphics Technology, Engineering Technology, and Technology Leadership & Innovation (About-College of Technology, 2014). In contrast to Purdue University's traditional Engineering programs, the COT focuses on hands-on application of theory.

The PPI was created in fall, 2013 as an independent entity within the COT with the goals of rethinking and innovating technology education and serving as a laboratory for higher education in the twenty-first century. PPI's virtual decoupling was meant to allow it sufficient freedom to re-envision what technology education could be, while its existence within the COT and Purdue University allowed it to benefit from institutional resources and support. The PPI also had strong partnerships within Purdue, notably with the College of Liberal Arts (CLA).

Process of Exploration

The vision for our design was developed by a leadership team (comprised of the Dean of the COT, and Head of the Department of Computer & Information Technology) who were inspired by the work of researchers, policy analysts, business leaders, and alternative models of education to provide a set of core values (Mili, 2014):

- Viewing the student as a whole person.
- Welcoming diversity/access for all.
- Student autonomy.
- Risk-taking as an important component to learning.
- Openness fostered through sharing, transparency, and collaboration.

The leadership team articulated the following goals for students to meet upon completion of the program (Mili, 2014):

- Technical fluency.
- Lifelong learning skills.
- Empathy and optimism for global stewardship.
- Individual and collaborative learning and work skills.
- Ability to ask big questions and take risks.

According to reports about employment for graduates in various disciplines (The Association of American Colleges and Universities & The National Center for Higher Education Management Systems (AACU), 2014; Gallup, Inc, 2014), succeeding in the twenty-first century workforce will depend more on being well rounded than on completing a specific degree. "Four out of five employers agree that all students should acquire broad knowledge in the liberal arts and sciences… [and] …93 % of employers agree that [the] candidates' demonstrated capacity to think critically, communicate clearly, and solve complex problems is more important than their undergraduate major" (AACU, 2014, p. 2). Given employers' desire to see graduates with an education spanning technical and traditional liberal arts disciplines, the leadership team felt that significant, deep liberal arts experience would be crucial to students' ability to contextualize technology education and relate that education to global issues in the twenty-first century. Consequently, the leadership team recruited faculty from the Colleges of Technology, Liberal Arts, and Education to participate in designing a transdisciplinary learning experience.

Team members recognized that in order to design instruction to meet learners' individual needs, we would have to focus on three crucial components: conditions, methods, and outcomes (Reigeluth, 1983). Designing the bridge from conditions to outcomes requires both an understanding of the conditions of each learner when they begin, and a clear definition of the expected outcomes. Research on contemporary learners provided some information about conditions: They will likely prefer group/collaborative activity; be fascinated by new technologies; prefer experiential activities; prefer structured coursework; and may not be well prepared by formal schooling for complex learning and self-guided abstraction (Levine & Dean, 2012; McGlynn, 2005, 2008; Oblinger, 2003; Wilson, 2004). The gap between these conditions and the aforementioned outcomes (to be lifelong learners, have empathy for optimism and global stewardship, ask big questions and take risks, and be able to work both individually as well as collaboratively) is significantly large. The learning experiences would need to encourage learners not only to master one or more technical knowledge domains (the traditional drive of the COT) but also acquire transdisciplinary skills (including creative and critical thinking, and oral, written, and visual communication skills) and metacognitive skills (such as metacomprehension, abstraction, and knowledge calibration).

To assist in the process of developing new learning experiences, in early fall 2013 participating faculty members attended seminars offered by a professional coach with experience in engineering education, and a team from Olin College (which had designed an engineering curriculum around similar values). The primary take-away from these seminars was that the new experience must be learner-centered. Faculty members spent weeks examining the culture of teaching in the current COT, and considering the ways in which it reflected "sage on the stage" practices. This exploration reinforced the opinions of team members that a new approach was necessary.

During our early discussions, it became clear that there were major distinctions between the pedagogical approaches of many COT and CLA faculty. Many COT classes are structured around a lecture-practice-test-assess model, with hands-on laboratory sessions functioning as practice, test, or both, whereas humanities courses in CLA often follow a seminar model, and visual and performing arts courses in CLA follow a studio model. These differences in experience had a direct impact on how faculty thought about new pedagogies.

After participating in workshops and discussions early in the fall semester, faculty were tasked with exploring models used at other institutions. Three faculty members from the COT and one from Theater (Rich Dionne, second author), toured d-School at Stanford University, IDEO (the design company tied to d-School), and CalPoly at St. Louis Obispo. The group members on this trip had a variety of backgrounds and teaching styles.

The team observed that at both d-School and CalPoly, students from multiple disciplines took studio classes to learn design thinking and solve ill-structured problems. In both cases, traditional coursework appeared to provide discipline-specific learning that was then applied in the studio courses. Members of the team were collectively excited by the emphasis on design thinking, creative process, and exploration at both d-School and CalPoly. Students were visibly engaged in exploring new knowledge, technologies, and skills, and appeared to be self-motivated, self-directed learners. A visit to EA, a game design firm, gave a further understanding of how the studio model was used in practice, and EA designers participated in a spontaneous brainstorming session, helping the team see how a curriculum could be broken down into challenges and competencies. Impressed by these examples of applying a studio approach to learning technology and the impressive development of highly desired soft-skills, the California travel team proposed using a studio model in our program.

Other faculty (particularly those from the CLA, including third author Christopher Lukasik) had extensive experience offering seminar courses, and suggested the team examine that model as an additional pedagogical approach. Seminar instruction emphasizes groups of learners exploring problems in conjunction with faculty through deep discussions and engaging in problems and questions (Chick, 2009) and has demonstrated efficacy in promoting transdisciplinary skills. Seminars provide the occasion for learners to practice collaborating with people from various disciplinary backgrounds, communicating their ideas effectively (both in person and through various media), addressing issues relevant to global and social contexts, and developing the agility, adaptability, and curiosity needed for lifelong learning.

Faculty quickly recognized that to gain the benefits of these *signature pedagogies* (Shulman, 2005) from other fields (i.e., the studio and seminar models), we needed to carefully examine the practices within the fields from which they are borrowed (Cennamo & Brandt, 2012; Cossentino, 2002; Shulman, 2005). We realized that, while we wanted to improve upon the perceived shortcomings of the existing signature pedagogies in COT, simply replacing them with alternative pedagogies such as studio or seminar models may risk inadvertently leaving out valuable learning experiences in an effort to be transformative. This was further complicated as we aimed to build a learning experience that simultaneously encompassed technical topics and other disciplines that traditionally supported technology education, such as math, science, and the arts. Some group members became concerned about the potential for "throwing out the baby with the bathwater," especially as our faculty team did not have experts in each of these areas.

Several faculty members had already experimented with a studio approach within their own classrooms and encountered constraints trying to implement this pedagogy, similar to what has been documented by others attempting to port the studio model to technical courses, such as lack of dedicated space and time for students to gain competence with practices such as critique (Cennamo & Brandt, 2012; Reimer & Douglas, 2003). Additionally, a lack of experience with the studio model proved to be a challenge. Faculty felt comfortable with using traditional lecture-practice-test-assess models to provide content-specific skills, but those with little experience with the studio model were uncomfortable with one of its fundamental qualities: teaching content-specific skills indirectly, through contextualized design experiences. As Ledewitz (1985) found:

> Only a fraction of the content of most studios is articulated explicitly and taught directly. The content is largely implicit in the nature and organization of the projects we give. . . Indeed, the content can sometimes merely provide the occasion or context for the learning of other skills not explicitly addressed as a "learning outcome." All the aspects of design education—the skills, the language, the approach to problems—are more effectively taught indirectly through experience than taught directly by explanation (p. 2).

Similarly, understanding the validity of the seminar experience as applied to technology education appeared to be challenging for some faculty for a number of reasons. First, the student-driven, project-based, and discussion learning environment, emphasizing self-directed projects over direct content delivery and assessment, is inherently unfamiliar to many faculty. Second, the risk of failure that comes with student-driven projects is much higher than with a more traditional lecture-practice-test-assess model. Projects may not always achieve desired results. The path to learning content-specific skills is vague at best; different students working on similar initial problems may follow wildly different paths to completion. Finally, the number of contact hours required to successfully manage student-driven projects may exceed the number faculty are expected to commit to teaching at this research-intensive university, especially when added to existing faculty loads.

In addition to the unfamiliarity of some of the faculty with both the studio and seminar models, some concern was expressed for the students' unfamiliarity with these models. Most of the incoming students would be freshmen primed by their high-school experiences to expect traditional lecture-practice-test-assess style courses. Ensuring that these learners were not overwhelmed by new learning experiences became a vital concern. COT faculty expressed fears that the studio and seminar experiences may not adequately allow learners to develop mastery of content-specific skills. Their misgivings were not unfounded. In their experience, many technical skills require significant practice to develop a level of automaticity. These procedural skills are wide ranging, from soldering to analyzing digital circuits, from making hydraulics systems connections to running fluid power calculations. Additionally, the team was not confident in assuming that all learners would be comfortable gaining new competencies solely through seminar- and studio-based experiences. The desire to address both of these concerns prompted the development of the idea of Individual Learning Modules (ILMs). These deliberately ill-defined experiences were intended to provide alternate pathways for learners to acquire competencies not otherwise available in the studio and seminar environments.

Concerns about the depth of rigor in discipline-specific content and integration of transdisciplinary and content-specific skills also led the faculty to consider a spiral curriculum model. Spiral curricula revisit topics across different strands multiple times with increasing difficulty and complexity, allow learners to relate new learning to prior material and gain competency over time (Harden & Stamper, 1999). This approach has been used in the fields of engineering (DiBiasio, Clark, Dixon, Comparini, & O'Connor, 1999; Lohani et al., 2005; Lohani, Wolfe, Wildman, Mallikarjuan, & Connor, 2011), and technology education (Cantu & Farine, 2007) to integrate across multiple courses or an entire curriculum, often incorporating elements from across subfields. Additionally, we were excited by the idea that consistent exposure to repeated material in new contexts would promote not just retention, but abstraction, as learners see new connections and new applications for acquired knowledge and skills.

As a result of our research, experiences, and group discussions, we concluded that designing a curriculum that included studio, seminar, and other learning experiences in a spiraling approach around a model emphasizing mentorship and close faculty–learner relationships would provide the necessary scaffolding for students' metacognitive development, allowing them to reflect upon their coursework, develop competency within and across knowledge domains, and establish effective practices for lifelong learning.

The First-Year Design

Our first-year design aimed to provide students with access to a breadth of cross-disciplinary skills and cognitive strategies, as well as deep experience in one or more domains, through the use of a personalized combination of seminar, design lab (studio), ILMs, and other outside experiences. Recognition of student achievement would be competency-based, with "digital badges" awarded as each student demonstrated levels of competency of specific skills within knowledge domains.

Seminar

The seminar component was intended to develop creativity, productive risk-taking, empathy, critical thinking skills, and written and oral communication skills as students played with and reflected upon the intersections between culture and technology. The goal of the experience was to rethink how we learn about humanities, social sciences, and technology across disciplines and curricula, by combining approaches, subject matters, and most importantly by bringing together students from CLA and COT. Ideally, the seminar would encourage students to think bigger and take risks by focusing on large-scale contemporary global problems such as inequality or sustainability, that have resonances with a number of Richard Smalley's (2003) ten nagging problems (food, energy, environment, and so on). The seminar included two main learning activities: student-driven discovery and learning through practical projects; and tutor-assisted skill and know-how acquisition. These activities would guide students in the development of skills to read, interpret, and communicate through a variety of tools and narrative or rhetorical strategies necessary to flourish as designers, managers, and promoters of innovative technology.

Unlike a number of interdisciplinary seminars, team members had co-taught in the past, the spirit of our seminar was not one of coerced interdisciplinary synthesis, but rather of applied transdisciplinary methodology: Students would learn about multiple disciplinary perspectives and their methods in order to approach a problem from several different angles. A student might, for example, complete a project on women in the STEM workforce and use statistical information and critical analysis of media representations, and create a number of different media forms from which to distribute results (written report, PowerPoint presentation, website, video, etc.). The idea was to foster creativity not only within the individual student projects (as they do when they design a website or create a video), but to instill a sense of creativity in how they approach problems (as they would by being introduced to the ways various disciplines might conceive of and address specific problems). The goal, of course, was to encourage risk-taking, failure, and innovative approaches to problems through long-distance connections, rather than the small steps of narrow and discipline-specific solutions.

The seminar sought to strike the middle road between the content delivery model of lecture-based courses and the self-directed experience of an independent study. Ideally, faculty would introduce their students to a particular subject (such as international distributive justice) or problem (such as climate change), or both, and guide them through course material that would inform and prepare students to eventually create and develop a project of their own.

The seminar was imagined as a sequential/spiral experience, since it would take time for students to learn how to create and manage projects on their own. Therefore, the seminar would allow for multiple opportunities for students to learn how to ask big questions, develop answers, and communicate them effectively to others. The seminar experience would be scaled so that between the first year and the last year, the professor's role would evolve from "sage on the stage" to project manager.

The main point was not to flip the classroom per se, but to scale down the professor's role while at the same time scaling up the student's. First-year seminars would therefore involve more collaborative work dedicated to developing technical, cultural, and humanitarian projects in response to the seminar topic. Second- and third-year seminars would gradually encourage students to develop projects on their own in response to questions that they had articulated independently or through working with others. The intent of developing increasing autonomy was to empower students to work on projects that they were intrinsically motivated to complete. Each seminar experience would return to the repetition of writing and oral communication skills, empathy, creativity, collaborative skills, and productive forms of risk-taking within the context of increasingly independent projects.

Design Lab

The Design Lab was based on the studio model and intended to provide a learner-centered approach to mastery of skills across the COT disciplines. Learners would be presented with multiple sequences of projects in the spirit of "task classes" (van Merriënboer, Clark, & De Croock, 2002; van Merrienboer & Kirschner, 2007) that comprise real-world, ill-structured problems requiring the application of multiple skills to complete. Over the course of the first year, learners would complete as many as 12 projects across two sequences; one sequence including projects of larger scale, the other comprised of several shorter projects. The longer projects would enable first-year learners to explore the elements of systematic approaches to problem solving, design, collaboration, and communication in great depth, while the shorter projects allow them to practice systematic approaches on projects of smaller scope in multiple contexts.

In the first year, a significant emphasis would be placed on learners developing not only transdisciplinary systematic approaches (problem solving, design, collaboration, and communication) and content-specific skills, but also on developing a strong sense of self and agency in a larger world. To that end, the longer-duration projects in the first year would emerge from conversations amongst learners focusing on the theme of "You Own Your Future," in which students explore global issues (for example, food equity and food desserts). Our aim was to guide learners through a process of seeing opportunities in a global environment, narrowing those opportunities down to specific technological challenges, and designing and prototyping solutions to those challenges. The cohort would be grouped into teams of three learners, each contributing to the process of identifying challenges and designing solutions within their teams.

Faculty mentors would be responsible for ensuring that project sequences led students to competency in both systematic approaches and content-specific skills based on the outcomes indicated by digital badges, through traditional studio practices (just-in-time intervention, critiques, self- and group-evaluation, etc.). To facilitate moving to competency, the longer-duration projects would feature significant scaffolding from faculty mentors as learners applied systematic approaches and procedural skills often for the first time; support would be decreased on the shorter-duration projects while they increase in difficulty across the year. Ideally, by the end of the year, learners would also be able to demonstrate the *integration* of systematic approaches, mental models, and procedural skills to solving ill-structured problems.

In our idealized vision, as learners progressed through the 4-year curriculum, projects would increase in scope and learners would receive decreasing support. Learners would share the same lab space with new incoming first-year cohorts; third- and fourth-year projects would engage small teams of first-year students to encourage partnership with peers as well as peer mentoring. Later cohorts of first-year learners would gain from the experience of seeing more experienced learners modeling systematic approaches, self-critique, abstraction, and knowledge calibration in the studio environment. Whether we will be able to implement this type of vertical integration remains to be seen, as there are many practical concerns.

Other Experiences

As mentioned above, while the Seminar and Design Lab components would provide the primary learning opportunities, learners would be encouraged to experience and provide evidence of learning gained through outside coursework, internships, travel abroad, extracurricular activities, participation in MOOCs, or other forms of self-study. We envision ILMs as the major path for these kinds of experiences. Learners would register for ILMs when they discovered (possibly with the aid of a faculty mentor) their need for additional practice or experience to gain competency in particular content-specific skills. We envision two major types of ILM: independent study with a particular faculty member, or traditional semester-long courses, in some cases designed specifically for Polytech students, allowing them to attend as a cohort and engage with material relatable to seminar and design lab. Ideally, this flexibility would allow for ILMs to be delivered as close as possible to just-in-time and address specific learning styles.

Credentialing

The team has partnered with campus instructional technology staff to use the Purdue Passport Badge e-Portfolio system, which augments Mozilla Open Badges (openbadges.org). Advantages of using Open Badges include:

- They use an open architecture technical standard.
- They contain data about the issuer, criteria, and submitted artifacts that demonstrate criteria are met.

- They can be collected in a "backpack" for easy portability to social networks, job search sites, and continuing education.
- They can be earned from any source that works with the Open Badges system.

Because each badge contains deep data, including the artifacts demonstrating competencies, learners would be well positioned to provide evidence for their knowledge after graduation in a way that can't be achieved with a few lines on a resume.

Faculty mentors would assist learners in developing and periodically revising a personal plan for badge acquisition each semester, based on individual learning styles and goals. Badges would be defined as learning outcomes, not as specific course projects, tests, papers, or similar requirements. Learners, with guidance from mentors, would determine each semester whether to pursue specific badges through Seminar coursework, their Design Lab projects, ILMs, outside experiences, or a combination.

The web-based Passport system permits assigning multiple faculty permission to assess learner work for a given badge. We have partnered with faculty from across campus to be subject matter experts with appropriate knowledge and skill to develop badges, as well as reviewing learners' work and awarding badges during a semester. It is our belief that using badges in this way would encourage students to grow as lifelong learners, as they improve their knowledge calibration, and learn that (a) knowledge and skill acquisition is a lifelong process; (b) the best plan for knowledge acquisition is one they develop themselves, based on the knowledge they need and in the way that they learn best. The badge process was designed to actively support students' developing agency, as they experience designing their own progression through competencies throughout their undergraduate experience.

Unexpected Challenges

After spending a year and a half designing the experience and completing the first semester, we are still relatively early in the process of developing and refining the PPI experience. The experience of designing an entirely new curriculum specifically intended to confront existing paradigms has revealed a number of challenges, which have affected everything from process to structure, semantics to content.

Large, Multidisciplinary Faculty Team

One particularly challenging aspect of the design process has been working on a large, ill-structured task with a multidisciplinary team. We have come to realize that there is wide variation in the way that individuals in our respective fields structure how we understand and address problems, and the assumptions we make about the best way to communicate our understandings. In addition, tenure earning and workload-related expectations vary widely across departments. This has posed a larger challenge than initially anticipated.

Additionally, interdisciplinary collaboration has at times been marked by a lack of understanding, trust, and equity between collaborators, especially those from widely different disciplines (as is the case when working across colleges as distinct as COT and CLA) or from disciplines with unequal institutional value (whether actual or perceived, as is sometimes the case when partnering performing arts with technology fields). If we are to continue to work across colleges, we will need time, empathy, and intellectual and institutional equity (Vanasupa, McCormick, Stefanco, Herter, & McDonald, 2012).

We believe that several steps must be taken to address these issues. First, interdisciplinary collaborators need to have the time to be able to recognize their disciplinary schemas—the ways in which their fields structure how they understand and address problems—and the assumptions they generate, before they can truly speak to, hear, and learn from each other. Second, collaborators must be equal partners fully invested in the project, and must be given the space and time to learn different academic cultures. Third, interdisciplinary work—particularly if it is to occur between Liberal Arts and STEM disciplines—needs to be recognized and valued institutionally. Without it, as Vanasupa et al. (2012) noted, the culture and structure of the "collaboration" risks being in fact noncollaborative as faculty members in positions of institutional strength impose their disciplinary schemas onto the project, while those from other disciplines never fully buy into the collaboration.

Knowledge of Instructional Design and Cognitive Theory

The authors feel that a major obstacle to effective progress on the design of this curriculum has been the lack of background in instructional design and cognitive theory amongst the faculty as a group. Much emphasis was placed on changing the culture of the learning environment to embrace a learner-centered approach to learning. The leadership team presented faculty fellows with numerous readings, but many of these centered on inspirational examples of learner-centered curricula or broadened perspectives in technology and hard sciences. Few of these materials examined theories of how learners learn, or the specifics of how to build a learner-centered instructional design model.

The authors suggest that much more reading and research must be undertaken by faculty members who are leading the instructional and curricular design for the PPI. They have collected and shared articles on instructional design systems (e.g., van Merriënboer et al., 2002; van Merrienboer & Kirschner, 2007), learning theory (e.g., application of the Zone of Proximal Development to learning environments, as in Doolittle (1997), Moll (1990)), adaption of studio and seminar models to technical disciplines (e.g., Cennamo & Brandt, 2012; Ledewitz, 1985; Reimer & Douglas, 2003), the development of spiral curricula (e.g., Cantu & Farine, 2007; DiBiasio et al., 1999; Lohani et al., 2005, 2011), and systemic change in higher education (e.g., Reigeluth & Garfinkle, 1994; Watson & Watson, 2013). However, they feel that further investigation and reading should be done now that they have a better understanding of learner needs and the challenges that arose during the first semester. A graduate assistant with expertise in engineering education has begun creating cartoon-style handouts that summarize valuable concepts and providing them at faculty reflection sessions.

Who Are Our Learners?

Another major stumbling block has been determining who our target learners are. Is our goal accreditation in the fields traditionally served by the existing COT (i.e., an ABET accredited degree in mechanical engineering technology, aviation technology, or building and construction management)? Or, will the degree be truly inter- or transdisciplinary, breaking the mold of traditional silos of learning?

As discussions have progressed, there has been a move toward creating a university-wide interdisciplinary degree outside of the boundaries of the COT. However, questions remain about the responsibility of faculty to the traditional COT knowledge domains. This has been complicated in the first year. The first cohort of PPI learners consists of freshman students, many of whom have previously declared COT majors and were promised that they would be awarded degrees in those fields. Negotiations with existing departments and curriculum committees to ensure these learners are maintaining progress on a path to completing preexisting majors has been tricky at best.

While the creation of a new interdisciplinary degree will provide freedom from constraints of existing plans of study, the authors fear that a fully interdisciplinary program may supplant a traditional liberal arts degree, while a degree that focuses on serving each of the individual departments within the COT may become as calcified and inflexible as the learning experiences the PPI aims to improve upon. Without deciding exactly what the degree will look like—what learners it will serve, what knowledge domains learners will achieve mastery in—the curriculum runs the risk of trying to serve too many purposes without achieving any of them with any level of proficiency.

Outcomes vs. Competencies: Language Barriers to Understanding

Semantics has proven tricky. Words like "competencies," "outcomes," "assessment," and "credentialing" come laden with values and historical connotations that vary between disciplinary boundaries, some of which are hard to recognize at first. We spent months simply attempting to come to agreement on common language to discuss topics such as "What should learners know when they're done?" and "How do we make sure they know it?" As the work continues, agreeing on—or creating—more acceptable language will likely continue to be vital.

Credit Hours and Badges

The traditional measure of learning on a student's transcript—the credit hour—has proven to be a thorny issue as well. The concept of credit hours as a measure of student learning is deeply ingrained institutionally at the university level. Degree programs are mapped out in terms of how many credit hours learners have completed in particular knowledge domains. Indeed, at Purdue, the *type* of credit hours—lecture, studio, laboratory, experiential—are strictly proscribed as a measure of contact hours. Credit hours are also fundamental to the business side of higher education, as the basis of tuition bills and financial aid eligibility.

However, one key goal of the team's development work has been to recognize all learning—whether inside or outside of the classroom—and to allow learners some degree of latitude in the length of time required to complete tasks and master competencies. Consequently, some faculty have pushed to decouple credit hours from achieving competency. This has proven complex, and many technical obstacles remain to be overcome.

Participatory Designers

From the beginning, the PPI has been envisioned as a student-centered endeavor. Having learners' input was a major goal. However, the team struggled with integrating learners into the design process. The largest stumbling blocks have been defining specific roles for learners within the design process, and preparing learners to adequately fulfill those roles. Early in the process, a small group of students was asked about what they liked and did not like about their existing courses, and what they thought could be improved to create a "college of the future." Students were only able to provide suggestions for small-scale improvements on the course structure they were already familiar with, providing little outside-the-box insight. Students were also invited to a design meeting, but the group was not prepared to take their input in an organized way.

The second integration of learners came late in the process, in the form of a focus group of students from across disciplines. Faculty briefly presented the in-progress program design, after which students gave their input. Unfortunately, this presentation came so late in the process that there was not much opportunity to make a substantial impact on the design of the first-year curriculum.

Students were hired to assist over the summer preceding the fall 2014 launch of the program. Once again, faculty were not able to find a way to utilize these students in the design process, and their work was largely related to assisting in building the learning spaces.

Organizational Support

The authors realized during the course of the design process that while the PPI enjoyed the full-throated support of the administration *in theory*, the amount of organizational support varied quite a bit at a detailed level. Sometimes lack of organizational support appeared to result from situations in which existing paradigms were directly challenged. For example, some academic units rejected outright the notion that discipline-specific knowledge could be obtained in any manner other than in existing courses, requiring that learners enroll in specific classes in the same semester they would in the traditional program. Other times, bureaucratic inertia appeared to be the cause of lack of support. For example, initial conversations with the Registrar's office seemed to suggest that the creation of the two nontraditional courses, Seminar and Design Lab, would not be possible because they didn't fit into existing paradigms of student/faculty contact hours. Further conversations directly with the Registrar helped team members to come up with compromises that allowed us to offer the courses largely as planned, albeit with workarounds that turned out to be confusing to students and complex for faculty. Some compromises ran counter to what the team felt would make best pedagogical sense. For example, it was decided that badges (measuring competency achievement) should be mapped directly to credit hours (a measure of student/faculty contact hours) in order to simplify translation back to the traditional system. Regardless of cause, there was a disconnect between the initial charge to, in essence, "throw out all the rules," and the actual implementation, which has required the team to make decisions that fit within existing university requirements.

Conclusion

The process of designing the first-year experience of the PPI has been both exciting and frustrating for the faculty involved. Although we are proud of what we have accomplished, much work remains ahead of us as we embark on the next step of our journey: developing a competency-based, transdisciplinary degree program which meets the needs of our twenty-first century learners.

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Repertoire of Precedents: Designers Kindling Fatwood During Reflection-in-Action

John Baaki and Monica W. Tracey

Abstract Fatwood is old pine tree roots that are split into kindling and used as a fire starter. As a metaphor in design thinking, designers call their fatwood a repertoire of precedents. Designers kindle their fatwood when reflecting-in-action. What impact does a designer drawing from a repertoire of precedents inside and outside the project have on the reflection-in-action process? This chapter explores the give and take relationships that eight designers designing projects had with their personal repertoire of precedents and frame experiments. From the exploration of the give and take relationships, we discuss how we can design fatwood learning experiences.

Keywords Design thinking • Frame experiment • Instructional design • Instructional designer • Interdisciplinary designers • Reflection-in-action • Repertoire of Precedents

A graphic designer designing a hip and cool college website draws inspiration from current trends in album covers. An engineer developing engine calibration looks for symmetry, pattern, and beauty in his calibration tables. An instructional designer facilitating DiSC behavioral training draws from past initiatives to make strong points during a workshop. An architect developing roof systems for US Post Offices pulls from his experience in reflection to decide on a multi-ply membrane roof rather than a single-ply membrane roof. An instructional designer developing anti-bullying training for a girls' organization reflects on her own bullying experience when she was in middle school. Engaging the whole experience outside and inside the design project, these designers saw unfamiliar situations as familiar situations. They drew on a repertoire of precedents to better understand the design situation in front of them. They embraced their fatwood.

Fatwood: In *Words I Wish I Wrote*, Robert Fulghum (1997) explains that fatwood is old pine tree roots and stumps that are split into kindling and used as a fire starter. From the heart of a tree, fatwood gets its flammability from having aged well.

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The concentration of sap hardens into a resin that is rot-resistant. Even if wood is still green, sticks of fatwood quickly can get a fire burning hot. In design thinking, we can call our fatwood a repertoire of precedents. For designers, a repertoire of precedents matures with designers and brings light, warmth, and certainty to unique moments of design uncertainty, discomfort, and those moments of tracking through a dark, thick, cold, and sometimes lonely design forest. This fatwood is a fundamental part of a designers' reflection-in-action.

Designers kindle their fatwood when reflecting-in-action. As a specific type of reflective practice, reflection-in-action emphasizes that unique and uncertain situations are understood through attempts to change them, and changed through the attempts to understand the situations (Schön, 1983). Reflection-in-action is based on a constructionist perspective of human thought processes and perceptions (Valkenburg & Dorst, 1998). Constructionism is where people construct meaning while they engage with the world they are interpreting (Crotty, 1998). Design worlds are consistent with a constructionist view (Schön, 1988). Drawing from constructionists like Papert and Goodman, designers not only construct objects in their design worlds, but also construct objects through closely interrelated courses of action like cognition, perception, and notation (Schön, 1988). As designers, focused on ill-structured problems, interact with design episodes by having a reflective conversation with the situation, they construct a worldview based on their experiences with the situations (Valkenburg & Dorst, 1998).

Embedded in reflection-in-action, designers draw on a repertoire of precedents (their fatwood) inside and outside design projects, which help give coherence, practicability, and alternative form to a concept (Cross, 2011; Dorst, 2008; Schön, 1983). As in the fatwood metaphor, a repertoire of precedents comes from deep within the designer. It is individual. A repertoire of precedents may be as ambiguous as remembered principles of art and recollection of a full-sized website image, and as specific as interests in the aesthetics of popular indie music artists, the use of Twitter in education, and how commercial websites tend to be forward thinking, customer-focused, and market-driven (Baaki, 2014; Cross, 2011). As an inspiration and idea fire starter, a repertoire of precedents may be gathered from every possible source (Brown, 2009; Dorst, 2011).

This chapter asks: What impact does a designer drawing from a repertoire of precedents inside and outside the project have on the reflection-in-action process? It explores the give and take relationships that eight designers designing real projects had with their personal repertoire of precedents and frame experiments. From the exploration of the give and take relationships, we discuss how we can design fatwood learning experiences where instructional designers learn to use it.

Repertoire of Precedents

A repertoire of precedents includes a designer's whole experience outside and inside the project that a designer can draw from to better understand an action (Schön, 1983). Drawing from outside of the project, a repertoire of precedents is seeing an unfamiliar situation as a familiar one (Schön, 1983). From inside a project, a repertoire of precedents can come from understanding the unfolding situation in front of the designer (Baaki, 2014). When a designer draws from a repertoire of precedents inside a project, a designer can note the effects of earlier moves on later moves (Schön, 1983). Through on-the-spot experiments from drawing, sketching, and modeling, designers construct new problems and models not from preexistent theories, but from an individual repertoire of familiar examples and themes (Schön, 1983).

Frame Experiment

Designers formulate a design problem that needs to be solved. The description of design here is different from what is often thought of an instructional design where designers encounter design problems already defined as a result of an analysis effort. To formulate a design problem that needs to be solved, designers frame and reframe a problematic design situation, set boundaries, select things that need designers' attention, and make the situation coherent so designers continue to move the design forward (Schön, 1988). Designers frame and reframe a situation in a frame experiment and then evaluate those experiments by: (a) whether the designer can solve the problem that has been set, (b) whether the designer values what he gets when he solves it, (c) whether the designer achieves in the frame a coherence of artifact or idea, (d) whether there is a congruence with fundamental values and theories, and (e) whether inquiry can keep moving (Schön, 1983).

Studying two engineering teams designing robots that dump balls, Valkenberg and Dorst (1998) confirmed a direct approach to framing and reframing in a frame experiment. In the reflective conversation with the situation, designers named relevant factors in the situation, framed the problem in a specific way, made the move toward a solution, and then reflected on the moves (Valkenburg & Dorst, 1998). Framing is very important as it is the space where moving toward a solution and reflecting on the moves happens.

The Give and Take Relationship

The relationship between a repertoire of precedents and a frame experiment is one of *give* and *take*. Designers *give* to reframing by drawing on a repertoire of precedents (Schön, 1983). As designers draw from anything and everything (their fatwood), they are able to validate design direction, guide the design, support the design purpose, and provide "what ifs" (Baaki, 2014). The *take* occurs when each new experience in reflection-in-action adds to a designer's fatwood. Like sap to resin, the concentration of experiences becomes an excellent fire starter for design ideas. Designers are able to realize what can and cannot be done, better grasp the design context, and find that uncertainty can become more certain (Baaki, 2014). Reflection-in-action does not create general principles but contributes to a designer's repertoire of precedents (Schön, 1983).

The Designers

As part of a larger interdisciplinary study that studied reflection-in-action in regards to design activity, this phenomenological research design used an interactive methodology and multiple data collection methods to study reflection-in-action. The study participants came from four design fields; three graphic designers, three instructional designers, one engineer, and one architect.

Using criterion sampling, participants: (a) were involved in their own, real short-term project that lasted between 37 and 87 days; (b) had at least 5 years of design experience; (c) were individually responsible for at least 75 % of the design work; and (d) were engaged in a nonroutine, nonprocedural design project. A nonroutine design was defined as one that lacked a well-formed approach to a solution (Snider, Culley, & Dekoninck, 2013). This last criterion was selected because the idea of reflection in action is that *unique* and *uncertain* situations are understood through attempts to change them, and changed through the attempt to understand them (Baaki, 2014; Schön, 1983, 1988).

Through the life of the design project, participants completed weekly reflection journals and participated in interview meetings. The first author used constant comparison to analyze the data. As he continuously collected data via reflection journals and interview meetings, he simultaneously processed the data (Lincoln & Guba, 1985). As a result, under the research question "What impact does a designer drawing from a repertoire of precedents inside and outside the project have on the reflection-in-action process?" Four themes emerged as the first author constantly engaged in developing salient factors and then exploring these factors in more detail.

Maintaining the process of most phenomenological studies, the study engaged each of the eight participants for a relatively long period of time (average of 64 days). Through the life of the design project, participants completed weekly reflection journals, participated in interview meetings, shared design artifacts, and reviewed design milestones. Table 1 provides a summary of the eight participants.

Table 2 provides a brief description to the nonroutine, nonprocedural makeup of the design projects.

The Results

Four themes provided insight on *how* interdisciplinary participants drew on things outside and inside the design while they took stock in unique situations to better understand the situation and then change the situations. Themes provided insight on how designers *gave* to reframing by drawing on a repertoire of precedents, their fatwood. Themes provided awareness on how designers *took* each new experience in reflection-in-action and added to their fatwood.

Table 1 Summary of participants

Participant	Design field	Design experience (years)	Design project description	Length of design project (days)
GD1	Graphic	6	Design a website for a Midwest health system	73
GD2	Graphic	6	Design a website homepage for a Midwest private college	71
E3	Engineering	5	Development of engine calibration to 80 % calibration for a major international car manufacturer	65
ID4	Instructional	20	Facilitate car dealership DiSC Behavior training for an international car manufacturer	39
GD5	Graphic	14	Design a website homepage and interior page for a Midwest law firm	37
ID6	Instructional	5	Design anti-bullying training using social media for a Midwest girls' organization winter camp	87
ID7	Instructional	8	Design phase 2 of National Health Care Reform training for customer service representatives at a large Midwest healthcare provider	81
A8	Architecture	18	Design roof system development for six individual US Post Offices across the United States	58

Table 2 Description of each design project's nonroutine, nonprocedural makeup

Participant	Description of the design project's nonroutine, nonprocedural makeup
GD1	To begin, no constraints were provided. Create a great user experience with only what GD1 already knew
GD2	First time GD2 designed a college website
E3	First design project as a calibration specialist
ID4	Due to varying DiSC results, each day of training at each dealership was different
GD5	Design a law firm website with a younger feel
ID6	First design project as the lead instructional designer. First time using Twitter
ID7	Designing CSR training for National Healthcare Reform training which was ever-evolving
A8	Never visited a site in person. Relied on information from on-site consultants

Four themes emerged under the research question what impact does a designer drawing from a repertoire of precedents inside and outside the project have on the reflection-in-action process?

1. Participants drew from anything and everything.
2. Drawing from outside of the designs validated design direction, guided the design, and provided "what ifs."

3. Drawing from inside the design informed what could and could not be done, supported the design purpose, and guided the design.
4. Drawing on participants' experience provided design context and made uncertainty more certain.

Themes 1, 2, and parts of theme 3 (supported the design purpose and guided the design) provided understanding on how designers gave to frame experiments. Theme 4 and part of theme 3 (what could and could not be done) contributed to how designers took from each experience and added to their repertoire of precedents.

Giving to Frame Experiments

In *giving* to the relationship between a repertoire of precedents and frame experiments, participants drew from anything and everything. Drawing from outside of the designs, participants validated design direction, guided the design, and provided "what ifs." Drawing from inside the design, participants supported the design purpose and, similar to drawing from the outside, guided the design.

Participants *gave* to frame experiments by drawing from anything and everything. GD1 went outside of the healthcare field and benchmarked university and commercial websites. ID7 pulled some elements from the ADDIE model and some elements from rapid prototyping and then combined them to find a design approach that would work.

In his intent to design a hip and cool college website, GD2 drew inspiration from current trends in album covers and www.designinspiraton.com. GD2 noticed that popular indie music artists were embracing a new trend in aesthetics. In addition, fitting in with an early solution idea around students concerned with "the me factor," GD2 drew on Swiss design, minimalism, Facebook, and Twitter (Baaki, 2014).

To E3, aesthetics found in a drawing or painting was important to his calibration tables. Since there is no such thing as a cup of calibration, E3 drew on principles of art to visualize something that is not visual. E3 pulled from outside of the design to bring art principles into the design (calibration tables) and then drew on these tables inside the design (Baaki, 2014).

GD5 enjoyed websites that utilize full width imagery because it provided the appearance of richness and professionalism. This worked well for a law firm website attempting to appeal to a younger audience. GD5 drew on her own aesthetic preferences to guide the fresh and younger feel homepage designs.

When taking stock in the designs and reframing design situations, participants often understood these unique and uncertain situations by drawing from outside the design. GD1 validated her initial design direction by looking at medical, university, and commercial websites. GD1 drew on specific sites for a reason (Baaki, 2014). GD1 looked at medical sites to see if they are doing anything different. She drew on university sites because they have similar challenges in organizing a great deal of information. Commercial websites tend to be forward thinking, customer-focused, and driven to market themselves.

Researching these websites helped guide GD1's design especially in taking a user's perspective in seeking out what works. GD1 noted, "This helped me to think outside the medical bubble and think better, but also realistically. I noticed things that users would like and even expect when visiting other websites (not just medical ones)," (Baaki, 2014, p. 89). GD1 started out with a simple design approach and drawing from outside the "medical bubble" validated her direction and subsequently guided the design.

As she engaged in frame experiments that were constantly fluid as more and more healthcare reform information was provided, ID7 was thankful that she was able to draw from a combination of the ADDIE model and rapid prototyping. Internalizing the model with a rapid prototyping twist, ID7 was able to keep up her design pace. ID7 found familiarity in a process using the elements of ADDIE and rapid prototyping while working in the unfamiliar territory of healthcare reform. She wrote, "Thank goodness for this process. I originally started with about 15 different topics that I needed to include in the design. I have since dropped several topics…and have added a few others…," (Baaki, 2014, p. 90).

GD2 dealt with a month hiatus in his college website design project. Despite the pause, drawing on another design project, GD2 reflected-in-action on "what ifs" for the college website. GD2 concluded, "During the wait period, an idea could be presented," (Baaki, 2014, p. 91). During the hiatus, GD2 admitted that if a solution or idea came up for the college website, he would document it.

From the start, GD2 had a purpose in mind for the redesigned college website. This purpose was messaging that resonated with prospective students. As GD2 designed with this purpose, he pulled from inside the design, which was an audience-message-action (AMA) workshop conducted by a project manager, to support the purpose. From the recorded AMA workshop, GD2 picked up on people's excitement about how students would choose their major on the site, and on people's indecisiveness regarding how to treat athletics (Baaki, 2014).

Participants noted that they drew on early drawings, sketches, or models (inside the design) to guide the design. E3, who was involved in a very complicated design project, explained that there were procedures and examples of what a calibration should look like. E3 began his design following the calibration procedures as they provided what to do and provided guidance. As the design development progressed, E3 reflected-in-action on previous calibrations. E3 noted, "So any calibration at this point starts from a previous calibration and essentially gets updated as things change on the engine and new learning occurs" (Baaki, 2014, p. 93).

Similarly, ID4 had the opportunity to draw from specific items inside the design. These items were different for each dealership. At each dealership, ID4 drew on a completed sample management DiSC profile, actual completed DiSC reports for each participant (completed prior to training), and a cumulative DiSC report (consolidation of results from all leadership team members).

Participants *gave* to the multiple frame experiments they embraced and engaged. This meant that participants validated design direction, guided the design, provided "what ifs" and supported the design purpose.

Taking from Each New Frame Experience

In *taking* from each new frame experience, participants added to their fatwood. Participants realized what can and cannot be done, grasped the design context, and found that uncertainty can become more certain (Baaki, 2014).

With very little to no direction early in the design project, GD1 started with very simplified design goals. As more complicated goals evolved so did the design's complexity. GD1, drawing on the early, simplified designs, realized what can and cannot be done as she tackled the more complicated design requirements. Collaborating with the lead developer, GD1 set needed boundaries (what could and could not be done) and added these to her fatwood. Taking stock in her conversations with the developer, GD1 reflected-in-action on what she had done and on now pushing the line on what she had done to see if it would function the way she designed it. GD1 drew from what she had designed at that point and changed it based on the developer's feedback. GD1 explained how she added to her fatwood, "…he (lead developer) has been able to say that we can't do something one way because of a technical constraint, to which I can then ask about if it would work still if I changed it in some way," (Baaki, 2014, p. 92).

A8 had the unique situation that he never visited any post office sites. In order to make decisions on what could and could not be done, A8 had to draw from a great deal of inside information. Each decision inside the design had the potential to limit what is possible or not for other decisions. A8 explained that he took something from each decision that would affect the next design problem.

A8 wrote in his first reflection journal:

> Every design decision has pros and cons to it. I review the pros and cons and make design decisions with the input of the client, code criteria, industry standards, personal experience. These decisions are ultimately done to achieve the overall objective which is to protect the inside of a facility from the weather. Each decision affects the next design problem. They are woven together or stacked like building blocks. An example of this might be the wind calculation for Tuscaloosa indicated wind speeds of 100 mph. This affects the uplift pressures and indicates the number of insulation fasteners required. (Baaki, 2014, p. 93)

Participants took from their own experience, be it inside or outside the design project. When participants drew on their own experience, they provided design context and made uncertainty more certain.

E3's 80 % calibration design development was unique because it was his first project as a calibration specialist. Drawing on his past engineering roles as a Product Line Combustion Engineer, E3 provided context for the 80 % calibration design. E3 reflected:

> In that role (Product Line Combustion Engineer), I gained considerable knowledge in terms of fundamental engine combustion. That includes the effect of spark timing on engine performance and the mechanisms with which knock occurs. Two-thirds of my current role as a calibration specialist involves spark calibration and knock calibration. So I have a firm understanding of spark and knock and just need to become well versed in calibration itself

> and not the fundamentals of spark and knock. So when I am developing a calibration, I first imagine what I want the engine to do and how I want it to respond under certain conditions. (Baaki, 2014, p. 95)

Designing a complicated calibration, E3 lessened his uncertainty with confidence that he had developed the correct algorithms from the data. One of the final elements of E3's 80 % calibration was dealing with a complex, "not regularly occurring" phenomenon called stochastic preignition (SPI) (Baaki, 2014, p. 95). E3 was, "…at the mercy of a 'chance' occurrence" to design an algorithm to handle SPI (Baaki, 2014, p. 95). Drawing on experience and intuition in order to design a solution for SPI, E3 determined that he needed to look at data from 30 SPI events. He elaborated, "The more events I have recorded data for, the more confident I have in the algo I develop from the data" (Baaki, 2014, p. 95).

From the information that A8 received from each site, he drew on his experience to provide context and then make a design decision. ID4 drew on his experience to know "where the holes are" and what can happen in a unique situation (Baaki, 2014, p. 96). Through engaging the frame experience, both A8 and ID4 drew on their experience and made changes. For ID4, drawing on experiences created design opportunities that he then added to his fatwood.

ID6 went beyond professional experience and drew from her childhood experiences, which were outside of the instructional design. This allowed ID6 to provide context to her bullying education instructional design. Drawing on a bullying situation in middle school, ID6 remembered her own sensitive feeling at that age which affected her reflection-in-action during frame experiments and what she took from frame experiments. ID6 explained, "Remembering my own sensitive feelings at that same age with the same topic constantly encouraged me to be very thoughtful about moving forward with this issue" (Baaki, 2014, p. 96).

Within each new frame experience participants drew from inside and outside the design project which added to their fatwood. Adding to their repertoire of precedents meant participants discovered what can and cannot be done, embraced the design context, and found that uncertainty can become more certain.

Kindling Fatwood

This study looked at designers designing real projects in the place where they design. Be it an 80 % calibration for a 2014 car engine, bullying prevention training for a girls' winter camp, national healthcare reform training for customer service representatives, a healthcare website redesign, or roof design development for six US Post Offices across the country, each participant reflected-in-action on an actual design project that had to meet a specific deadline. The fact that participants were designing in reality (real-world projects and contexts) provided an interesting balance between the driving elements of the repertoire of precedents and frame experiment give and take relationships found in the literature and what actually happened on the frontline of design.

In the literature, across engineering, graphic design, and instructional design, designers rely on and draw from experience and intuition when reflecting and making judgments on what they tacitly know. Spitas (2011) concluded engineers' exploration of a design space is driven by designer intuition and experience. Human-centered designers like graphic designers follow a structure where they reflect on and compare experiences that result in new insights about practice (Conley, 2004). In instructional design, designers use personal experiences, frames of references, design principles, and context knowledge to consider alternative solutions during the design process (Kirschner, Carr, & van Merriënboer, 2002; Pieters & Bergman, 1995; Rowland, 1992).

Kindling their fatwood, participants drew on their experience to provide design context and make uncertainty more certain. A8 and ID4, interestingly the two most experienced designers in the study, clearly used their experiences and intuition, "… to fill in the missing pieces…" (Baaki, 2014, p. 112). When facing uncertainty and doubt, A8 and ID4 engaged in the give and take relationships of a repertoire of precedents and frame experiments. They drew on what they knew, what they had experienced in the past, and what their gut told them. Embracing each new frame experiment, they then added to their fatwood.

A8's unique situation was that he did not visit the post office sites. He reflected-in-action on information that was not always complete. To keep roof design developments moving forward, A8 confidently compensated for missing pieces of information by drawing on his experiences. A8 explained that waiting for answers sometimes meant leaving holes in a design or making assumptions based on his experiences (Baaki, 2014, p. 112). Without the 18 years of building up his concentrated sap (i.e., his highly developed and nuanced experiences), A8 could have missed trouble spots which could have stalled the design development. He commented, "My past experience tells me that given the amount of mechanical equipment and foot traffic that this roof might see, we will need a multi-ply membrane rather than a single-ply membrane" (Baaki, 2014 p. 95). In an interview meeting, A8 admitted that a single-ply was cheaper and could work. Because of durability, his experience told him the best design decision was a two-ply membrane. "It is all experience with post offices and the trouble spots" (Baaki, 2014, p. 112). Can instructional designers learn to kindle this fatwood?

Instructional Opportunities to Kindle Fatwood

Where is instructional design's opportunity to kindle designers' fatwood and cultivate the opportunities of the give and take relationships of a repertoire of precedents and frame experiments? We need to look no further than how our design colleagues in engineering and architecture encourage design thinking with design students. It is in instructional design classrooms. Instructional design students need to study and learn instructional design from a design thinking approach where they can kindle the fatwood inside and outside the design. This means allowing students to design in spaces that are grounded in instructional design principles such as: (a) be an advocate for the learner, (b) design to reach outcomes and show achievement, (c) design with an eye on the learning and real-life contexts, and (d) design authentic learning.

What are these design spaces? Foremost, they are supported with the elements of good instructional design. There is no need to reinvent a new design thinking approach. Similar to and a variation on other design fields, as instructional designers we can discover, define, ideate, prototype, and test. We can discover and understand learners' fears, dreams and hopes, and what they want to accomplish. We can define and frame problems as opportunities to generate lots of creative solutions, and we can test and learn what works and what does not work to improve solutions. The spaces overlap. The spaces inform one another. The spaces allow for reflection, allow designers to draw from a repertoire of precedents, and allow designers to design in frame experiments.

For example, in a graduate instructional technology design thinking and knowledge course, the first author conducts an activity called On Your Mark! Get Set! Design! Working in groups, students kindle their fatwood as they face challenges like:

- Design a Michigan railroad where you can embark in either the far southwestern corner or far southeastern corner and disembark in the opposite corner. The railroad travels along a coast of all the Great Lakes except for Lake Ontario.
- Design a safe light source for a home with no electricity in the land of the Midnight Sun, specifically Finland's Lapland.
- For a group of five people crossing by foot across Death Valley, design a way to block wind and sun.
- Design a way for the Michigan State Parks to get children (9–17 years old) to embrace, engage in, and enjoy creative writing, music, and pencil sketching.

Over a week, each group collaborates and provides a design that other groups can react to—a map, a sketch, an outline, etc. Each design solution is full of context from the information provided. Students are encouraged and then draw from outside and inside the design to guide the design, develop "what ifs," update what can and cannot be done, and support the purpose. Assigned in week 6, On Your Mark! Get Set! Design! often causes group uncertainty and anxiety. Drawing from outside and inside their design and on their experience, group members provide context and bring certainty to the uncertainty.

Fatwood is a fire starter. Fatwood quickly gets a fire burning hot. For designers, kindling their fatwood brings light, warmth, and certainty to unique moments of uncertainty and discomfort in a dark, cold, thick design forest. Designing in the give and take relationships of a repertoire of precedents and frame experiments, designers can validate design direction, guide the design, provide "what ifs," support the design purpose, grasp the design context, and find that uncertainty can become more certain.

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Mastery Learning Within Accelerated Nursing Learning Environments

Amy M. Grincewicz

Abstract Many colleges and universities are creating accelerated courses and programs. Accelerated education refers to any attempt to speed up or compress the educational process beyond the traditional semester or quarter systems that most colleges and universities utilize. Institutions are developing accelerated nursing programs in an effort to meet the learner's busy personal and professional lives. Accelerated learning environments need to focus on creating an activity-based positive learning environment emphasizing collaboration between learners in a learning community, offer a variety of learning options to focus on a variety of learning styles, and focus on contextual learning. Accelerated programs accomplish programmatic outcomes in a short time by building on previous learning experiences. Instruction is intense within courses, and institutions are offering these full-time programs with no breaks between sessions. Mastery education has proven to be a useful strategy for improving learning outcomes. There is a strong need to research mastery learning within accelerated learning environments because previous studies disagree on how course length affects mastery of outcomes. The published research indicates that length does not significantly affect mastery of learning outcomes; however, the theoretical framework of mastery learning theory had not been discussed in these studies. In addition, the existing research fails to provide a framework for how to implement mastery learning with accelerated nursing environments. This chapter explores the theory, research, and design of accelerated nursing learning environments as means of establishing best practices for designing courses to ensure mastery learning.

Keywords Mastery learning • Accelerated learning • Nursing education

Accelerated nursing programs are available in 43 states, the District of Columbia, and Guamand; in 2011, there were 235 accelerated baccalaureate programs and 63 accelerated master's programs available with more in development (American

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Association of Colleges of Nursing [AACN], 2012). The reason for the numerous accelerated programs is that hospitals are requiring nurses to have advanced degrees, increasing the demand for these programs (AACN, 2012). Accelerated programs accomplish program-learning outcomes within a compressed time by building on previous knowledge and experiences.

This wide-scale use of accelerated education directly reflects the twenty-first century pattern for information on demand. Development of accelerated nursing programs has changed the teaching and learning environment, and educators need to ensure that learners in these programs are still competent by mastering content quickly.

The role of competency in education has dramatically grown as healthcare employers and educators have identified gaps between practice and education. Through a concept analysis, Tilley (2008) discovered that competency within nursing focuses on the learner's ability to meet outcomes, having increasing levels of competency, learner accountability, practice-based learning, self-assessments, and individualized learning experiences. These competency attributes align with focusing learning experiences on mastery learning. Mastery learning also referred to as outcomes-based and competency-based education ensures learner success through preset criteria. Mastery learning focuses on learner's academic abilities and flexible instruction and content to meet a wide variety of learner needs. The Institute of Medicine (2011) has emphasized the value of competency-based education because it connects clinical performance and decision-making skills that are needed in all medical fields.

This chapter explores the theory, research, and design of accelerated nursing learning environments as means of establishing best practices for designing courses to ensure mastery learning. A discussion of mastery learning theory and its application to accelerated learning is examined to provide best practices for this integration.

Accelerated Nursing Learning Environments

Many colleges and universities are creating courses and programs that are fast paced compared to traditional program lengths. Accelerated education refers to any attempt to speed up or compress the educational process beyond the traditional semester or quarter systems that are used in most colleges and universities (Tatum, 2010). Sometimes this means simply shortening the duration of the course (e.g., from 15 to 6 weeks) without changing the number of contact hours in the classroom (e.g., 40 h). In addition, accelerated education may also refer to programs that learners can complete in less time than a traditional degree. Since accelerated learning programs require less time than traditional programs, they are appealing to busy learners. Learners in these programs must quickly adapt to the academic rigor and expedited pace associated with an accelerated format.

Accelerated learning is a total system for speeding and enhancing both the design process and the learning processes. Accelerated learning, also referred to as brain-based learning, has shown to be an effective method for increasing learning (Bellah et al., 2008; Meier, 2000; Trníková, 2013). Many of today's leading organizations and educational institutions are benefiting from the power of accelerated learning. Accelerated learning is effective because it is based on the way we all naturally learn and the quick pace unlocks much of our potential for learning that has been left largely untapped by most conventional learning methods (Bellah et al., 2008; Meier, 2000; Trníková, 2013). It does this by actively involving the whole person, using physical activity, creativity, music, images, color, and other methods designed to get people deeply involved in their own learning.

With the US Department of Labor projecting the need for more than a million new and replacement registered nurses by 2018, nursing schools around the country are exploring creative ways to increase capacity and reach new learner populations (AACN, 2012). One innovative approach to nursing education that is gaining momentum is the accelerated degree program for non-nursing graduates. Institutions are developing accelerated nursing programs in an effort to meet the learner's busy personal and professional lives (Teeley, 2007). Baccalaureate nursing programs developed in response to the nation's growing elderly population, the nursing shortage, and demands from learners holding previous bachelor degrees and associate nursing degrees (Penprase & Koczara, 2009). Academic institutions are offering accelerated nursing programs at the baccalaureate and higher education levels, these programs build on previous learning experiences and provide individuals with undergraduate degrees in other disciplines to transition into nursing (AACN, 2012).

Instructional design is the practice of creating "instructional experiences which make the acquisition of knowledge and skill more efficient, effective, and appealing" (Merrill, Drake, Lacy, Pratt, & ID2_Research_Group, 1996, p. 5). Designing effective accelerated learning environments poses challenges to instructional designers to design effective instruction for shortened courses. Meier (2000) describes that accelerated learning environments need to focus on creating a positive learning environment focused on activities, collaboration, and offering a variety of learning options to focus on a variety of learning styles, and develop contextual learning. Contextual learning utilizes a continuous cycle of content immersion, feedback on assessments, reflection, evaluation, and back to immersion in content. In order to create the optimal accelerated learning environments, instructional designers need to focus on appropriate instructional strategies and theories designed for shortened courses since this is the most accessible learning path for working individuals. Therefore, this shows a need to further research these environments and establish best practice for mastery learning.

Need to Research These Environments

There is a strong need to research mastery learning for practical and scholarly reasons. The goal of accelerated nursing programs is to ensure mastery of program and course competencies. The competency outcomes and performance assessment model has been used in nursing to promote competency in practice (Lenburg, Abdur-Rahman, Spencer, Boyer, & Klein, 2011). The framework of this model focuses on specific competencies, interactive learning strategies, objective competency-driven performance assessments, and course learning outcomes.

As learners gain competencies, their motivation increases (Changeiywo, Wambugu, & Wachanga, 2011) and motivation is associated with educational achievement (Wlodloski & Ginsberg, 2010). Researching effective instructional methods for accelerated learning environments is practical within nursing education because of the increase in these programs, the need for nurses to be competent, and the need to create authentic learning experiences to keep learners motivated to help increase learning and achievement.

Research has identified common hindrances learners report as to their experience in accelerated nursing programs, including elevated stress levels, keeping up with the fast pace, workload intensity, financial difficulties, lack of program support, personal and professional difficulties, and curriculum organization (Cangelosi, 2007; Hegge & Larson, 2008; Kohn & Truglio-Londrigan, 2007; Meyer, Hoover, & Mapose, 2006; Neill, 2011; Seldomridge & DiBartolo, 2005; Weitzel & McCahon, 2008). These environments may be overly compressed, sacrificing reflection and breadth and resulting in poor learning (Wlodloski & Ginsberg, 2010). Stephens (2012) found that learners preferred to be in longer courses to process the same amount of material covered in a shorter course. The existing research shows variation in how speed of the course affects mastery (Johnson, 2009; Shaw, Chametzky, Burrus, & Walters, 2013). Therefore, it is necessary to visit how to design accelerated courses for mastery of competencies.

Mastery Learning Theory

Mastery learning has been around for many years; however, educators have primarily implemented mastery-learning practices in K-12 settings. However, mastery learning can be implemented within nursing education to promote mastery of competencies (Sutton, Ingram, Flack, & Jones, 2013). The implementation requires an educational and cultural shift to prepare learners for the mastery approach. Educators tend to use general instructional strategies that may not benefit a diverse population of learners. The mastery instructional process involves organizing the concepts and skills around the goals and outcomes. Assessments and feedback empower learners to address their learning needs and correct learning errors to achieve mastery (Guskey, 2007). Two basic assumptions of mastery learning are that the majority of learners can master content and that educators design the environment to help learners achieve stated goals and outcomes (Guskey, 1997, 2007; Sutton et al., 2013).

Bloom's mastery learning theory is a group-based, teacher-paced instructional strategy focused on instructional alignment and providing learners with corrective feedback (Guskey, 1997, 2007). Mastery learning is grounded in the work of Benjamin S. Bloom (1971, 1976, 1984), who considered that adapting learning strategies may improve learning. Bloom (1971, 1976, 1984) believes that the majority of learners (95 %) are capable of learning if they are provided favorable learning conditions. Guskey (2009) suggests that 80 % or above is considered mastery. Mastery is based on learners having sufficient time and appropriate learning conditions to reach a high level of achievement (Guskey, 1997, 2007).

Bloom (1971, 1976, 1984) describes the learning process through three categories: the characteristics of the learner, of the instruction, and of the learning outcomes. Learner characteristics focus on cognitive and affective conditions where learner preparation and learner perceptions of themselves and the content can affect mastery. Key instructional components that affect the quality are providing cues as to what is to be learned, encouraging learner participation, reinforcement, and feedback (Bloom, 1971, 1976, 1984). Finally, learning outcomes need to increase in cognitive level as the course progresses to ensure learners have mastered low level skills prior to tackling higher cognitive level tasks.

Foundational Theories

Mastery learning theory is based on the behaviorist learning family, specifically operant conditioning. According to operant conditioning theory, learning occurs when an association forms between a stimulus and response (Skinner, 1984). Operant conditioning is a type of learning in which an individual's behavior is modified by rewards and consequences. Operant conditioning enforces repetition of a behavior through the educator providing the learner with a stimulus, followed by a response, and offering feedback to reinforce the behavior (Chase & Houmanfar, 2009; Houmanfar & Hayes, 1998; Martinez, 2010).

Aligning with operant conditioning, mastery learning focuses on observable and measurable behaviors (Baum, 2005). In order to demonstrate mastery over each unit, learners must be able to show evidence of an understanding of the material before moving to the next lesson or topic (Anderson, 2000).

Components of Mastery Learning

The two essential elements of mastery learning are (1) feedback, corrective activities, an enrichment process and (2) instructional alignment (Guskey, 1997, 2007). After the content is provided to the learners, educators would provide formative assessments to provide learners with feedback on their learning needs. The feedback assists learners in identifying their learning strengths and weaknesses, so that they can manage their time more efficiently. Formative assessments help guide the formation of corrective activities that allow learners to remediate concepts or skills they have not mastered. Using a variety of corrective activities assists learners with different learning styles to select activities to suit their needs.

Instructional alignment focuses on aligning the critical course components such as learning objectives, assessments, instructional materials, learner engagement, and technology (Quality Matters Program, 2014). Each of these components enables learners to achieve the desired outcomes, yielding effective learning. Effective learning requires constructive alignment of the curriculum, which ensures that the program, learning outcomes, instructional approaches, assessments, and course evaluation complement each other.

Implementation

Mastery learning has two methods for implementation: professional development and establishing curriculum materials (Guskey, 1997). This paper only addresses ways to utilize the framework within establishing a curriculum. Establishing a curriculum based on mastery has several advantages, including large-scale implementation, little work for educators when teaching, standardization across the curriculum, and the curriculum is unchanged when the educator teaching the courses changes. These advantages ensure that multiple offerings of a course are identical no matter who is teaching the course. In addition, these advantages focus on developing courses prior to their offering to ensure alignment of instructional materials.

Designing Instruction for Mastery

Steps for achieving mastery are to define the level of mastery, planning, orientating, and teaching for mastery (Block, 1980). The six essential steps to creating a curriculum based on mastery are (1) having specific goals and outcomes, (2) developing formative assessments, (3) organizing corrective activities, (4) planning enrichment activities, (5) developing summative assessments, and (6) including classroom applications (Guskey, 1987, 1997). These elements help educators design systematic quality instruction. Educators primarily design curriculum into units where a summative assessment normally appears at the end of the unit. Bloom outlined a strategy to incorporate these feedback and corrective procedures, which he labeled mastery learning (Bloom, 1971). In using this strategy, educators organize the important concepts and skills they want learners to acquire into learning units, each requiring about a week or two of instructional time. Following high-quality initial instruction, educators administer a formative assessment (Bloom, Hastings, & Madaus, 1971) that identifies precisely what learners have learned well and where they still need additional work. The formative assessments included feedback on where learners are struggling and excelling.

Mastery learning depends on five basic components: formalization of cognitive outcomes, dividing content into units or modules, formative evaluations, feedback to correct instruction, and summative evaluation (Guskey, 1997; Ryan, Schmidt, &

Ontario Dept. of Education, 1979). A review of the research reveals that mastery learning significantly improves learner acquisition of cognitive skills and reduces the variability in achievement within groups of learners. Mastery learning leads to retention and transfer of learning. Mastery learning theory focuses on learners mastering one concept before moving onto the next (Diegelman-Parente, 2011) in this format, developers and designers sequence outcomes from simplest to complex, developing units individually (Ryan et al., 1979).

Researchers have shown that including the following within curriculum helps to improve mastery: preassessments, group-based direct instruction to begin a learning unit, formative assessments, corrective instruction, and extension activities (Guskey, 2009; Marzano, 2009; Rosenshine, 2009). Utilizing these core elements along with mastery learning can adapt instruction to the individual learner.

Effect of Mastery Learning on Outcomes and Skills

Tang and Dong (2013) designed a clinical skills training program using mastery learning theory and found that the theory is effective for competency-based training method for clinical skills acquisition. Mobile learning integrated into a mastery learning theory instructional approach improved learners' learning outcomes for nursing training (Wu, Hwang, Su, & Huang, 2012). In addition, in helping to gain skills, mastery learning instructional approaches have increased learner motivation (Changeiywo et al., 2011).

Guskey (2007) found that the positive effects of mastery learning are not limited to cognitive or achievement outcomes; the mastery process improves confidence, engagement, and attendance as well as affective and psychomotor learning domains.

Guskey (1987) discussed alternate ideas associated with utilizing mastery learning. These ideas include how much data to collect to achieve the best evidence, the selection criteria to obtain the evidence, the time needed for mastery, and how much material educators cover within the instruction. These are important variables to consider when designing instruction for mastery.

Variables to Consider

In addition to ensuring alignment of instructional materials and including essential components into the instructional strategy, developers and designers should include five variables integrated into the instruction on mastery (Block, 1971; Guskey, 1987). Effective mastery needs to consider learning aptitude, quality of instruction, learners' ability to comprehend the instruction, perseverance, and time allowed for learning. Time is the main component that needs addressing. The amount of time needed to achieve mastery varies amongst learners; therefore, designers should take steps to reduce the learning time. However, in accelerated learning environments, time may be a factor in achieving mastery.

Mastery learning theory is an instructional theory built on establishing a process and alignment of course components. Reviewed literature mentions the importance of alignment, but fails to focus on the processes designers and developers use for organization and design for implementing mastery into courses. Organizing instruction for mastery may lessen many of the stressors learners experience in these environments. In the next section, the author discusses how to apply mastery learning into accelerated learning environments.

Implementation of Mastery Learning in Accelerated Nursing Courses

The main point of mastery learning is that all learners can achieve mastery if provided enough time, meaningful learning opportunities, a variety of formative assessments, and corrective activities that utilize prompt feedback. Nagel and Richman (1972) developed an approach for mastery learning built on four learning axioms: achievement is constant while time varies; learner analysis provides entry data that is useful for designing individualized instruction; requirements are explicitly stated; and opportunities are provided to assist learners with furthering their learning development. This framework has proven successful for increasing achievement and improving test scores (Sutton et al., 2013). The key to this framework is allowing learners the ability to retake exams or providing multiple ungraded assessments that provide feedback to assist learners with mastery. The main elements of the mastery framework are preparing learners for mastery, organization of outcomes, content presentation, formative assessments, alternate activities, and summative evaluations that focus on a teach-assess-feedback-assess ongoing cycle (see Guskey, 1987, 1997, 2007, 2009).

Preparing Learners for Mastery

Mastery learning courses are structured differently than other courses, so it is important for educators to inform learners of this change. In many courses, learners complete assessments within a provided timeframe and move onto the next unit in timely fashion. However, in mastery courses, learners usually do not move onto the next unit until they have mastered the previous unit's material. Educators may want to consider placing a welcome message in the course that highlights how the course will run including the mastery elements that are included in the course (see Box 1 for a sample message).

The important items to include in the message are that this is a mastery class, what mastery learning is and how it works, and that you are committed to helping them in mastering the material.

Box 1 Sample Message

Instructors may to want to modify the following message for posting in the course

This is a mastery classroom. That means I will be operating under the assumption that each of you is capable of mastering the content. You will learn the material so well that everyone is expected to achieve 80 % or higher on the summative assessments in the course. I want you to know that I am here to help each of you achieve this goal. I have clear expectations within the course and will be posting frequent updates in the course, to ensure my expectations are clear. Prior to starting each unit, you will complete an ungraded preassessment to help you acknowledge your strengths and weaknesses to help guide you with the content. You are encouraged to complete these preassessments many times throughout the unit to gauge your learning. Each unit includes a variety of formative assessments that offer prompt feedback to assist you on your learning journey. In addition, numerous corrective and enrichment activities are provided to enhance your learning. When you feel comfortable you are encouraged to complete the summative assessment. If you don't achieve at least an 80 % on the summative assessment, we will find a method together to help you master the material before moving onto the next unit.

Organization of Outcomes

The first task at creating a mastery course is to have clear outcomes and goals that align with all course components. The critical components are learning objectives, assessments, instructional materials, learner engagement, and technology (Quality Matters Program, 2014). Each of these components enables learners to achieve the desired outcomes. In order for this to happen, effective learning needs to occur. Effective learning requires constructive alignment of the curriculum, which ensures that the program, learning outcomes, instructional approaches, assessments, and course evaluation complement each other. The Centre for the Study of Higher Education (2011) states that "Successful on-line assessment is most likely if that assessment is aligned with teaching and learning objectives. In other words, there should be a strong relationship between the purpose of on-line assessment task(s) and the intended outcomes of the subject" (p. 6). The key aspect of any course is for the students to show mastery of learning through measuring mastery of the course outcomes. Educators should consider organizing the course into modules or units based on specific topics.

The outcomes should be sequenced using step-by-step sequencing (Rothwell & Kazanas, 2008). Rothwell and Kazanas (2008) indicate step-by-step sequencing is best used when the learner is introduced to a task. Sequencing the outcomes helps learners, so they master one skill before moving on to the next skill. In sequencing the outcomes, content should be chunked to help participants achieve this. An appropriate sequencing method enables learners to move from lower cognitive levels to more advanced levels.

Content Presentation

Each unit or module should begin with an overview that is explicit and specific to the module contents. Providing a modular checklist may help reduce instructor workload and encourages learners to stay on track (Cavanaugh, Lamkin, & Hu, 2012). In the overview and the checklist, it may help to break the module components into daily activities. With the fast pace of accelerated learning, providing a daily structure may help students stay on track and provide high expectations to keep their motivation.

Formative Assessments

In the teach-assess-feedback-assess cycle of mastery learning, there should be at least two formative assessments prepared for each module/unit that are parallel in structure with consistent content. The formative assessments focus on the module outcomes. Mastery courses should provide a variety of formative assessments that are graded and ungraded to support self-regulated learning. The key to these assessments is that they provide prompt feedback to the learner, so keep them learning at a fast pace.

Self-regulated activities focus on the four stages of self-regulated learning: planning and goal setting; self-monitoring; controlling; and reflecting (Rowe & Rafferty, 2013). The use of self-check activities/ungraded quizzes are examples of self-monitoring activities to assist with comprehension. Self-check exercises are ungraded activities to assist learners with mastering content. Feedback is provided immediately to assist learners with their studying. These types of activities help learners keep tabs on their progress and adjust their efforts, know when to seek help, and stay on track. These outcomes are especially important in accelerated courses. Some of the most important benefits of self-check exercises for online learning include (Shank, 2007):

- Helping learners determine what they do and do not understand so they can target where extra study is needed.
- Providing immediate feedback to learners and an option to link to additional materials (which may reduce the number of unfocused questions sent to the instructor).
- Providing feedback to the instructor about where learners are having difficulties so immediate interventions can be implemented.
- Increasing learner satisfaction with the instructor and the course.

Alternate Activities

Alternate activities should focus on corrective activities and enrichment activities to help all learners. Corrective activities are necessary for learners who did not achieve mastery on the formative assessments. Providing a wide variety of activities such as reteaching, alternate readings, alternate instructional materials that learners can do with others or alone to provide more support to assist with mastery. The instructor should work with the individual learner to provide corrective activities that specifically target their learning challenges. For learners who mastered the formative assessments it is worthwhile to provide enrichment activities that focus on higher cognitive levels to further enhance their mastery.

Summative Assessments

Summative assessments are designed to evaluate learning over several units. These assessments should be similar to the formative assessments, but rather than focusing on all module content, summative assessments should focus on the broader course outcomes.

Conclusion

Accelerated learning is the most accessible learning path for working individuals. In designing these learning environments, instructional designers must be cognizant of learner needs and design instruction for these needs using learning and instructional theories. In creating accelerated learning environments, instructional designers need to use the most appropriate theories, models, and evidence-based practices to make these environments effective for learners.

Accelerated learning requires a learner, an instructor, and an instructional design plan designed to motivate learners to learn and interact with one another. Learners acquire information through instructional materials, instruction, and interactions with one another to increase motivation and engagement to facilitate the learning process. The fundamental pedagogical questions that drive instruction are (1) what will learners be able to master at the end of the instruction and (2) how should the instruction be designed to allow for mastery of the course's goals, and outcomes. To answer these questions it is imperative for educators to understand and facilitate the learning process by using appropriate theories, models, and practices to guide the course design.

The goal of accelerated nursing programs is to ensure mastery of program and course competencies. As learners gain competencies, their motivation increases (Changeiywo et al., 2011) and motivation is associated with educational achievement

(Wlodloski & Ginsberg, 2010). Researching effective instructional methods for accelerated learning environments is practical within nursing education because of the increase in these programs, need for nurses to be competent, and the need to create authentic learning experiences to keep learners motivated to help with effective learning. In addition, research in this area expands on mastery learning theory by applying it to accelerated learning environments.

Mastery learning, with effective planning and goal setting, can positively impact self-confidence, learner motivation and success, and program completion rates. They key to implementing mastery is in allowing learners the ability to resubmit assessments until mastery is achieved and providing feedback to assist learners with mastery. In accelerated nursing learning environments the focus needs to be on encouraging mastery rather than just getting learners through the content. This may require including a variety of ungraded assessments to remove the grade pressure, but still provide feedback to help with mastery.

The main elements of the mastery framework are preparing learners for mastery, organization of outcomes, content presentation, formative assessments, alternate activities, and summative evaluations that focus on a teach-assess-feedback-assess ongoing cycle (see Guskey, 1987, 1997, 2007, 2009). It may also improve learner and instructor satisfaction. Therefore, using mastery within accelerated learning environments may lessen the nursing shortage.

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Building a Competency-Based STEM Curriculum in Non-STEM Disciplines: A sySTEMic Approach

Robert Kenny and Glenda Gunter

Abstract Educational research strongly suggests that the creativity and problem-solving abilities in young children in the United States have decreased dramatically over the past 50 years. There exists a vast difference in opinion regarding the definition of what it means to be creative and its related measurement in the fields of science technology math and engineering. We suggest that the real problems we face are founded on an overarching creativity loss on the part of the general population of students. In this chapter we describe what we believe are appropriate instructional strategies and design experiences to facilitate instruction on how to be more creative and think more critically that reach out to students majoring not only in the STEM disciplines but also all students regardless of career choice. We further describe ways to design effective, research-based curriculum that extend the traditional, problem-based instructional practices present in the individual science, technology, and, math disciplines into non-STEM subject areas. We refer to our initiative as an "engineer-think" curricular approach to indicate that our goal is to demonstrate to all students, regardless of discipline, how apply *systematically* steps that support their learning how to solve ill-defined problems using the same skill methods that are taught in the engineering courses. We also delve into the overarching principles behind our engineer-think curriculum framework and present a path (via educational design research) to ensure that the goals and outcomes are appropriately integrated.

Keywords Engineer-think • Exemplary STEM curriculum framework • Problem solving • Systems thinking • Increasing teacher efficacy

Educational research strongly suggests that the creativity and problem-solving abilities in young children in the United States have decreased dramatically over the

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past 50 years (Cramond, Morgan-Matthews, Bandalos, & Zuo, 2005; Runco, 2010; Sternberg, 1988). Educators and researchers often base their definition of what it means to be "creative" on the Torrance Test of Creative Thinking (TTCT) (Kim, 2011; Torrance, 1980, 1981a, 1981b) that claims to measure creative potential in several different areas, including artistic endeavors (such as literature and architecture), science, mathematics, and engineering. In practice there exists a vast difference in opinion regarding the definition of what it means to be creative and its related measurement in these various fields. Regardless of which definition one supports, there is common concern among educators about the lack of teaching creative foundations in school curricula. While efforts to increase interest in STEM disciplines abound, we take issue with the perception that the real challenge for educators is to focus efforts solely on producing more scientists, mathematicians, and engineers. We suggest that the real problems we face are founded on an overarching creativity loss on the part of the general population of students Fig. 1.

In recent years, STEM partnering initiatives have emerged with several colleges and universities partnering with local K-12 schools to implement STEM-based curricula. These efforts should be applauded and appear to demonstrate that focusing instructional efforts on the STEM disciplines can have a significant, positive effect on student outcomes. But we suggest that the only way to achieve the ambitious goals set forth (Cantrell, Pekcam, Itani, & Velasquez-Bryant, 2006; Nugent, Kunz, Rilett, & Jones, 2010) is to expand these efforts to include ways to include the general student population.

In this chapter we describe appropriate instructional strategies and design experiences to facilitate instruction on how to be more creative and think more critically that reach out to students majoring not only in the STEM disciplines but also all students regardless of career choice. We further describe ways to design effective, research-based curriculum that extend the traditional, problem-based instructional practices present in the individual science, technology, and, math disciplines into non-STEM subject areas. We refer to this initiative as an "engineer-think" approach demonstrating how to apply *sySTEMatic* steps to solve ill-defined problems using the same skill sets taught in the engineering disciplines. The foundational skills are a re-conceptualization of current notions about constructivism in that assessment and evaluation of the efficacy of a particular curriculum needs to focus on evaluating selected artifacts that students build (i.e., construct) to demonstrate their understanding of what is being taught.

Fig. 1 sySTEMatic Wordle diagram, environmental scan

Problem Statement

In its 2012 report, the President's Council of Advisors on Science and Technology (PCAST) noted that "one million more" STEM graduates are needed in the next ten years for the United States to remain a global leader in science and engineering. We believe that this number may well be unattainable, but to come close to meeting this demand it is crucial to increase the creativity and critical thinking skills of ALL future members of the workforce, regardless of career choice. While serious discussions about this phenomenon are finding their way into several emerging initiatives (i.e., *twenty-first Century Skills*, *Quantitative Literacy*, *Computational Thinking*, and *Career and Technical Education*, among others), we sense that few of these new instructional developments are finding their way into classes being taught to students in other disciplines.

We believe a serious flaw in many current STEM education initiatives is that they often tend to emphasize enhancing the content in the four major STEM areas and view them as independent academic subjects. Many of the STEM initiatives that we have investigated describe attempts to employ, develop, or reinvent the teaching methods and course delivery systems found within each discipline. A less explored approach is to employ the applied, "best practice" models that emanate out of engineering. In those courses, students are taught how to "engineer" (i.e., create) artifacts and products that represent possible solutions to the problems that are being posed.

This teaching framework borrows from the maker movement found in museum/informal learning environments (also referred to as *Maker Culture*). The Maker Culture represents a technology-based extension of so-called "do-it-yourself" (http://diycultures.org/) movement. Typical activities include electronics, robotics, 3-D printing, the use of automated machine tools, and other technology education disciplines such as metalworking, woodworking, or even traditional arts and craft in which new and unique applications of technologies encourage invention and prototyping.

Maker culture stresses new and unique applications of technologies, and encourages invention and prototyping. It is, in our view, a repurposing of the ideas found in constructivist approaches to learning positioned in social environments in that it emphasizes informal, networked, peer-led, and shared learning. Maker culture provides the motivational aspect often missing in traditional STEM curricula that sometimes serves to disengage students from STEM subjects taught in formal educational settings. Such an instructional model facilitates the shaping of our "engineer/student" concept. Engineer/students utilize structured applied research methodologies (supported by scientific approaches) supported by formulaic representations of physical realities and truths (mathematics) and technology, and give rise to what we believe is the true spirit of STEM education and an approach that also can be extended to many non-STEM classroom situations.

According to Webster, the word *engineer* derives from the Latin verb meaning to *design or devise*. A successful engineer is one who can apply rules or laws of nature or science to design a solution. It is important to note that the proposed solution is *engineering-based* but not specifically *engineering-oriented*. What we mean is that we utilize universal concepts that are commonly taught to future engineers, but not be limited to a single discipline. In the end, our "engineer-think" concept becomes a framework for creating an engineer/learner without necessarily fostering one specific academic discipline.

Engineering disciplines also teach students how to apply theory into practice, providing a significant opportunity to develop potential interest on the part of those who may not have previously considered entering a STEM-based career. The United States appears to have a significantly large untapped resource in its current and future student population that could be attracted to these disciplines if the correct approach to teaching them was adopted (Presidents Council of Advisory on Science & Technology, 2012).

Exemplary Curriculum

We are designing a curriculum that incorporates engineering concepts, exemplars, and activities into classrooms by adopting and connecting them to topics that are already being taught. As will be shown below, we view science, math, and technology as applied learning tools that challenge/allow students to look at complex, ill-defined problems through the eyes of an engineer. We believe there is carryover into other related academic disciplines because we are not teaching engineering theory but, rather, we are utilizing the discipline as a context to teach the universal concepts of diagnosis, application, and implementation of practical outcomes.

A review of STEM curricula, whether they be science (biology, chemistry, physics, etc.), technology (information technology, educational technology), engineering (chemical, computer, electrical, environmental, mechanical, etc.), or mathematics (any branch), has demonstrated that they are generally taught individually, without much interaction among them (Fig. 2):

We advocate an integrated approach to STEM that is very rarely seen in current teaching practices (Bybee, 2012). Figure 3 shows how the materials and knowledge from all four disciplines are incorporated into a single course or series of courses in which each activity spans the spectrum of all STEM domains. Science and engineering disciplines draw support from math and technology, while simultaneously developing their respective content at higher levels. In this view, science disciplines rely on inquiry and discovery, while engineering activities apply to scientific concepts to the construction of artifacts. To illustrate this approach, we present an example of a familiar notion utilizing the quadratic formula as its basis:

$$\mathrm{f}\left(x\right) = a_{*}x^{2} + b_{*}x + c$$

$f(x) = 0$, where x is an independent variable and coefficients a, b and c are real numbers

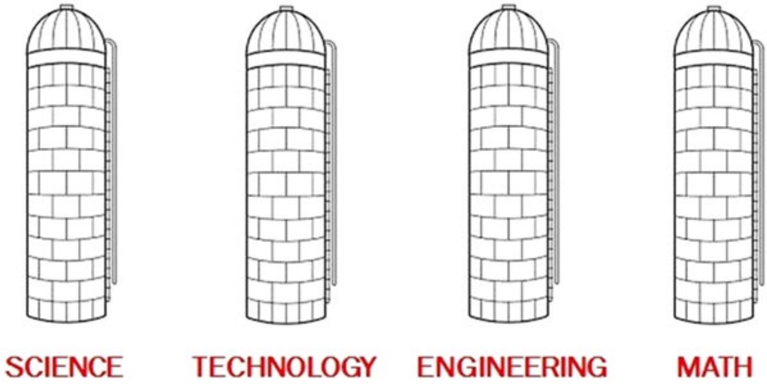

Fig. 2 Silo approach to STEM (McGeown, 2013)

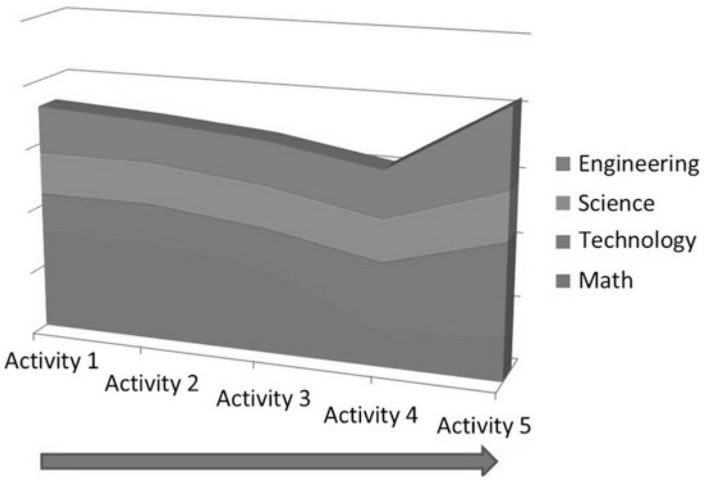

Fig. 3 Integrated approach to STEM

This is an elementary calculus concept that carries significant value in the teaching of abstract thinking and developing analytical skills. Once mastered at the math level, it can be applied further in engineering to solve a quadratic equation of the form:

$$a_* x^2 + b_* x + c = 0$$

Using this equation it is possible to describe multiple concepts relating to physics in various ways and forms: For example, the distance $s(t)$ passed in time, t, by an object with initial constant speed, *v0*, and constant acceleration, *a*, starting from point *s0*, which is expressed by a quadratic formula with respect to *t*:

$$s(t) = s_0 + v_{0*}t + (a/2)_* t^2$$

Selected STEM concepts can be applied using this formula and corresponding equations across the entire spectrum of disciplines, allowing teachers to teach (and students to learn) in an integrated fashion. For example, we could utilize this same formula to develop programming skills in software engineering through which students can present a practical implementation of any one of many potential solutions. It also could be applied to solve several minor practical engineering problems using technology. For example, students can easily demonstrate solutions in physical terms using software that regulates a tiny microcontroller (such as Arduino or Raspberry Pi), enabling them to witness/apply their solutions in authentic situations.

Guiding/Overarching Principles

We envision a scenario in which we place each teaching unit into a larger context in which we introduce academic standards that based on other successful programs, such as *Engineering the Future* (National Research Council, 2009). A prominent feature in this curriculum emphasizes story invention. The key to making this work is the proper contextualization of the proposed set of issues and problems to make them real and endogenous, just as video game producers do when they design their fantasy lines for the narrative games they build. Instead of the player/learner watching vicariously, the idea is to "gamify" the modules in such a way as to fully engage and embed him or her into the storyline (Kapp, 2012):

> The unit begins with an engaging story in which the protagonist confronts a problem. He or she solves it with the help of a set of helpers/cheats (borrowing from game design concepts) that introduces the learner to the engineering design process. The subsequent lessons help the student learn more about how an engineer might think about the problem at hand and culminate in the student engaging in the same engineering design challenge as the story's protagonist.

Care must be taken to ensure lesson contexts are relevant to all students, regardless of (lack of) career choice and also should be relevant to both elementary and high school students. To do this, the foundation for our curricular framework is based on the following overarching principles, as explained below:

- Creativity and problem solving.
- Brainstorming.
- Sustained perseverance.
- Embracing randomness/change.
- Candor in assessment/evaluation.

Creativity: Important to the implementation of this curriculum is to instill a sense of creativity and wonder in the students. It is important to note that the word *imagination* does not appear in the government's list of "*Goals 2000*," nor does it turn up on lists of behavioral objectives or educational outcomes. A review of college and K-12 curricula reveals very little pedagogy aimed at teaching about imagination. On the other hand, when asked, most business owners and managers will respond that one of the most important skill sets needed in employees is creative/critical thinking. So important is creativity to their corporate goals, many businesses have devised ways to assess these skills in the employee candidate interview process. Companies such as Microsoft, Apple Computers, and Google, among others. hold competitions to find the brightest individuals. The scenes in the movie *The Internship*, for example, were not entirely contrived.

A catalyst for the STEM initiative, as stated in the federal science, technology, engineering, and mathematics (STEM) 5-year strategic plan (The Whitehouse, 2013), is to emulate a climate of critical/creative thinking in schools. In our view, the debate revolves around whether creativity is something one is born with or is it a learned function. In our attempts to garner a consensus on that topic, we have found that opinions were both diverse and emphatic. The answer depends on what one believes is meant by the term. Often the concept of creativity has different meanings based on its context. We suggest that creativity and associated brainstorming used to bring out potential solutions to problems be expressed in a very broad sense: creating = "bring into existence." When considered in this light, the term can apply to ideas, scientific experiments, math solutions, and/or engineering problems, as well as art, music, dance, etc.

In another context, creativity refers to an ability to generate new ideas/concepts by forming new connections between existing ones that were not recognized or previously thought to be unrelated. With this refined definition, we support the notion that creativity can be developed/learned with appropriate training. What we have noticed is that in schools the actual learned behavior as students pass from grade to grade is non-creativity. For example, one study conducted by NASA, in which the same tests were administered to select creative scientists and engineers, revealed that almost all kindergartners scored at the genius level while only a small portion of adults were able to reach this level (Cannon, 2001). In other words, children are naturally able to use their imaginations to generate many different and unique ideas, while many adults have learned it is safer to stay within accepted norms, especially in business situations. Yet when they are provided with a psychologically safe environment, a few techniques, and a warm-up period to shift thinking gears, adults have been shown to significantly increase the sheer number of ideas and originality of ideas for a given problem or challenge. The appropriate teaching style is to empower students to achieve a few small wins to build confidence and self-efficacy, leading to greater willingness on their part to reach for more creative accomplishments.

Brainstorming: Most STEM initiatives are (rightly) based on a foundation of Problem-based Learning (PBL) (Markham, 2011). The first great debate centers on

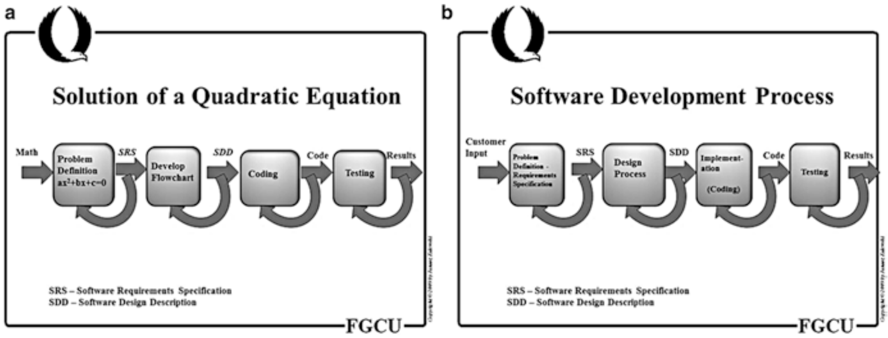

Fig. 4 (**a**, **b**) PBL information flow chart— (Used with permission)

the fact that, for an engineer, the most difficult part of the process may well be properly defining the problem (formulating the hypothesis). As shown in Fig. 4a, b, for example, the information flow is informed by the mathematical function (continuing with our quadratic equation example), which in turn helps to design the solution. This translates into a specification process that is designed coded, implemented, and tested. For trained engineers (in our example software design engineers), finding a solution is a systematic process. In short, a properly formulated/worded specification document can either make or break an experimental design.

The second great debate surrounds the formation of one's definition of what brainstorming consists of (i.e., creating fail-safe environments to resolve problems as a group). As demonstrated previously, the definition of creativity varies greatly among individual disciplines. It follows that the methods one employs to become creative or think critically also vary greatly. *Creativity*, *Inc*.: *Overcoming the Unseen Forces That Stand in the Way of True Inspiration* by Ed Catmull, co-founder of Pixar (2014) describes weekly/monthly *brain trust* meetings in which producers, writers, directors, etc., gather to do critical reviews of productions in progress. In these brainstorming sessions, no actual solutions are suggested—only problems and issues are posed. Doing otherwise, it was thought, would actually stifle creativity. It was up to the production staff to figure that out.

On the other hand, this kind of brainstorming is often considered to be anathema to a scientist/engineer. Their idea of the idea conceptualization process is more closely related to feedback control (Fig. 5):

Figure 5 visually describes the concept of a feedback loop that controls the dynamic behavior of a "system." In this case, brainstorming comes into play when it involves the learner/knower receiving feedback so he or she adapts the variables in order to find a more correct solution. This process can actually be mapped out using mathematical equations. (Recall our ideas about quadratic equations as noted previously). Because we relate this kind of feedback to educational purposes, our conceptualization of the concept of "brainstorming" is in line with the

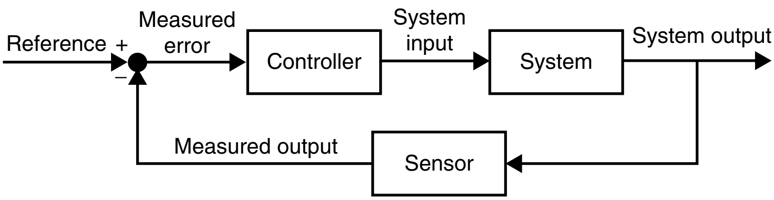

Fig. 5 Feedback control

sociological/psychological aspect of Perceptual Control Theory (PCT) even though it differs in several important respects from engineering control theory (Powers, 1973).

In PCT theory, organisms (i.e., students) control neither their own behavior, nor the external environmental variables surrounding them, but rather their own perceptions of those variables. Actions are not "controlled," but varied. According to the standard catch phrase of the field, "behavior is the control of perception." This fundamentally contradicts the classical notion of linear causation of behavior by stimuli in which environmental stimuli are thought to cause behavioral responses, mediated (according to Cognitive Psychology) by intervening cognitive processes.

Sustained Perseverance: The two versions of brainstorming and creativity as described above really do not have to be an "either/or" proposition. Catmull (2014, p. 113) describes the process of developing a story as one of discovery. He likens the process to being "iterative trial and error in which experiments are fact-finding missions that, over time, inch scientists toward greater understanding." Any outcome is a good outcome because it yields new information. He implies that problem solving is based on removing the pallor of failure, so that the experimenter learns to reframe the question. In short, there is the need to "be wrong as fast as possible." While there is value in slow planning, there is the risk that even that will not always yield appropriate (i.e., error free) results.

The idea about finding out which assumptions do not work should not be confused with impatience. Often, as demonstrated the study of our most famous inventors, new inventions are simply the result of running out of things that did not work. Edison was famously quoted as saying, "I have not failed. I've just found 10,000 ways that won't work."

Another concept that is important and relevant to this principle is the concept of *Ockham's Razor*, named after William Ockham, a seventeenth-century scientist who theorized that, in situations where there are competing explanations for why something occurs the way it does, one should pick the one that relies on the fewest assumptions and is the simplest. While one should never discount randomness in any experiment, it is always smart to control for it (which speaks directly to using the quadratic function/equation for non-linear-types of problems… the multiple linear part accounts for random behaviors/outcomes).

It is said that a similar point of view guided George Washington Carver while he was investigating crop rotation in the south. At the time there was a specific need to find an alternative to the tobacco plant, which was going through a period of deterioration. Carver hypothesized that the peanut would provide an appropriate change to regenerate the soil. But it wasn't until he investigated the peanut down to its most basic elements that he discovered/identified over 400 uses for the peanut (McKissack & McKissack, 2002).

Breaking things down into their most basic form played a similar role in helping computer scientists with their work in figuring out file compression algorithms. In information theory, entropy is a measure of the uncertainty of a random variable. In the context of file compression, the term usually quantifies the expected value of the information contained in a message. Entropy provides an absolute limit on the best possible opportunity to compress an element of communication/data with it losing its core value/identification (Arndt, 2004). To support the development of sustained perseverance, we should encourage students to pare a problem down to its most basic elements, and account for randomness in some systematic fashion.

Embracing Randomness/Change: In science, experimentation and problem solving focus on the ability to systematically remove randomness. For an engineer (or an artist), being creative often demands that one embraces change and considers the fact that sometimes randomness can't always be controlled for. In this case, the idea of protecting oneself from resisting change and/or randomness does not equate to preserving the status quo but to actually learn from the patterns that evolve. A person's penchant for absolutism can often lead to misconceptions and bad assumptions. Engineering disciplines teach students to look at change (deltas) as a fact of nature and learn to take it into consideration when designing solutions to problems. It is this view of change/randomness differentiates the engineer (who operates in authentic settings) from the pure scientist who most often works in isolation and in a laboratory setting.

Candor in Assessment/Evaluation: There are several invariant underlying principles that inform the concept of assessing one's work, whether it is the educational design research that looks at the curriculum or even the self-assessments made on the part of the teacher and/or student in each lesson. Those are a part of the final investigation or self-reflection:

(a) *Consolidate what has been learned*—summarize in reflective form ah-ha! moments in terms of what was known, what misconceptions were clarified and what was not known before.
(b) *Teach or explain to others who were not present*—It has been said one significant way to learn something is to teach it to others. Being able to make this explanation to others in a concise way provides opportunity for students to demonstrate what they now know.
(c) *Pay it forward*—What was learned that can be incorporated in the next experiment/activity? Keller (1987) often refers to that in his Motivational Model as relevance… what did we learn prior that will help inform the current opportunity?

Gradual Introduction of STEM Thinking

In teaching STEM concepts, it is essential to introduce to students the related material gradually, step-by-step (i.e., scaffolding), since some may not have the required background or ability to grasp all intricacies of the concept at once. This approach relies on teaching teachers/instructors facilitation techniques so that their students can develop minimal skills and understanding at first, then move gradually to the next, more sophisticated steps of acquiring/internalizing that knowledge. This is accomplished by offering three basic enforcement vehicles: *demos*, *exercises*, and *assignments* that loosely correspond to a Bloom-like hierarchy to ensure that the learning process and associated knowledge correspond to each student's respective experience level (see also http://www.myreaders.info/html/assignments.html).

At the higher levels, students learn how to conduct *experiments* and develop full-scale *projects*, which result in extensive reports documenting knowledge acquisition and a reflective learning process: In short, the respective, hierarchical five-step process of teaching a concept *sySTEMically* using engineering teaching principles (Wanaka & Oreovicz, n.d.) can be described as follows:

1. *Demonstration*—This activity shows the student the application of a concept, for example, by demonstrating an operation of a device without a manual intervention of a student. A specific example would be to use a telescope to show a certain object on the sky
2. *Exercise*—This activity allows a student not only to witness how a certain concept works in practice, but also how to run a device demonstrating this concept, perhaps by changing the device parameters. A specific example would be to let a student programmatically set the parameters of a telescope to move automatically through a predefined segment of a sky.
3. *Assignment*—This activity relies on developing the concept. In the computer science or software engineering context, it would be developing a program to run the telescope, focusing on the program development cycle, including writing (or editing) the code, compiling, executing, and debugging it.
4. *Experiment*—This activity relies on enforcing the essential concept of scientific inquiry, which in the context of computer science or software engineering would be testing the software developed for a telescope, including test plans, conducting actual testing experiments, and showing the results of actual tests.
5. *Project*—This activity is typical of a full-fledged engineering process that is developing software in four stages, with formal (a) requirements, (b) design, (c) implementation, and (d) testing. This is the most sophisticated activity, which is normally done in a capstone course in computer science or software engineering.

It is up to the instructor/teacher to determine actual ending points (i.e., critical tasks) or which specific activities from the hierarchical list above would be actually pursued. All activities are listed in an order that matches the application of this concept into a hypothetical computer science or software engineering curriculum and is only meant to be an illustration. Courses in other disciplines can adapt the hierarchy to suit their needs.

Although we initially focus on engineering supported by the science, math, and technology domains, we believe there is carryover into all academic disciplines, including the arts. This is because in our approach we are not teaching engineering theory; rather, we are utilizing that discipline as a context to teach universal concepts of diagnosis, application, design, and implementation of practical outcomes that closely parallel those found in the ADDIE Instructional Systems Design (ISD) model developed at Florida State University (Morrison, 2010).

We recognize that it may be unrealistic to assume that every child wants to become a mathematician or scientist. Nor does every child necessarily have an aptitude for it. We do suggest, however, that there exists the need to teach all children how to think logically and critically in order to apply rules theory to solve problems regardless of his or her academic level. We also suggest that our framework provides opportunities for all students to apply the appropriate tools to begin to see problems in discreet ways that they can carry with them throughout their lifetimes.

In summary, our "engineer-think" approach differs from other programs in several ways:

- It does not simply focus on integrating problem-based learning methodologies into individual STEM disciplines.
- It focuses on improving metacognitive learning skills in ALL students, regardless of their career goals or skill levels.
- We implement "design thinking" best practices that emanate from the engineering disciplines.
- We build in a real-world framework that can be applied to a broad range of academic disciplines beyond science and engineering. For example, the principles of "design thinking" mirror the practical problem-solving processes appropriate to architects, artists, and even musicians.

Teacher Efficacy

Teacher efficacy (or teacher confidence in their ability to promote learning) plays an important role in creating and obtaining successful instructional outcomes. Increasing teachers' self-perceptions as to their ability to teach the concept of systematic thinking is important to a successful implementation of any curriculum. Content knowledge supplemented by an understanding of a signature pedagogy plays a large part in a teacher's feelings towards their own self-efficacy (Caprara, Barbaranelli, Steca, & Malone, 2006; Riggs & Enochs, 1990). Since we are creating turnkey solutions for teachers who may not yet understand engineering processes, it is anticipated that their self-efficacy will increase significantly, which should translate into more successful, scalable, and sustainable student outcomes.

If a paradigm shift of this significance is to be successfully implemented, there needs to be a major effort into design to develop robust, appropriate in-service and preservice professional development courses for teachers to learn how to integrate our strategies of systematic thinking that parallel those processes taught to engineering students.

Perhaps there needs to be more emphasis in empowering teachers using other approaches such as focusing on Hope Theory. In The Oxford Handbook of Positive Psychology (2013), "Hope is defined as the perceived ability to produce pathways to achieve desired goals and to motivate one to use those pathways" (p. 323) Hope theory suggests that in order to obtain one's personal goals, individuals must view themselves as being capable of producing workable ways to accomplish those goals. This process is referred to as pathways thinking (Rand & Cheavens, 2009). defined hope as "a positive motivational state that is based on an interactively derived sense of successful (a) agency (goal-directed energy) and (b) pathways (planning to meet goals)" (p. 8).

Educational research has found that teachers with a strong sense of teaching efficacy are more persistent and resilient even when strategies do not go smoothly and they are more willing to find other instructional strategies to teach their students (Tschannen-Moran & Hoy, 2001). These teachers are more open to change and tend to display higher planning, scheduling, and organization skills. As we know, a teacher needs to be a facilitator of learning in order to encourage/support students in finding solutions. We suggest that they find them together and this can be achieved when teachers have increased teaching efficacy. Teachers are then more open to new ideas and are more willing to experiment with new methods to better meet the needs of their students. Hence, our purpose is to provide robust training with research-based science methods to teach teachers to stimulate and engage creative thinking in their students.

Design Challenges

The basis for the motivational aspect of our curricular framework is to put in place a competitive aspect in the classroom that is similar in nature to science fairs or informal learning challenges sponsored by local museums. We agree with the National Center for Engineering and Technology Education (NCETE) that "…engineering design experiences should be an important component of the high school education of all American youth" (Householder & Hailey, 2012, p. 2). In most instances, these activities can be integrated into instruction and in standards-based courses in science, technology, or mathematics. The basis of design challenges is to introduce ill-structured problems that may be approached using strategies and approaches common to engineering practices. To apply a proper context and relevancy, the types of problems typically involve the human experience and affect some aspect of the quality of human life. These activities are perfect for our curriculum because they are culminating tasks that mirror our "engineer-think" course curriculum that requires students to develop solutions to problems and involves processes similar to those used in the professional practice of engineering. In addition, they tend to integrate knowledge and practice from mathematics, science, and technology. Solutions typically require the creation or modification of artifacts or procedures used by humans in dealing with the physical environment. Students are asked to confront an unresolved problem in the human-made environment.

Because design challenges have multiple possible solutions of varying applicability under differing sets of constraints, the curriculum and associated professional development needs to provide educators with the avenues to contextualize these challenges within their own teaching pedagogy.

Theoretical Underpinnings

While there is significant anecdotal evidence in support of our curricular conceptual framework, there is no consensus among STEM researchers that sufficient empirical evidence has been presented to date that the engineering habits and thought processes proposed in this paper lead to significant, generalizable improvements in problem-solving abilities, systems thinking, increased interest in engineering, and feelings of self-efficacy about pursuing STEM careers (Opportunity Education, 2013). We have attempted to draw as many inferences as possible that we believe correctly reflect the current body of knowledge regarding promising contemporary practices. It is our belief that a more effective research approach would investigate the assessment and efficacy of our approach using action research—more specifically, educational design research (McKinney & Reeves, 2012). We believe that action research is more appropriate in these circumstances because it is more useful to planning, organizing, and implementing the infusion of these principles to specific circumstances. As such, this paper is not intended as a detailed guide for curriculum development or comprehensive instructional design, or even the final assessment of achievement across the range of STEM courses. By design, this form of educational research is intended to provide guidance to the decisions of the implementation of those specifics as the curriculum is implemented.

One of the more subjective assessments that can be made regarding this curriculum is to figure out a way to evaluate creativity. This challenge is a perfect example of the value of using educational design research for this project. For example, if creativity involves deciding on how to define previously ill-defined problems, how do we in fact know that our creative responses to designing curricula are correct? Few would argue that the success of any significant change in curricula requires appropriate formative and summative assessment plans. We suggest that the novel curriculum approaches require equally novel research methodologies to evaluate outcomes. Educational design research is a scientific inquiry that aims at generating new understandings of important issues while solving identified problems simultaneously with the actual implementation as the newly designed products in the real world. Educational design research is different from other forms of scientific inquiry in its commitment to developing together with all stakeholder's theoretical insights and practical solutions simultaneously, and in the real world (as opposed to laboratory) contexts. This is a very specific form of Action Research. According to McKenney and Reeves (2012), educational design research enjoys the following characteristics:

- Theoretically oriented: The research is informed by existing theories in framing the problems to solve while it contributes to theoretical understanding of issues under investigation.
- Interventionist: The research goals are not limited to theoretical understanding of the issues under investigation, but aim to make a real change in the ground.
- Collaborative: The research is conducted in collaboration with scholars and practitioners.
- Responsively grounded: The research is "structured to explore, rather than mute, the complex realities of teaching and learning contexts and respond[s] accordingly (p. 15)."
- Iterative: The research evolves over time through multiple iterations of investigation, development, testing, and refinement. As we said, the initial findings will inform us as we move forward.

Ties to Rapid Prototyping

Consistent with the concept of rapid prototyping utilized in electrical, computer, and software engineering design, we use a parallel research methodology to simultaneously develop and test our suppositions. A Rapid Prototyping Model (RPM) for educational use first appeared in the literature in the late 1980s and early 1990s (Tripp & Bichelmeyer, 1990). The original model was based on a popular design model with the same name that was especially popularized by software and engineering development companies who wished to speed up delivery of their products to market. The term "rapid" associates with the fact that a product is knowingly provided to and used by the client in "prototype" form (commonly known as an "alpha test"), prior to it being completely finished. The authors insisted that speed did not necessarily equate to a sacrifice in quality. Contrary to some earlier criticisms, the authors of the RPM method championed the use of prototypes to gain a clear understanding of, and attention to preproduction analysis. They present an iteration model in which alpha testers participate earlier in the standard preproduction steps common to many instructional design models. Figure 6 depicts the iterative cycle, as described by Tripp and Bichelmeyer.

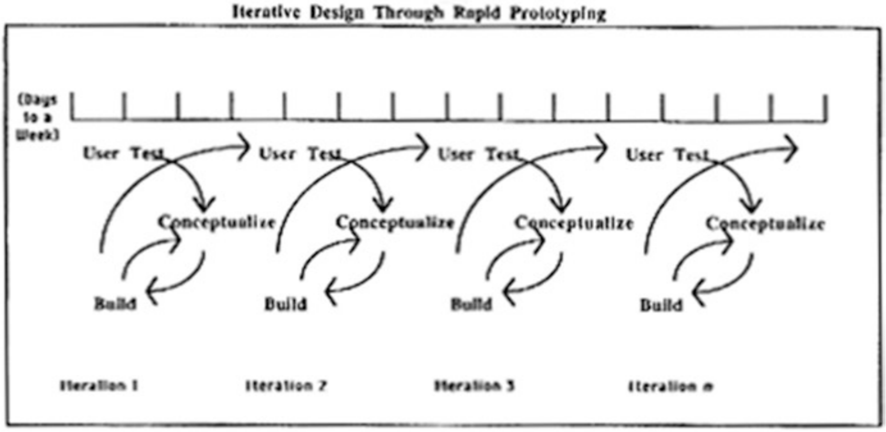

Fig. 6 International design of RPM

Research Questions

The specific research questions that need to accompany the implementation of this curriculum are as follows:

- Does the development of engineering habits of thought and action as described in this curriculum design lead to improvements in any or all of the following?
  (a) Problem-solving abilities.
  (b) Systems thinking.
  (c) Integration of content.
  (d) Increased interest in engineering.
  (e) Feelings of self-efficacy about pursuing additional engineering activities.
  (f) Does it develop an empowerment for teachers to continue the practices in their own classroom?
- What is the anatomy of the engineering design process and what are its essential components?
- What instructional practices based upon engineering design challenges can be effective in supporting student learning?
- In what ways can teachers design and implement an authentic system for assessing student progress as well as their success in completing engineering design challenges?
- How can the assessment provide support for using engineering principles to solve design challenges in contrast to simple trial and error approaches?

Summary

We suggest the framework we envision is based strongly on research (Williams, n.d.), and one that can be applied in a number of different subject-specific disciplines and instructional circumstances. The core content strongly supports the notion of life-long learning in which students are encouraged to think critically and creatively regardless of the academic subject area. This, we believe is the real aim of STEM initiatives and the only way that we will realize ambitious goals set forth. The nation needs critical thinkers in all markets, disciplines, and vocational areas. We also believe, taken in the context of a teaching and learning framework, that the value added proposition is that this *sySTEMatic* framework can have a revolutionizing impact on more students becoming motivated to study the sciences, technology, engineering, and math in which these disciplines are correctly looked upon as "tools of the trade" utilized to solve relevant real-world problems.

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Critiquing the Role of the Learner and Context in Aesthetic Learning Experiences

Colin M. Gray

Abstract I critique the role of learners and context to more fully explore the latent conceptions and performance of aesthetic learning experiences in instructional design and technology. This critique is intended to allow for a fuller interrogation of how individual learners apprehend designed learning experiences, heightening the role of the instructional designer in envisioning such experiences. Using a 1-year ethnography of a graduate human–computer interaction program to document the felt student experience, I highlight the importance of understanding how learners construct their own experiences during the learning process through the roles they take on and the informal pedagogical experiences they create. I identify additional areas of research that are needed to expand our notions of designing for experience, informing both theory construction and practice.

Introduction

Instructional design and technology (IDT) is still coming to terms with how to approach the concept of aesthetics in learning, most frequently observed in an active or performative sense as an *aesthetic learning experience*. While many of the core concepts relating to learner experience go back to Dewey (1938/2005), only in the past decade (e.g., Miller, 2011; Parrish, 2005, 2008, 2009) has IDT begun to engage in this discussion in a meaningful way. As we view the machinery of a traditional learning intervention through the language of experience, this shift foregrounds issues such as: the paradigmatic relationship between learning objectives and temporal moments in an experience; how the instructional designer (ID) captures the often ineffable moments of an experience in a formal design process; and perhaps most importantly for this discussion, how to shift the focus to the learner in this conceptual space—a learner who lives inside, around, and through a designed experience.

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Defining Aesthetic Experience

In situating this discussion, it is important to understand how aesthetic experience has been historically defined, and what implications these definitions have on our creation of aesthetic *learning* experiences. Parrish (2005) defines "an aesthetic experience [as] one that is particularly heightened and especially meaningful," while McCarthy and Wright (2004) note the phenomenological qualities that aesthetic experience often foregrounds: "life as lived, not just as theorized" (p. 49). Shusterman (2000) expands on this, noting that an aesthetic experience is heightened in an important way, a "more consummate and zestful integration of all the elements of ordinary experience" (p. 15).

While other fields such as human–computer interaction (HCI) have capitalized on the notion of experience as a way of framing the design of interactive affordance as well as the actual interactions of users (e.g., Löwgren, 2006; McCarthy & Wright, 2004), IDT is still at a more formative stage, with attempts being made to locate how notions of experience relate to elements of the traditional instructional paradigm. For example, according to Parrish (2009), the primary qualities of an aesthetic learning experience should include: a plot-like character, where there is a felt beginning, middle, and end; learners are the protagonists of their own experience; the activity of learning is central, rather than the subject matter; and the context is somehow meaningfully used to create immersion on the part of the learner. While there are several ways of accomplishing these goals in a practical sense (McCarthy & Wright, 2004; Parrish, 2009, 2014), this is still an active area of investigation in the research community. Meanwhile, in IDT there has been little focus on the development of generative tools and methods that might support designers in the creation of such experiences, or guidance on how to teach future instructional designers to craft experiences in this way (Boling & Gray, this book).

When we apply this understanding of aesthetic experience to learning, we can assume that most curricula are felt as an experience (aesthetic or not) by the learner, even though many learning materials are designed in a less holistic, more modular way (e.g., Wiley, 2002). In the IDT tradition, many learning interventions are defined more by their proscribed learning outcomes than by the kinds of feelings and emotions the designer wishes the learner to feel while experiencing the learning. But the designed intervention is not the "thing" that is experienced by the learner—the learner's experience of or response to the designed intervention cannot be deterministically defined beforehand (Boling, Eccarius, Smith, & Frick, 2004; Boling, Gray, Modell, Altuwaijri, & Jung, 2014; Jin & Boling, 2010), and is temporally and contextually situated in a social milieu (Lave & Wenger, 1991), interpretively constructed, and bound to the individual learner's lived experience (Parrish, 2014; see also Bardzell, 2011 in interaction design).

We are left with a "wicked" problem: We can design an experience, but we cannot guarantee that learners will experience it in the way that we assume the experience to exist or as we define or specify it. Learners bring with them an active and unknowable lived experience through which they interpret the designed experience (Kress, 2004, 2010; McCarthy & Wright, 2004), and the learner is shaped by complex interactions between the designed experience and other external forces that may or may not be known or able to be isolated by the designer. But yet, we want the learner to have an experience that is heightened (i.e., aesthetic) and meaningful, which results in some tangible learning gains. While we have traditionally dealt with these sorts of issues through lenses such as cognitive load theory, a purely cognitivist perspective does not allow the designer of learning experiences to demarcate which elements might universally cause extraneous load, or which load might actually cause learner engagement, regardless of its perceived extraneousness to a non-situated instructional designer. To address this design paradox further, I will address the evolving IDT understanding of the learning situation, along with components of that situation that are deeply affected by this shift in focus, including the context of learning, and the ontological and phenomenological status of the learner.

Issues in Confronting Experience

For decades, IDT has tended to treat the learner as a faceless blob in the enactment of a seemingly singular "ID Process"; the learner as a disembodied ratiocinator (Bannon & Bødker, 1991) that is recognized primarily for how it thinks, often with little accounting for the distinct agency, identity, and lived experience of the *individual* learner. While constructivist approaches to learning have combatted this stereotype to some degree, positioning the learner closer to the center of the learning experience, guidance on how to design for learners that have a unique lived experience and forge their own path in constructing knowledge is still nascent (Ertmer & Simons, 2006; Tobias & Duffy, 2009). In accounting for these learners in the design process, the tools we currently have to represent these unique learners bear more resemblance to the learner as ratiocinator, with a learner profile that results from formal learner analysis often taking on the characteristics of a marketing profile and with the implementer of the design often forced to fit a learning intervention onto a diverse group of learners which were not envisioned or adequately designed for by the original designer.

If, as IDs, we recognize and heighten the unique identity and agency of the individual learner in our design process, this shifts our understanding of how an aesthetic learning experience is brokered between the designer, designed experience, and learner. Learners actively engage with learning experiences, interacting in ways that are unique to them (Parrish, 2009); and this engagement results in an outcome that cannot be deterministically projected onto the learner by the designer. This reveals weaknesses in the traditional IDT understanding of the design process in two substantial ways, neither of which are adequately explored in existing ID theory and methods: our tendency to make context generic or underspecified, and our perception of the learner as a normalized "ideal type."

Genericization of Context

A genericization of the learning context assumes uniform or otherwise predictable roles for teachers/instructors/trainers and learners, often still implicitly relying on the transmitter–receiver model from message design (Bishop, 2014; Fleming & Levie, 1993). This genericization can have a number of practical implications for learners, including a lack of attention to the context within which they experience the design, such as its physical and material qualities, lack of relevance to the learner's lived experience or future practice, or a felt mismatch between the designed learning and the constraints of the actual learning situation.

In the 1990s, Tessmer led a discussion in IDT regarding the role of context in learning and the affordances of the learning environment (e.g., Tessmer, 1990; Tessmer & Richey, 1997), but this has not had a profound effect on the theories that undergird our field. In fact, this assumption of generic context is reified in our models and theories (e.g., "approaches to instruction" in Reigeluth & Carr-Chellman, 2009), even as some learning theories drawn from other fields (e.g., problem-based learning, case-based learning, studio education; see Gurung, Chick, & Haynie, 2009 for a fuller exploration of signature pedagogies) have pushed us to move beyond these assumptions in some ways—casting constructivism as a learning paradigm or problem-based learning as an instructional strategy. As a field, we have not relocated these contextualized assumptions as a critique for how the "design process" is commonly viewed.

This lack of critique at the lowest levels of ID theory has resulted in a slow transition to newer instructional methods—both in their design and implementation. When addressing the design process in this experiential mode, it is more difficult to show a rigorous, quasi-deterministic link between learning objective and content, as compared with other models like programmed instruction, which have come into vogue again through deconstructive methods like the 4C/ID model (van Merriënboer & Kirschner, 2007). This lack of attention to the contextual variables of a specific learner interacting with a design in a particular context has oriented our attention in the wrong direction; rather than relying on an understanding of context which does not and cannot represent reality, we must create and enact new theory, tools, and methods for instructional designers to use that more adequately reflect the situational properties of instruction. This should include borrowing from other fields where context has been central for decades or centuries; an understanding of physical and spatial relations from architecture and interior design; a richer sense of embedded affordances present in physical and digital media from human–computer interaction (HCI); knowledge about how individuals relate to graphic elements and holistic branding from graphic design and marketing; temporal and spatial renderings of experience, including journey moments through multiple forms of media and physical spaces from service design.

Normalization of the Learner

Within this genericized context, our perception of the learner as an entity or actor is also affected. Our poor definitions of context often result in a *normalization of the learner*: a collapsing of unique characteristics into a convenient, generalized description that tells us little about the unique challenges of specific learners. The learner profile, as it is currently implemented in much of ID theory and practice, is more similar to a stripped down version of Weber's "ideal type" (1904/1949) than a "round" character as found in literature. This latter assumption of "roundness" is inscribed into tools created for empathetic design (e.g., Cooper, 2004; Young, 2008) and is commonly implemented through the use of personas in marketing and user experience design (Chang, Lim, & Stolterman, 2008).

Current learner analysis in ID practice results in profiles that read more like market segments, including components such as basic demographic characteristics, reading level, and past experience with the instructional content (e.g., Morrison, Ross, Kalman, & Kemp, 2010). These components are not without value, but they are also not sufficient to develop empathy with the learner and develop a rich understanding of how the learner may perceive and interpret the designed experience. Designers are left to make substantive assumptions about the learner—in an often-caricatured form—which frequently shapes the ways instructional materials are designed, as the designer inscribes their ethical standpoint into the designs they create (Nelson & Stolterman, 2012; Verbeek, 2006). In addition, a lack of knowledge about the learner results in a designer ineffectually position-taking and advocating for the learner, and thus unintentionally designing for themselves or another "projected" learner. Parrish (2014) describes this difficulty well:

> …the individual qualities of learners, and how these will contribute to an experience, are always only half-known and not something that can be directly impacted. We can go through the process of learner analysis, but that is often a relatively superficial process, yielding only general characteristics. To understand learners in a way that helps design experiences, one needs empathy. (pp. 264–265)

Assumptions about the identity of the learner affect design outcomes in a deep way, including the way designers think about and employ instructional strategies, how content is sequenced, what existing skills/knowledge the learner might have, and what type of vocabulary is appropriate. As designers, we actively inscribe our understanding of the reality of the user in the designs we create (Bardzell, 2011; Nelson & Stolterman, 2012), so it logically follows that we should seek to understand learners in a deep way, as autonomous actors with goals that transcend the moment of instruction (e.g., Suchman, 1987). As with the discussion of context above, there is a wealth of knowledge from other fields that may be of value as we extend our knowledge of the learner, some of which is already in use in professional ID practice, but has not been explored in substantial depth in the IDT research literature. Additional sources of inspiration and validation of learners can be drawn from contextual inquiry and mental models in Human–Computer Interaction (HCI), data- and narrative-driven persona development in marketing and user experience (UX), and deep study of learners through ethnographies in the sociological tradition.

A Case: Students Learning to Design Experiences

To illustrate how this complex interaction of learners within a designed experience occurs, I will briefly summarize findings from a 1-year ethnography in which I sought to document the student experience of a graduate program in HCI, taught with a design focus. A fuller reporting of this ethnography can be found in Gray (2014). In contemporary approaches to HCI, a significant focus is placed on designing for UX (e.g., Bødker, 2006; Harrison, Tatar, & Sengers, 2007), often coinciding with a focus on design (Fallman, 2003), with many students taking jobs as UX designers once they graduate. So, somewhat ironically, these learners are embedded in a learning experience that is teaching them how to design for experience once they graduate.

I collected data over two academic semesters, with the goal of cataloguing and understanding how students related to the formal pedagogical experience, creating their own informal learning experiences in the studio and other physical and virtual spaces that surrounded the curriculum. Primary data sources included: participant observation in a nonclassroom design studio space and observation of classroom instruction, with contact hours totaling over 450 h; 53 critical interviews; over 3,000 photos; and 276 h of audio recordings that supported the primary field note record.

Students in this cohort-based 2-year residential Master's program came from a wide range of academic disciplines, and almost none had a design background before entering the program. They experienced an intensive curriculum with theory and practice components and a substantial emphasis on team projects. Students quickly learned how to communicate with other students in the process of doing design work, conducting team meetings in the studio, engaging in critique of their fellow students' work, and engaging with the practice community through recruitment events and conferences. Students moved seamlessly between the virtual space students had created on Facebook (Gray & Howard, 2013, 2014) and the physical studio space, and the affordances of each space shaped the kinds of interactions that could take place. The studio space was not used for classroom instruction, and as such, was only nominally under the control of the faculty, created with the intention of supporting collaboration and design activity. Meanwhile, the Facebook groups that supported offline and virtual layering of experience in the physical spaces of the curriculum were entirely student-created and led. Students frequently used the virtual space to organize classroom interactions (e.g., data collection for team projects, shared notes), but just as frequently documented informal social activities on the Facebook groups, bringing those exterior to the studio at any given time into the activities of the space (e.g., whiteboard sketches, jokes/memes).

Students communicated in complex ways that were consistent with their future profession, and they actively sought to shape the curriculum and interact with other students and alumni as they looked toward their future practice of design.

Students Experiencing the Formal Pedagogy

The formal curriculum included a range of courses relating to HCI, including foundational readings, an introductory design experience, design methods, prototyping, design theory, and a rapid design course. Some faculty members created studio or studio-like approaches in their formal classroom environment, with a wide range of experiences, relationships to subject matter being taught, and relation to professional design activity. This may indicate that faculty members envisioned different "ideal types" of learners—with some taking on a more academically focused design role than professionally focused role. For instance, while one introductory design course included primarily lecture and demonstration activities, supplemented by summative student presentations of projects, there was a strong focus on building professional communication and presentation skills (Fig. 1). In another course taken by second-year students, the focus was on building physical prototypes with cardboard, foam, Arduino microcontrollers, and perceptual computing cameras. In this case, there was a diminished focus on presenting final work in exchange for the experience of the studio as a place to engage in design activity, with little lecture or formal instruction (Fig. 2). While the implicit goal of both courses

Fig. 1 A student team presenting their project in an introductory design course

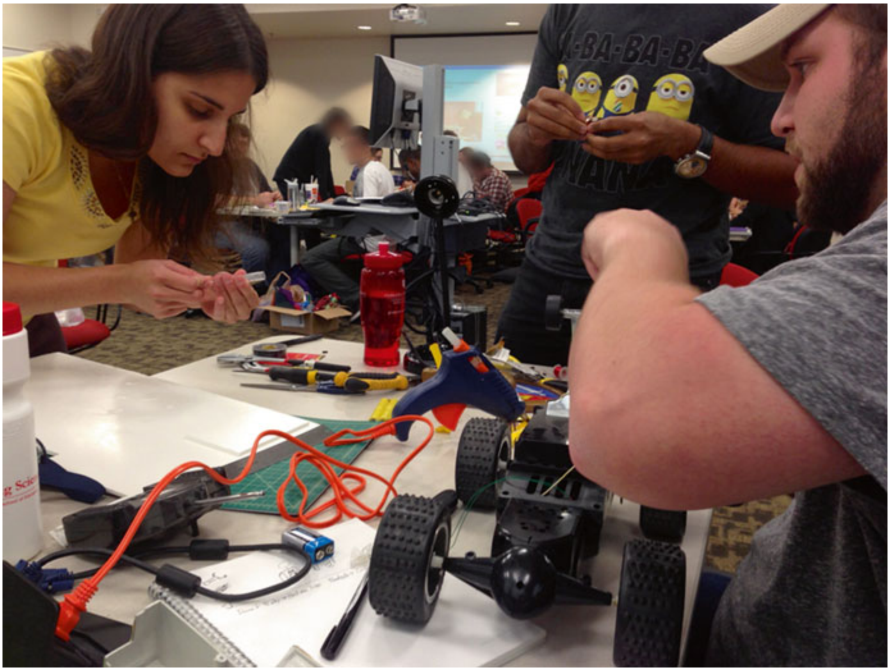

Fig. 2 Students participating in a repair-centric assignment during studio time in class

was presumably the same—to produce capable, professional UX designers—the approach to instructing these future designers, mediated by various instructional strategies and activities, was remarkably different. Both courses assumed that students would engage in design activity, but one faculty member placed designing, making, and building at the center of the educational experience, while the other faculty member foregrounded soft skills of communication, collaboration, and problem framing. In this way, the projected Weber-ian "ideal types" of learners were largely the same, but with dramatically different impacts on the formal educational experience of the learners due to the varied nature of the faculty members' beliefs about design, and how those beliefs informed instructional strategies and content explicitly taught to students.

Students Crafting Their Own Studio Experience

Outside of the classroom, students interacted with each other in relation to their formal educational experiences in the main nonclassroom studio space (Fig. 3). While these interactions were shaped by classroom activities to the extent that design activities were centered around the topics and materials of assignments, the

Fig. 3 Students interacting in the studio, engaging in individual and group work

social and collaborative nature of the space was created and negotiated by the cohorts themselves, with little outside pressure or guidance from the faculty. Students created and sustained certain forms of interactions that were informed more by their experiences in internships and professional design settings, with the guidance of program alumni, a set of interactions that I have termed *proto-professional*—those activities in which students take on the role of professional designer, even as they interact in an academic setting. One of the most dominant examples of this proto-professional behavior was a semi-regular, student-led event colloquially known as "Mad Skillz Club," a collaborative workshop structure where students shared knowledge and critique in relation to their design work. Each semester, students led the formation and scheduling of these meetings, often defining topics for discussion or engagement that mirrored the concepts being taught in the formal curriculum (e.g., critique, usability testing). In Fig. 4, one student is informally sharing and demoing perceptual computing tools such as the LeapMotion, Kinect, and other hardware. This interaction between first- and second-year students was typical, and following the first semester of the program, first-year students began to lead these sessions as well, with the informal mantra (as posted on a whiteboard advertisement) that "everyone has something to teach, and everyone has something to learn."

Faculty played a minor role in nonclassroom studio interactions, with only one or two of the five faculty regularly communicating with students in this context. On most occasions, these interactions between students and faculty were affirming, relating to project work, or more informal social interaction. But on occasion, these interactions revealed dissonance between the student-generated community—generally characterized by students engaging in proto-professional behaviors such as Mad Skillz Club—and the academically oriented formal curriculum. In one particularly dramatic event, two groups of students hung draft versions of posters they were planning to present at a professional conference a month later. The student teams intended these posters to represent a first attempt, so they could get more rounds of *formative* critique from their peers—an attitude that represented a proto-professional

Fig. 4 A second-year student demonstrating the affordances and use of perceptual computing devices to a group of first- and second-year students in the program

desire for formative critique. However, one of the faculty members that regularly interacted in the studio space saw the posters, and assumed that they were intended to be final; after making this assumption, he rendered a *summative* critique, leaving an excoriating note on the whiteboard shaming the students and requesting that they consult graphic design professionals. He left this note alongside the posters, which were already starting to fill with Post-It notes from students in the program (Fig. 5), who had correctly interpreted their presence as a request for formative critique. In this example of dissonance in the studio, we can see how the roles that some of the faculty imagined for students were not necessarily the ones they took on, and in this case, students took on a more rigorous, professionally oriented design perspective than did the faculty member.

Context and Learner Roles

In the brief program experience related above, the formal curriculum was not the only indicator of what kind of experiences the students would have and/or create for themselves, although it did contribute in scaffolding the overall program logistics

Fig. 5 Formative critique on a student team poster left by other students in the design studio

(e.g., coursework, cohorts, and physical spaces) that made student interactions possible. While the genres of activities students created for themselves in a proto-professional role were related to the kinds of design work promoted in the classroom experience, their specific structure and content were largely self-determined by the students, sometimes in reaction to the formal pedagogy rather than in support of it. In this sense, students not only took on the roles expected of them in the classroom—of student and collaborative team member—but also created roles that the formal pedagogy did not dictate, underscoring their collective goal of joining the professional design community.

Similarly, the contexts available to the students and faculty shaped the kinds of experiences and interactions that could take place—but these contexts did not *determine* the nature of the experience. In Figs. 1 and 2, we can see two very different studio experiences, one centered around summative presentation and critique, and the other focused on design activity itself. Each faculty member interpreted the surface features of the classroom studio (Brandt et al., 2013; Shaffer, 2003) in different ways in relation to their learning goals and pedagogical content, crafting a different set of activities with which students could construct their own experiences. As the students moved out into the nonclassroom studio, the surface features again informed the kinds of interactions that could take place, but in this case, it was the socialization of students, their trust for one another, and their shared experiences in the program that allowed them to negotiate appropriate forms of interaction—a socially mediated view that is closer to the demands of professional design practice.

Through this case, I especially want to note the necessary tension between the student-generated experience—both on the part of individual learners, and through the student cohorts at large—and the formal pedagogy. Neither entity was in control of the resulting experience in its totality, but both groups contributed to the pedagogy that was experienced by faculty and students alike. An instructional designer would not be able to fully account for the roles learners would take on in advance, and the flexibility of the spaces used for classroom instruction and the nonclassroom studio may not have indicated the potential range of uses that actually occurred in real time. Thus, the experienced pedagogy that played out in this year of data collection can be seen as situationally and temporally bound: the experiences that resulted were due to student and faculty interactions with the spaces and curriculum that shaped the program, and are not, in their entirety, replicable experiences.

Implications for Research and Practice

There are numerous implications for this heightened view of a learner within a specific learning context, many of which are illuminated by the case of the HCI graduate program above. For researchers in IDT, this indicates a need for substantial, engaged research about the people who will be using or engaging in the learning experiences we design. Our theories and conceptions of design must shift to reflect the realities of how designs are experienced by learners in an active, constructive way, rather than a mere recitation or performance of a design specification.

There have been some limited attempts outside of IDT to address these issues. Critical and dialogic pedagogy seeks to equalize classroom power roles, with some scholars proposing a new set of instructional strategies to minimize power and empower student participation (Freire, 1970/2000; Giroux, 2011; Lefstein & Snell, 2014). From a different perspective, experiential learning foregrounds the importance of students learning through first-hand experiences (Kolb, 1984). Both of these existing lines of inquiry allow us to critique the current state of IDT theory and practice in various ways, but both tend to view formal instruction—regardless of the instructional strategies at play—to be the locus of the learning experience. The case I provided above demonstrates how a more critical view of informal learning in a graduate context can reveal the discursive and dialectic roles and practices that can be taken on by students and faculty alike; an equalizing of power which results in contributions to the learning experience across the informal and formal pedagogy from all participants.

Beyond the insights this perspective might provide to instructional practices, there is also a need for the role of the instructional designer to be heightened—seeing the design process as one that is enacted by a designer as human instrument (Boling, 2008). This includes a more substantive realization of the ethical and normative impact of what is designed in terms of how it provokes emotive, not only cognitive, responses from the learner (Nelson & Stolterman, 2012; Norman, 2004; Parrish, 2014; Verbeek, 2006). A situated view of aesthetic experience—both temporally and spatially—informs us that the designed experience is much bigger than a set of learning objectives and desired outcomes, and in order to adequately design these experiences, designers need more vocabulary, tools, and methods to support their work. HCI as a community has made a substantial effort to create design tools and methods that support this kind of inquiry, but without the explicit learning focus that distinguishes IDT. So while there exists already a multiplicity of tools and methods spanning user and context analysis (e.g., Hanington & Martin, 2012), the IDT community must take up this effort themselves (e.g., Boling & Gray, this book), and not be content to merely use and adapt the tools and theories developed for other less situated purposes.

We must find ways to monitor and evaluate the ways learning experiences are designed and experienced, with the goal of improving our understanding of how to create and mold these experiences over time. As seen in the case I have described, learners are active constructors of their own experience, and do this even when we fail to give them space in the formal curriculum. This active construction process must be recognized both in our research and theorization of instructional design activity, and systemically engaged in ID practice in a way that heightens the role of the learner and learning context in an experiential mode.

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Designing Authentic Educational Experiences Through Virtual Service Learning

Jennifer A. Maddrell

Abstract This chapter explores the theory, research, and design of service learning as a means of offering students real-world authentic learning opportunities. Service learning, an educational approach that combines community service, academic coursework, and work-based experience, has been shown to positively affect academic achievement, as well as personal and social outcomes. Within online education, the term e-service learning is used when the coursework or service is conducted virtually. A recent implementation of an e-service-learning project involving students and faculty from 14 different colleges provides instructional design insight into required practices for client engagement, project management, and student mentorship, including suggestions to overcome constraints associated with facilitating e-service learning in a virtual setting.

Keywords Service learning • e-Service learning • Applied learning • Experiential learning

Designing Authentic Educational Experiences Through Virtual Service Learning

As of the fall 2010, 21 million students were enrolled in US postsecondary degree-granting institutions, an increase of 18 % from the fall of 2006, and enrollment is predicted to increase to 24 million by the fall of 2021 (Hussar & Bailey, 2013). Of those students, an estimated 6.1 million were taking at least one online course, an increase of 74 % from 2006 (Allen & Seaman, 2013). Fostering opportunities for authentic and engaging real-life application of the course content is a central challenge for designers and instructors of higher education courses. Given the time and geographic separation of online students from the instructor and the college or university, the task of offering authentic experiences in online courses is an even greater challenge.

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This paper explores the theory, research, and design of service learning as a means of offering students real-world applied and experiential learning opportunities. A discussion of how student learning is facilitated outside the boundaries of traditional coursework is framed within an examination of the design of a 100 % virtual service-learning project.

Service Learning Defined

While definitions vary with regard to the underlying instructional characteristics and practices, service learning is an educational approach that combines community service, academic coursework, and work-based experience (Bringle & Hatcher, 1996; Furco, 1996; Kenworthy-U'Ren, 1999; Kraft, 1996; Lehman & DuFrene, 2008; Mooney & Edwards, 2001). Within online education, the terms *e-service learning* or *service eLearning* are used when either the instruction or service components are conducted virtually (Dailey-Hebert, Sallee, & DiPadova, 2008; Waldner, Widener, & McGorry, 2012).

A unique aspect of service learning is the focus on the reciprocal benefit derived from the service provided to the recipient, and the learning experience gained by the student service provider (Furco, 1996). In addition, the credit-bearing aspect of the experience contrasts service learning from extracurricular voluntary service (Bringle & Hatcher, 1996, 2009; Mooney & Edwards, 2001).

Service Learning Prevalence

While volunteerism and civic engagement have a long tradition in the United States, interest in service learning has grown since the mid-1980s due to national initiatives and federal funding of programs, including the National and Community Service Act of 1990 and the National Service Trust Act of 1993, as well as the growing contribution of the Campus Compact (Corporation for National & Community Service, n.d.; Bringle & Hatcher, 2009; Kraft, 1996; Mooney & Edwards, 2001). Started in 1985 as an initiative of Brown, Georgetown, and Stanford Universities to coordinate community engagement efforts, Campus Compact is now a national coalition of over 1,100 US colleges and universities that promotes campus–community partnerships and provides training and other resource support to integrate community engagement into higher education courses. The most recent annual survey of Campus Compact membership indicated that 95 % of the responding institutions offer service-learning courses (Campus Compact, 2013). Initiatives to recognize community-engaged institutions, such as the Carnegie Foundation's Community Engagement Classification (Carnegie Foundation, n.d.) and the President's Higher Education Community Service Honor Roll (Corporation for National & Community Service, 2014), have also increased the focus on service learning in US colleges and universities.

Service-Learning Theoretical Foundations

While interest in service learning increased in 1990s, scholars and practitioners have struggled with how to conceptualize the service-learning educational approach (Furco, 1996; Kenworthy-U'Ren, 1999; Mooney & Edwards, 2001), as well as how to clearly define a commonly shared theoretical foundation (Carver, 1997; Giles & Eyler, 1994). Attempts to offer a conceptual framework have placed service learning within the context of related theories of learning and instruction, including *experiential learning* (Carver, 1997; Dewey, 1938; Giles & Eyler, 1994; Kolb, 1984; Kraft, 1996; Mooney & Edwards, 2001) and *authentic learning* (Correia, Yusop, Wilson, & Schwier, 2010; Herrington, Reeves, & Oliver, 2014; Hung, Lee, & Lim, 2012). Common to many perspectives is the emphasis placed on (a) authentic real-life experiences, (b) active engagement by the student in interactions with both the content and others, (c) inquiry that is tied to problems or opportunities within the experience that create uncertainty and challenge, (d) activities related to the student's reflection on the experience, and (e) the mutual benefit of the community.

Service-Learning Effects on Students, Faculty, and the Community

Meta-analyses and reviews of service-learning research suggest a thriving research base across a range of disciplines (Astin et al., 2006; Astin, Vogelgesang, Ikeda, & Yee, 2000; Celio, Durlak, & Dymnicki, 2011; Conway, Amel, & Gerwien, 2009; Novak, Markey, & Allen, 2007; Warren, 2012; Yorio & Ye, 2012). As forwarded in a service-learning assessment model by Driscoll, Holland, Gelmon, and Kerrigan (1996), the primary subjects of examination include the main constituencies in the service-learning process, including students, faculty, and the community. The following sections review the central findings from research in these areas.

Service Learning and Students

Reviews of service-learning studies suggest a research focus on the effects of the experience on students, including (a) academic achievement, (b) career choices, (c) self-awareness, (d) personal development, (e) awareness and involvement with community, (d) sensitivity to diversity, (e) autonomy and independence, (f) a sense of ownership, and (g) communication (Andrews, 2007; Celio et al., 2011; Conway et al., 2009; Eyler, Giles, Stenson, & Gray, 2001; Novak et al., 2007; Strait & Sauer, 2004; Warren, 2012; Yorio & Ye, 2012). Findings from these reviews suggest traditional service learning and e-service learning are used as educational tools in a variety of disciplines and formats, and can have positive effects on academic achievement, as well as personal and social outcomes. Some argue that the service activities offer an opportunity for enhanced performance over traditional classroom-based instructional approaches due to the students' increased interest and involvement in the subject, as well as their ability to practice real-world problem-solving skills (Bringle & Hatcher, 1996). However, given the range of service-learning practices employed within the various studies, many have expressed the need for additional research to identify preferred service-learning methods and conditions that foster improved outcomes (Andrews, 2007; Celio et al., 2011; Novak et al., 2007; Warren, 2012).

Service Learning and Faculty

Service learning involves faculty within teaching, research, or direct service. Impact variables to examine the effects of service-learning experiences on faculty include (a) awareness and involvement with community, (b) level of volunteerism, (c) professional development, (d) scholarship, (e) teaching methods, (f) faculty and student interaction, (g) philosophy of teaching and learning, and (h) role in community-based teaching (Driscoll, Holland, Gelmon, & Kerrigan, 1996).

Campus Compact's recent member survey suggests instructional support for faculty engagement in service learning and community-based outreach is strong, with 79 % of members providing faculty with service-learning development opportunities, and 68 % contemplating service learning and community-based research as part of tenure and review (Campus Compact, 2013). Similarly, institutions completing the Carnegie Foundation's Community Engagement Classification application reported a range of faculty support and development strategies that included revisions to promotion and tenure guidelines, fellows programs, course development grants, instructional design support, and training (Bringle & Hatcher, 2009; Saltmarsh, Giles, Ward, & Buglione, 2009). However, while service learning has become more engrained within higher education, political and institutional deterrents persist, including lingering negative perceptions that service learning is a time consuming co-curricular practice, concerns over funding and logistical support, uncertainty regarding course design, and fears that service-learning efforts will not be taken seriously and rewarded during tenure and promotion reviews (Abes, Jackson, & Jones, 2002; Butin, 2006; Lambright & Alden, 2012).

Service Learning and the Community

A primary driver of service-learning initiatives is the desire to offer support to the community. Unfortunately, as compared to the attention placed on how service-learning initiatives affect the student, there is a relative lack of research on how service-learning projects affect the served community, such as (a) economic benefits, (b) social benefits, (c) awareness of the institution, (d) establishment of relationships,

(e) identification of prospective employees, and (f) satisfaction with the experience (Blouin & Perry, 2009; Campbell & Lambright, 2011; Cruz & Giles, 2000; Driscoll et al., 1996; Edwards, Mooney, & Heald, 2001). Within a review of over 120 service-learning studies from 1993 to 2000, Eyler, Giles, Stenson, and Gray (2001) reported only ten studies examined whether service learning provided useful service in communities. Since then, research on the effects on community-based partners has generated recommendations for improved protocols to manage the campus–community partnership, including relationship initiation, relationship development and maintenance, relationship dissolution, and partnership assessment (Bacdayan, 2008; Blouin & Perry, 2009; Bringle & Hatcher, 2002; Holland, 2001; Scharrer & Cooks, 2011).

Designing an E-Service-Learning Project

The noted theoretical and research base offers a conceptual framework for the design of service-learning experiences to offer students authentic applied and experiential learning opportunities outside the boundaries of traditional coursework, while affording a mutual benefit to the served community-based organization. The following describes the design, development, implementation, and evaluation of a recent e-service-learning project involving 21 college students and 18 faculty advisors from 14 different instructional design programs who collaborated in a 100 % virtual project to adapt or create open educational resources (OER) for adult basic education for a nonprofit client. Practices for service-learning client engagement, project management, and student mentorship are discussed. In addition, the potential design constraints of incorporating service learning in a virtual environment are examined.

Service-Learning Project Aims

Scholars in the field of instructional design have long contemplated the alignment between the preparation of instructional students in college and the real-world practice of instructional design (Bannan-Ritland, 2001; Curtis & Nestor, 1990; Kenny, Zhang, Schwier, & Campbell, 2005; Larson, 2005; Larson & Lockee, 2009; Schwier & Wilson, 2010; Tracey & Boling, 2014). Such examinations have resulted in many attempts to offer students authentic learning experiences as part of their instructional design programs, including course design projects (Bannan-Ritland, 2001; Shambaugh & Magliaro, 2001), design studios (Boling & Smith, 2014; Wilson, 2013), instructional design challenges (Bishop, Schuch, Spector, & Tracey, 2004), and service-learning experiences (Correia et al., 2010; Tracey, Chatervert, Lake, & Wilson, 2008).

The central aim of a recent e-service-learning project was to build from these approaches within a 100 % virtual opportunity that did not require any participant to be physically present at any location. Rather than involving only students within a single course or at one institution, the e-service-learning experience was offered to any currently enrolled college student within an instructional design program to support collaboration across institutions.

Project Initiation

The community partner on the project was a nonprofit organization that offers tutored instruction to its clients who are recovering from drug or alcohol addiction. Those in the residential recovery program who have not earned a high school diploma (or equivalent) are required to take in-house classes to prepare for the General Educational Development (GED) test in order to stay in the program. In 2014, the GED Testing Service changed the test requirements to align with the 2013 College and Career Readiness (CCR) standards released by the US Department of Education as a guide for adult basic education programs (Pimentel, 2013). Given the changes to the GED test requirements, the client needed help in designing and developing instructional resources that align with the new CCR standards.

Faced with a lack of available resources, budgetary constraints, and the desire for quality instructional materials, the client contacted an instructional design instructor to request help from students. Following several discussions with the client team about a possible design for the service-learning experience, the instructor signed on to help and assumed the role of Project Coordinator.

Client Memorandum of Understanding: While the initial inquiry from the client was based on the assumption that support would come from one class of graduate-level instructional design students, the client was interested in piloting the Project Coordinator's suggestion of an e-service-learning approach that included working with geographically dispersed students enrolled in multiple instructional design programs. Taking into consideration the constraints of the typical 15-week semester, the client and Project Coordinator narrowed the focus to five instructional design projects that could be completed by instructional design students as part of a course project or internship requirement during a single semester.

Given the alignment of CCR standards to the Common Core State Standards (Pimentel, 2013), a project aim was to identify and adapt existing open educational resources (OER) developed for a K12 audience to an adult audience. To that end, one project focused on the mining and mapping of existing OER that could be adapted to the client's needs. Three projects focused on the design and development of prototype units of instruction that align with the CCR standards, and the fifth project focused on instruction that introduced students to the use of computers for learning. To help support the missions of other organizations that offer adult basic education, all resources created on the project were released under a Creative Commons Attribution 3.0 license (Creative Commons, n.d.).

A Memorandum of Understanding was prepared by the Project Coordinator that confirmed the parameters of the project with the nonprofit client. The Memorandum of Understanding outlined the central aspects of the project, including:

- the volunteer relationship with the student service learners.
- the scope of services to be undertaken during the 15-week term of the service-learning project.
- the educational qualifications and related background information required of the student candidates.
- the reporting protocols among the client team and the Project Coordinator.
- the ownership of intellectual property from the work products created during the project with the requirement that all work be released under a Creative Commons license.

Call for volunteers: Based on the project parameters outlined in the Memorandum of Understanding, an online Call for Volunteers was initiated that outlined the expectations and requirements of the students. The Call for Volunteers described the project and asked potential volunteers to respond to questions about their work and academic backgrounds, as well as their preferences for design projects. The Project Coordinator reached out to hundreds of potential faculty and student participants via email, on a popular instructional design listserv, and through social media. Nearly 30 applicants responded to the Call for Volunteers with completed applications. Respondents included both students and faculty looking for projects to fulfill course or internship requirements, as well as students who did not desire course credit, but simply wanted to gain real-world experience while helping others. Each student applicant was required to have a faculty sponsor with expertise in instructional design who was willing to advise the student through the duration of the project. Student selection was based on their eligibility, and subject to verification that the faculty sponsors were willing to volunteer in an advisory capacity.

Selected students were required to sign a Service Learner Agreement that documented their acceptance of the project terms. Like the Memorandum of Understanding with the nonprofit client, the Service Learner Agreement confirmed the volunteer relationship between the client and the student service learners, the scope of services to be undertaken during the 15-week term of the service-learning project, the reporting protocols with the client team and the Project Coordinator, and the intellectual property provisions.

Other participants: Volunteer subject-matter experts and advisors were recruited to support the students. The Project Coordinator also consulted with a small panel of advisors to design the e-service-learning approach. In addition, a team of students from outside of the project volunteered to conduct an evaluation of the service-learning experience to fulfill a class requirement within an instructional design course in their college program. The instructor of the course supervised their evaluation process. The goal of the evaluation was to generate feedback for improvements of the e-service-learning design. In total, approximately 50 participants volunteered their time on the project, including the education specialists employed by the client community partner, the student designers, the student evaluators, college faculty sponsors, other subject-matter experts, and the project advisors.

Project Implementation

Student roles and responsibilities: As presented in Fig. 1, five project teams were formed that included between four or five students per team. The student design teams had 11 weeks to complete their product deliverables. While student involvement on the projects varied, each student agreed to volunteer a minimum of 30 h from the project start date to the deliverable due date.

Students and other participants on the service-learning project were assigned specific roles and responsibilities. One student volunteer was assigned as an overall Project Manager who acted as the primary client liaison during the project, as well as the coordinator of the project teams. Five students were assigned the role of Coordinating Designer and had the same types of responsibilities as the other student designers in the team, but also took on the role of being a point person or team leader for his or her respective team. The primary function of the Coordinating Designer role was to ensure the team was making forward progress toward achieving the team's goals, and to coordinate the team's efforts with the other Coordinating Designers and the Project Manager.

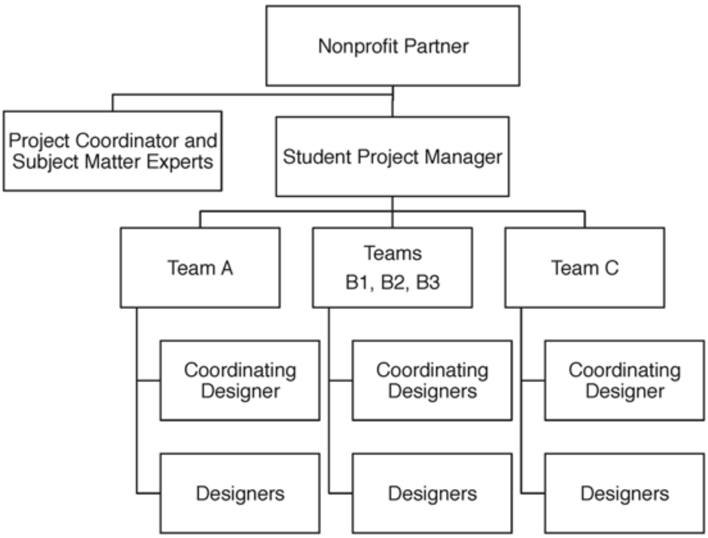

Fig. 1 Participant roles on the service-learning project team

Virtual collaboration: Given the project was a 100 % virtual e-service-learning opportunity that did not require any participant to be physically present at any location, a collaborative online learning environment was developed on a website dedicated to the project. This website served as a home base for communication and content management that included an asynchronous discussion forum and a synchronous web conferencing platform. To facilitate collaboration and interaction among the dispersed project team members, all participants were asked to use a shared Google Drive folder dedicated to the project. To encourage feedback from others outside of the project team, group spaces were set up on the Google + social network and a social bookmarking website. In addition, a special hashtag was assigned to the project, and participants were encouraged to use the hashtag in online communications about the project. All tagged communications were aggregated using a content curation website.

Communication: The Program Coordinator was responsible for the initial communication to the teams at the project kickoff and worked closely with the Project Manager through the duration of the project. Communication from the Program Coordinator was in the form of updates to the project website, emails, posts to the asynchronous discussion board, and facilitation of the synchronous live sessions. Once the project was underway, the student Project Manager became the main point of day-to-day contact and communication with the teams. The Project Manager's main point of contact was with each team's Coordinating Designer using both email and online conferencing.

Deliverables: Based on each team's project description, specific deliverables were established in the initial weeks of the project. While the students were also encouraged to coordinate their efforts across teams, they worked independently within their teams on the project deliverables, and submitted work for review and evaluation at set times during the project. Students worked at their own pace to meet the deliverable requirements, and contacted the Project Manager, faculty advisors, subject-matter expert volunteers, and the client when they needed help or clarification.

Project Evaluation

The purpose of the evaluation was to examine the e-service-learning experience from the perspectives of both the student volunteers, as well as the client. As part of the evaluation, the students (a) interviewed the Program Coordinator, the client, and the Project Manager, (b) conducted an online survey of the student designers, and (c) reviewed archived project documentation. While this evaluation was limited in scope, the student evaluators offered important observations in the following areas.

Student experiences and satisfaction: The majority of students responded that they become involved with the service-learning project in order to gain work experience. While students felt they gained the real-world experience they were seeking, some expressed a desire to gain additional experience beyond what was expected. In addition, many students voiced interest in continuing their service on future projects. Interestingly, students' assessments of their Coordinating Designers were somewhat lower than those of the other teammates, suggesting there may have been a breakdown in the team leader function on some teams. Additionally, students who did not receive school credit for their participation had lower satisfaction ratings than those who were gaining school credit.

Client satisfaction: While the client contacts had not yet received the final deliverables at the time they were interviewed, they were pleased to have this opportunity and enjoyed the experience of working with the volunteers. They expressed some concern about the usability of the draft deliverables they reviewed, which suggests the need to restructure and clarify the deliverable requirements of the students, as well as the evaluation process of their work. However, the client contacts have since started working with the prototypes, and have agreed to participate in another e-service-learning project to continue the work that was started by this first group of student volunteers.

Faculty mentorship: Most respondents to the survey reported receiving little direct mentorship support from their faculty advisors. While some indicated that they did not feel mentor involvement was necessary, others indicated that they would have been pleased if the advisor had shown more responsiveness and interest in the student's success. Whether this is due to a lack of interest on the part of the faculty advisor, unclear expectations established by the Project Coordinator, or a lack of initiative on the part of the student to request help, the students' feedback points to the need for clearer guidelines for the faculty advisors.

Student skill-level: While selected students indicated in their applications and survey responses that they felt qualified to work on the program, the students' overall experience level was not as high as was predicted from their responses on the project application. This disconnect suggests the need to refine the initial vetting process.

Workload: Student responses varied in terms of their perceptions of workload. While students were asked to commit to a minimum of 30 h during the project (which was confirmed within their acceptance in the Service Learner Agreement), four students did not complete their responsibilities on project. Two students left the project with about five weeks until the final deliverables were due, and two others did not complete their portions of the final deliverable. While some level of attrition is to be expected in any volunteer-based project, the departures meant an increased workload for the remaining students. Aside from teams affected by these departures, the majority of the students felt the actual workload was comparable to their expectations. Additionally, in reflecting upon the workload of the teams, the Project Manager suggested that teams would likely function more effectively and efficiently with a smaller number of team members.

Communication and expectations: Responses were mixed in terms of the students' perceptions of overall communication, as well as the communication of expectations in particular. While some felt the expectations were clear, some students felt the expectations were either not well defined, or poorly communicated. Respondents noted that the live web conferencing sessions helped to clarify expectations and to answer questions, but some noted confusion over the presentation of information on the project website, suggesting the need to review the usability of the online collaborative space. Participants relied on email as the primary form of communication, while the project asynchronous discussion board and social networking spaces were rarely accessed by the participants. The evaluators noted that those expressing concerns over the communication of expectations were not Coordinating Designers. Given the lack of direct involvement between the Project Manager and the student designers, this feedback may suggest the need for more direct communication between the Project Manager and all members of the design team. In addition, the feedback also suggests the need to formalize student reflections as part of the service-learning process, which will help to monitor student progress, perceptions, and understanding of expectations.

Lessons Learned for Future Service-Learning Designs

As seen in prior examinations of service learning, the described e-service-learning project offered students an authentic real-world educational experience that is difficult to replicate in a traditional classroom setting. In turn, the project offered the nonprofit client pro bono services and products to support their operations. However, the implementation and subsequent evaluation suggested the service-learning design and facilitation process is complex, and involves the coordination of many processes and constituents (i.e., students, faculty, subject-matter experts, and other advisors). Management of constituent expectations was seen to be paramount to project success. This management began with a careful assessment of client's needs and goals, as well as a thorough analysis of what work can be accomplished by the target audience of student service-learners within the term of service. A misunderstanding of the client's needs or the students' capabilities could lead to a misalignment that would doom the project.

While a well-defined Memorandum of Understanding and Service Learner Agreement helped frame the initial expectations in the described project, diligent ongoing communication and project management was necessary to avoid misunderstanding and project failure. Based on participant feedback during the project evaluation, the incorporation of a service-learner orientation early in the project is needed to solidify project expectations. In addition, support for ongoing feedback between the project coordinator and service-learners is necessary. Beyond ad hoc communication and scheduled participant meetings, one-to-one communication could be enhanced through the implementation of written student field journals that would offer both information to the facilitator on project status, and an opportunity for the students to reflect on their practice (Tracey, Hutchinson, & Grzebyk, 2014).

As was seen in the described e-service-learning project, conducting a 100 % virtual experience in which participants never meet face-to-face increases the complexity of service-learning design. While the students benefited from the unique cross-institution collaboration and the opportunity to volunteer with geographically dispersed participants, the separation posed a significant design challenge in terms of project management and facilitation. In addition to the need for an online platform to present content and to broadcast messages from the facilitators, participants needed asynchronous discussion options (i.e., email and discussion forums), online collaboration spaces to share work-in-process and final deliverables, and synchronous technologies to facilitate real-time communication among the dispersed participants.

While the described experience suggested approaches to design an effective and authentic educational opportunity through e-service learning, it also illustrated the importance of mitigating problems associated with the participants' physical separation. Along with the design of project management, facilitation, and collaboration protocols, appropriate communication technologies must be carefully considered, selected, and managed throughout the process.

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The Feminist Instructional Designer: An Autoethnography

Katy Campbell

The following excerpts reflect a set of values and assumptions about instructional design as a scholarship and a practice. However, one of them is not like the others.

> In an age when the economy depends more on the brains than the brawn of its workforce, and when training dissemination via the Internet is ubiquitous, training that optimizes organizational performance is more germane than ever…. So how is ISD related to the production of knowledge workers? (David) Merrill suggests that ISD is essentially a "series of empty boxes, and we need more content for those boxes if we are to deliver better training[1]" Thanks to the recent advances in cognitive science we have a number of new tools and methods to fill those boxes.
>
> (Clark, 2002, p. 10)

> To fulfill this scenario an instructional design theory must offer guidance for designing a learning tool that can do much of the analysis and decision-making during instruction that are now made by a designer for a whole "batch" of learners well ahead of the actual instruction.
>
> (Reigeluth, 1999, p. xx)

> Instructional Design as a Science: Instructional design is the science of creating detailed specifications for the development, implementation, evaluation, and maintenance of situations that facilitate the learning of both large and small units of subject matter at all levels of complexity.
>
> (http://www.umich.edu/~ed626/define.html)

[1] Merrill, in Zemke & Rossett, 2002, 30.

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> When I was a young girl, I assembled the materials to build a crystal radio. My mother, usually encouraging, said, "*Don't touch it*, you'll get a shock." Her tone, however, did not communicate fear for my safety, but distaste.
>
> (Turkle, 1997, p. 56)

Preamble

This is a chapter I have long wanted to write. It is part poststructuralist autoethnography, part narrative analysis, and part Standpoint Theory (Harding, 2004). As I take my first leave in over 10 years of administration, reflecting through writing has helped me pull together and integrate, for the first time in 30 years of practice and scholarship, the theoretical construct(s) that guide(s) me as I perform design and reflect on its social impact. It unapologetically and, hopefully, provocatively cracks the door open onto my remembered instructional design world. I've almost put behind me (almost) the long-ago reviewer for *Radical Pedagogy* who described my work with female faculty using learning technologies as "tendentious bullshit" (Campbell, Schwier, & Kenny, 2010), although now, as a journal editor, I would never let a colleague hide anonymously behind such vicious rhetoric. Accepting a singular view of knowledge and truth reflects what Donna Haraway called "the view from nowhere" (Haraway, 1991, in McDowell, 2007, p. 220). I believe that our field is established enough, and now inclusive enough, to accept that there may be acceptable multiple perspectives on the scholarship and practice of instructional design. In fact, we may actually be experiencing an identity crisis or, as we poststructuralists might say, multiple identity crises.

Discussing the influence of feminist Standpoint Theory on Human–Computer Interface design (HCI), Bardzell (2010) asserts that it is a natural ally "due to its central commitments to issues such as agency, fulfillment, identity, equity, empowerment, and social justice" (p. 1301). I argue that Standpoint Theory underlies epistemology and drives practice. Emerging from feminist work, Standpoint Theory acknowledges "all knowledge attempts are socially situated and that some are better than others as starting points for knowledge" (Bardzell, 2010, p. 1301). In our domain, effects are visible through the language of design, the theory of design, the practice of design, and the study of design. In principal, Standpoint Theory "makes three principal claims: (1) Knowledge is socially situated; (2) Marginalized groups are socially situated in ways that make it more possible for them to be aware of things and ask questions than it is for the non-marginalized; and (3) Research, particularly that focused on power relations, should begin with the lives of the marginalized" (see The Internet Encyclopedia of Philosophy, IEP, n.d.). I submit that there are many ways to practice and understand instructional design (ID), and we have privileged only one, disguised as normative, for far too long. *ID-as-science*—a mechanized, industrial, tools-based, unemotional, system geared to the production and optimal performance of knowledge workers—is reflected in the first three opening quotes, in contrast to Sherry Turkle's account of breaking the "cultural taboo" of women involved with machines.

As an instructional designer of my generation and genesis—i.e., Canadian from an activist matriarchal family, a teacher finishing a graduate degree in curriculum design in the 1980s, and finding myself doing instructional design without really knowing what it was—I backed into the field as a practitioner and later became curious about *what was really happening among the participants* in a design project, because I knew it surely wasn't systematic and emotionless. I tried to fit the square peg into the round hole by gobbling the research literature during and after each design project, but was always left hungry unsatisfied. So many models; so little useful advice. So much impersonal technological language; so little regard for the personal interactions among team members, clients, teachers, and designers! Instead, we were on the crusade for the principles of instructional science, the optimal blueprint, the bulletproof one that the teacher couldn't screw up.

However, based on my own design practice and scholarship over time, which focuses on instructional designer identity and the social situatedness of practice, I have come to understand instructional designing, at least as practiced by many female design colleagues, as process-based, relational, and transformative. This construct for understanding, practicing, describing, and learning about design has precedents in architecture (Rothschild, 1999), museums, and other public spaces such as landscapes; industrial design; human–computer interface design, and other design professions. Feminist approaches to design have problematized a range of taken-for-granted assumptions, for example, about the nature of design, its conceptualization, purposes, users and audiences, language, methods, artifacts, evaluation, marketing, and positionality, to name a few (Verbeek, 2006).

Instructional design traces its roots to the 1920s (or even earlier) and the emergence of behaviorist theory, through the era of media attributes research, cognitive theory, systems design, and constructivist theory. Given its long history, systems design thinking has dominated the field for over five decades; instructional design literature paralleled the ID-as-science paradigm, reflecting the research and preparation of instructional designers (if not the actual practice) until the 1990s. Applying Elliott Eisner's (1981) insight to the prevailing, and exclusionary culture, i.e., his suggestion that "looking with one eye" results in a shallow depth of field, equally the language and procedures of design reflected a Western (American) genesis and domination based on the cultural values of liberalism, egalitarianism, individualism, competitiveness, and exceptionalism (Hongladarom, 2001). Said in a different way, "we language things into being" (The Philosophy Thread[2]). This field has long been masculinized by language, by discourse, by metaphor; by tools we have chosen to use. For illustration, this explanation appears on Martin Ryder's (very useful) site at the University of Colorado Denver. Note the utilitarian, workshop/tool-orientated language of parts and mechanization, the focus on doing rather than thinking.

[2] Retrieved October 11, 2014, from http://www.draftcountdown.com/forum/showthread.php?s=c78d7734383302b65fea8db29ddb8676&p=1965425#post1965425

> Models, like myths and metaphors, help us to make sense of our world. Whether derived from whim or from *serious research*, a model offers its *user* a means of comprehending an otherwise incomprehensible problem. An instructional design model gives *structure and meaning* to an I.D. problem, enabling the would-be designer to negotiate her *design task* with a semblance of conscious understanding. Models help us to visualize the problem, to break it down into discrete, manageable *units*. The value of a specific model is determined within the context of use. Like any other *instrument*, a model assumes a specific intention of its user. A model should be judged by how *it* mediates the designer's intention, how well it can share a *work load*, and how effectively it shifts focus away from itself toward the *object* of the design activity.
>
> (http://www.instructionaldesigncentral.com/htm/IDC_instructionaldesignmodels.htm#kemp).

In the critical literature of feminist pedagogy, mid-century and beyond, scholars and teachers are asking and refining questions about social context, inclusion, authority, participation, and access, among others, and challenging notions of such desired outcomes as the well-known and oft repeated "the optimal blueprint." Along with engagement scholars constructivists, connectionists, and other critical theorists have cracked the door to the possibility of institutionalized instructional design practice as participatory, socially situated, and even emancipatory.

To wit, in this chapter I explore the metaphor of instructional design as feminist practice through my own narrative and later in the project (in its initial data-gathering stage), in subsequent conversations, those of other female designers. Using the auto-ethnographic method, this chapter builds on my past work exploring the instructional designer as change agent in higher education (Campbell et al., 2010), and will suggest ways in which graduate design education may change to acknowledge or reflect these practices. We have heard the critique/resigned acceptance/proud declaration that "instructional designers design for themselves." I think that is true; I also believe that if we accept and leverage the power of identity work, we might be able to really impact social change through the learning environments we have had a hand in creating. In other words writing as a feminist, poststructural instructional designer, I want to persuade you that instructional designers *will* practice out of the meaning they make of their past and present social worlds. This conversation about "design precedents" is unfolding in many design fields; for example, in architecture, and relates to identity and discourse. Describing the evolutionary nature of architecture, or art and design, Zazar (2005) explores how design precedents (such as topology). . .

> "might express some of these aspects inherent to identity, in particular the social and cultural aspects. It focuses on how architects, using precedents, communicate ideas and answer the users' need, and, in particular, it focuses on the effort to 'create' a new identity and/or to reinforce the extant one; as well as on the use of local potentials and critical import of technology and/or building methods" Boling, Easterling, Hardre, Howard, & Roman, 2011.

As scholars, teachers, and practitioners, it makes sense to understand our own cultural assumptions and scaffold on rich-life experiences. Most of us were baptized into a culture of outward-gazing "engineering, expected to objectively apply the tools in an instructional design toolbox in a systematic, mechanical, way." (ibid, 4) For example, at one point "intelligent design" programs were developed to replace most or all of the designers' expert input (e.g., *Designers Edge*™), although the faculty clients with whom I worked were never able to use it by themselves to design a learning activity. However, in the research journey I've taken with other colleagues, we found that instructional designers not only play important roles in the design and development of instructional products, but they also act in communities of practice as agents in changing the way traditional colleges and universities implement their missions. They can work as co-creators directly with faculty, to help them think more critically about the needs of all learners, issues of access, social and cultural implications of information technologies, alternative learning environments (e.g., workplace learning), and related policy development. And so through interpersonal agency and critical, reflexive practice, designers may actively help shape institutional and societal agendas for change. This is my position: Designers may be agentic—quietly, invisibly, subversively, without status—if we "raise" them in an alternative culture of reflective, mindful practice—we necessarily accept that who they are, the decisions they make, are based on their current identities shaped by, among other things, their current practice context. This implies important political and theoretical, epistemological, and institutional issues at stake in this view.

The Theoretical Approach

A Word About Autoethnography

Autoethnography is an autobiographical genre of writing with a close relationship to narrative inquiry. While narrative accounts are often described as "stories," and narrative inquiry is the method by which these stories—about the meaning people make of their experiences—are teased out, autoethnography is a more autobiographical genre of writing, usually written in first person, illuminating multiple layers of consciousness and understanding, explicitly linking the personal to the cultural (Ellis & Bochner, 2000). Both are reflexive methods and permit the author to critically examine the sociocultural, physical, and epistemological forces that have shaped his/her practice and understanding. Autoethnography rigorously embeds personal experience in the examination of cultural context in which practice has occurred. Creating this autoethnography, or the "act of telling (one's) stories" implies sharing, challenging, and co-creating knowledge with others in a public performance, "within a framework of sociohistorical narratives or 'big D Discourses'" (Gee, 1996, p. xx) "that simultaneously enable intersubjective understanding and constrain the meanings that can be taken from the stories" (Lapadat et al., 2010, p. 78). I have chosen this form of representation because it is compatible with both feminist pedagogy and poststructuralism, urging me to reflect upon my experiences as an instructional designer, beginning in a stage of theory-building (1980–2014), and how I might engage with my professional culture to affect social change (Fleming & Fullagar, 2007). An autoethnography may confront normalized practice and belief and ask, "Why do we do it this way? What have I assumed is true? Who is included, and who is excluded in this approach?"

Because we take, or are granted, different positionalities in different discourses, feminist designers are sometimes in view, but more often we are marginalized. My insider/outsider state opens up a cultural conflict, a space that autoethnography problematizes. As a genre that connects the personal to the cultural, and in harmony with my primary work in narrative, autoethnography feels like the most productive approach for situating myself within the social contexts of feminist, designer, Dean (Reed-Danahay, 1997). I can reflexively use my own experiences in these cultures, look more deeply at Self-Other interactions, and write myself in as a major character. Autoethnographic texts may feature dialogue, emotion, and self-consciousness, in relational and institutional stories affected by history, social structure, and culture (Ellis & Bochner, 2000). Not surprisingly then, this use of self as the only data source has been roundly challenged, and autoethnographers criticized for being self-indulgent, narcissistic, egocentric, and tunnel-visioned (Coffey, 1999; Lincoln & Denzin, 1994; Sparkes, 2002). However, we do not accumulate our experiences in a social vacuum (Stanley, 1993) but, rather, as actors in chains of relationships with others: We are protagonists in the narratives of others as they are in ours. And so as we struggle to make some sense of who, what, and especially *how* we are in a narrative, autoethnography allows us to situate ourselves in the social and institutional frameworks that contextualize our personal and professional identities.

Sparkes (2002) has suggested that autoethnography is at the boundaries of academic research because such accounts do not sit comfortably with traditional criteria used to judge qualitative inquiry. Charmaz (2005) cites Christians (2000) and Denzin (1989) calls for "interpretive sufficiency" that "takes into account cultural complexity and multiple interpretations of life" (p. 528). She argues that a strong combination of credibility and originality increases resonance and the usefulness of the narrative. I hope my account will resonate with feminist designers who, depending on the context, find themselves all at once on the inside looking out and the outside looking in at cultures to which they somewhat belong, certainly in higher education—experienced *and* novice scholar, protector *and* protected, member *and* interloper, authoritative *and* incompetent, nuanced *and* detached, knowledgable *and* uncertain, skilled problem-solvers *and* unnerved with ambiguities.

What Is a Feminist, Poststructural Approach, and How Does It Fit My Practice?

As I worked on this piece, I found myself unusually vigilant about language and its reflected assumptions. In the same way that language represents culture, instructional design works with and through the multiple intersecting cultures of learning, education, technology, institutions and workplaces, gender, geopolitics, theory, and so on. Feminist poststructuralism problematizes the ideas of "discourse" and knowledge production. As theorists, we examine competing "texts" related to social process, power relations, subjectivity, and consciousness as "sites of struggle, resistance and social change" (Weedon, 1997, 28). Terms like "resistance," "appropriation," "myth," "metaphor," "grand narratives," and "dominant groups," among others, began to dance with the language of design, which is not gender-neutral. Taguchi (2005) explains the humanist shift from identity as coherent, unitary, and essentialist, to the poststructural subjectivity of "multiple, often contradictory, discursively constituted subjectivities, where subject positions shift in different contexts and in relation to other subjects and how they position themselves or are positioned" (245). In other words, from, "now that I've absorbed all the ID models and am called an instructional designer I must be one" (unified identity), to "I fundamentally believe that my own values are important and I can refuse to design a learning object reflecting a real vivisection. However, I will design a simulation of an animal vivisection that will substitute for the living pig" (the personal is political and shifts by context). Humanist feminists believe that if the patriarchal contexts are mediated, the barriers removed, women could encounter a world of equal promise and opportunity, because agency is innate to every human being. The world exists as an objective reality ("we know that a verbal learning style is supported by text"). The text and context is our only challenge. In contrast, poststructural feminists are always caught up in webs of social practices, discourses, and subjectivities; we have agency only when "we can speak ourselves or be spoken into the available discourse" ("designs reflect narratives that are socially constructed").

Poststructuralists who are feminists distinguish themselves from humanist feminists in many ways. Fundamentally for this chapter, these schools of feminist thought differ both in their assumptions about the patriarchal world and women's struggles for equality, and plans for social action or agentic practice in these contexts. On May 30th 2014, I picked up a copy of *USA Today*, my attention pricked by the headline "Testosterone Valley: The world of high tech looks like an exclusive boys' club" (Weise, 1-2A). Weise chortles that Google finally released its diversity numbers after years of social pressure (83 % male to 17 % female), and quotes anthropologist Coleen Carrigan, "Women and minorities have been denied access to resources and opportunities that would allow them to enter and succeed in computer science" Academy of Achievement (1995), a version of "the pipeline argument." Presumably, all other things being equal, gender would not create a barrier.

In *Bringing Men into the Light*? *Women's Studies and the Problem of Men* (2001), Michael Flood identifies the politics and processes of the classroom as central to feminist scholarship and pedagogy. He characterizes the entry of Women's Studies programs (now under attack in many universities, as budgets tighten) as profoundly challenging to "traditional models and methods of teaching and learning, particularly to pedagogies which are hierarchical and teacher-centred and which position students as ungendered empty vessels to be filled with objective knowledge" (p. 3). Not only does this description resonate with the narratives of individuals like me who were undergraduates in the 1970s and 1980s, but it also captures my personal struggle with the canons of instructional design research and practice during this era. Although I did not graduate from a formal graduate program in Canada, which were few and far between at the time, as I began to practice instructional design in 1983 the foundational literature identified the genesis of instructional design as behavioral and cognitivist, maturing as a "science" through its implementation in military training, and expressed in the writings and teaching of male scholars who were often military alumni or funded directly by military organizations[3] (e.g., Gagne, Duffy, Reigeluth…). In fact, I don't recall a single prominent female scholar from this period (the 70s). Weedon (1997) explains why the female instructional design voice was silent (silenced?) for so long,

> In order to be effective, discourses need to be in circulation, available…(which texts) are widely disseminated through education and publishing is not a neutral issue. It is possible to trace the formative power of patriarchal, class and racial interests not just in modes of reading and the constitution of the canon, but in what is available to be read by all (p. 165).

Through the 1990s, however, feminist pedagogies began to emerge that emphasized learning and teaching as egalitarian, learner-focused, democratic, participatory, relational, collaborative, inclusive, empowering, interactive, and experiential (Storrs & Mihelich, 1998). Coincidentally (?) at about this time constructivism began to emerge as a counterpoint to objectivism (Duffy & Jonassen, 1992; Vrasidas, 2000).

Both feminist pedagogues and instructional design scholars began to question impermeable boundaries between disciplines and feminists, at least, engaged in a discourse about relationships among disciplinary power, personal experiences, and politics. As Flood (2001) points out, and as I experienced at that time in my career, "classrooms are embedded in wider relations of dominance" (p. 3). Recognizing a faint sense of dissonance between my predetermined, institutionalized ID practice and my personal/professional leanings/yearnings toward relational conversations, through reflexive, narrative practice, I began to subvert the dominant, objective, systems-based, scientific paradigm of instructional design theory and models in which the personal was absent. "Feminist critiques of the dominant modes of social inquiry at the time suggest(ed) that they represent(ed) fundamentally masculine ways of viewing the world" (Flood, 2001, p 3) and the production and organization of disembodied, detached, abstract, and rational knowledge about that world…(as) "the 'god trick' of seeing everything from nowhere" (Haraway, 1988 p. 581; Morgan, 1992). We have seen this in the design of buildings, bridges, houses, cars, tools, pharmaceuticals, space, medical instruments, computers, and many other objects and spaces of daily use. For example, in the report "Why So Few Women in Science-Technology-Engineering and Mathematics?" the Association of Academic University Women (Hill, Corbett, & St. Rose, 2013) cite the avoidable deaths for women and children struck by automotive air bags that were designed by "predominantly male groups of engineers" (Boling et al., 2011) who tailored the design for adult male bodies.

It is interesting, and astonishing to me, that even though the field emerged from, and was really dominated by, such typically masculine experiences and perspectives as military training, systems-thinking, experimental design, and computer engineering,

[3] For example, US Air Force Human Resources Lab, Navy Personnel Research and Development Center, US Air Force, US Department of Defense, the Navy Project, NATO Advanced Study Institute, NATO Advanced Research Workshop.

we have been so defensive about our theoretical frameworks and practice, apologizing that it might be considered a trade, a craft, or even, Heaven forfend, an art. Critiques among ID scholars have, at times, been quite ferocious, although male academics would probably insist it "was nothing personal." For example, David Merrill, one of *the fathers* (emphasis is mine) of instructional design "reclaimed" instructional design, saying, "It is possible to know where we are going. We still have a long way to go, but abandoning the path of scientific method and following the uncertain wilderness of philosophical relativism will distract us from our goal and unnecessarily delay our journey" (Merrill, Drake, Lacy, & Pratt, 1996, p. 3). Marjorie Garber (1999) observes this tendency to regard the quantitative social sciences as "masculine," serious, and hard, while social sciences that use narrative, interpretive, and descriptive techniques rather than crunching numbers as "soft" or "feminine" (p. 68). She (1999) attributes this disciplinary chasm to a perceived, or conceived, inferiority among a group of persons (i.e., instructional designers and educators). "Another class of persons, already more socially or politically powerful and more highly esteemed, is thought to possess the real thing, of which one's own version is 'inferior,' smaller, bogus, merely titillating, insignificant" (p. 69). Nelson describes this very same situation from the point of view of "damaged identities" which can best be repaired with counterstories (2001). Counterstories, positioned against a "master narrative" (in this case, ID as a scientific domain), are a "cluster of histories, anecdotes, and other narrative fragments…(resist) an oppressive identity and attempts to replace it with one that commands respect" (p. 6). This is a difficult conversation to have, not only among designers, but also in the context of a "disrupted" higher education system that has lost public support in the form of grants and respect and the private support amid the clamor to redistribute support from humanities and social sciences to STEM disciplines in service of the so-called skills shortage. A more relational ID process in practice runs counter to efficiency and the tendency towards the "fast fashion" approach of productivity.

Language, Identity, and Power

From the poststructuralist perspective, the terms "teacher" or "instructional designer" have no intrinsic meaning, only the meanings with which we have agreed to imbue them. Once disciplinary language is embedded in competing discourses with which we make meaning of our research and practice, we understand ourselves and are viewed by others to have a placement in the social order of things. For example, I continually seek to place my own learning about design—a range of theories, how design informs my role as Dean—into an interpretive narrative frame with which to understand how my life experiences, values, and intentions interlink to shape and reshape multiple identities that include feminist, teacher, supervisor, mentor, researcher, administrator, colleague, grandmother, partner; friend. In other words, we participate in a hierarchy of social power. Sometimes I possess social power, and often I don't. Deans certainly have only the social and moral power granted them by their colleagues and staff.

I offer, for your consideration, the social power in the language of "profession," or that "professional" enjoys. A "profession" is accredited, and regulated, through rigorous, evidence-based practice standards agreed upon expert practitioners, and regularly assessed against standard criteria by "anonymous" experts. In fact, the current Minister has recently done just that despite the sanctions that have already been imposed on four teachers by the Alberta Teachers' Association. Neither the Justice Minister nor the Minister of Health has the power to interfere with disciplinary decisions of the Alberta College of Physicians and Surgeons (Simons, 2014). Note that among those three professions neither the highest social power nor salaries belong to teachers. I suggest that because women were historically, and still are, a majority of the profession, the language about teachers and teaching will remain politically charged. The other two professions mentioned have become much less gendered and approach equality in social power, although the salaries of female lawyers, academics, and doctors remain lower than salaries of their male counterparts, and the women are overwhelmingly located in "feminine" specializations such as family law and family practice[4] (Catalyst, 2014). In Canada, by the way, women earned 82.4 % of men's earnings (Statistics et al., 2014),[5] although as with their American counterparts, they tend to be clustered in the lower-paying professions. I have wondered if this helps explain why female instructional designers tend to be "clustered" in non-academic roles in educational institutions (a vulnerable space), while male instructional designers gravitate towards higher-paying industry jobs (Lorenzen, 2002; eLearning Guild Report 2014; Herring, Ogan, Ahuja, & Robinson, 2006; Ogan, Robinson, Ahuja, & Herring, 2006).

Although instructional design has resisted, for some reason, the status of "profession," the language has reflected a "masculine" perspective possessing some degree of social power, but only if aligned with, and fixed in, technological discourse. For example, over 40 years we have developed a massive research base in online and blended learning; engaged, process-based and experiential learning, but it takes a physicist (male, scientist) to create worldwide enthusiasm for MOOCs and "the flipped classroom." As I observed earlier, for much of its existence the language of instructional design has reflected "hard/masculine" cultural references (e.g., violence, war, construction, military jargon) like "boot up," "Trojan virus," "first-person shooter," "malware," "spyware," "tools," and "denial of service (viral) attack." The problem with language is that its meaning, socially situated as it is,

[4] In 2013, the median weekly earnings for women in full-time management, professional, and related occupations were $973, compared to $1,349 for men.

[5] This may be partly because women tend to cluster in lower-paying fields. The most-educated swath of women, for example, gravitates toward the teaching and nursing fields. Men with comparable education become business executives, scientists, doctors, and lawyers—jobs that pay significantly more. *Times*, April 20, 2011.

does not remain fixed in its social contract over time. Consequently, it is always open to redefinition, changes in representation, social challenges, even cooptation. In order to understand and act on differences in social power, a feminist poststructuralist must pay keen attention to the cultural contexts (social, geopolitical, institutional) of language and textuality, because "social meanings are produced within social institutions and practices in which individuals, who are shaped by these institutions, are agents of change, rather than its authors, change which may serve hegemonic interests or challenge existing power relations" (Weedon, 1997, p. 25). Discourses are institutionalized to sustain certain practices and processes "at the expense of others" (Martimianakis, 2008, p. 47). In other words, instructional designing involves an historically, socially, and politically situated social discourse, competing with other discourses, justifying actions and negotiating meaning; that has had social power of "truth" within academe as long as it is based on a masculine, scientific paradigm or, contrarily, devalued for the same reasons ("Isn't she just a technologist?" one faculty member protested when I was assigned to his course, even though I had just finished his graduate course in phenomenology). But, for a feminist instructional designer, that is, the subject, I am constantly being "constituted, reconstituted, and (am) reconstituting (myself) by and through discourse and discursive practices within (design)…(which is) a complex context of cultural, social, gendered, scientific, and academic meanings, signs and practices including the outer and inner architecture, and usage of space, materials and things, and how these, as well as time, are organized and planned within these institutions" (Nordin-Hultman, 2004, in Taguchi, 2005, p. 245).

In the early 1980s I left my French classroom to complete a graduate residency in curriculum and design. I thought I would become a better French teacher. But instead, I entered a frustrating world of hermeneutics in which all I had learned, believed, observed, and practiced as the daughter and granddaughter of two teachers, and as a language teacher myself, was critically challenged. I cried every day in the car on the way home. From beloved French teacher to resistant qualitative researcher–what a shift in social power! When I think of this struggle now, I remember adding "ingness" as a suffix to every word and laughing about it, through my tears. But, somewhere around 1983, I was assigned to an "early adopter" supervisor who was just beginning to explore a new technology—the interactive videodisc. It was a transformative experience. I went from resistant novice researcher to enamored instructional designer in a matter of months. Not that the shift in identity was valued by the Faculty; learning technology was viewed with deep suspicion and disdain. When it came time to return to the K-12 classroom, my stomach began to hurt. I was easily persuaded to stay as a full-time student another year and take on a project to lead the design of a videodisc on classroom management and then critical questioning techniques (now my husband was crying in the car on the way home, since we had just moved up on mortgage row).

A serious identity struggle ensued—from a relatively understood positionality (political teacher of Canadian French), I intuitively aligned myself with a marginalized domain in teacher education. It was puzzling, because I could clearly see what technology could offer to those of us creating engaging learning spaces, but then (as now) it certainly disrupted the big D discourse of "the expert lecture." I hinted earlier at how I coped, how I was taught to cope with uncertainty, seeking out expert, received wisdom with texts and issues of *ETR&D*; attending *AECT* conferences, and slavishly following the work of Rick Schwier (University of Saskatchewan), Ron Oliver (in Australia), and anyone from Wollongong University. However, I had the identity of "instructional designer" because no one in my institution really knew what that was and that left me space to create it. Actually, I never have perfected my elevator speech and even now few people in Canadian academe know what an instructional designer is. I knew my expected practice was inauthentic, according to the big D discourse of educational technology—inauthentic, perhaps, in the prevailing (American) scholarly domain, but agentic in that it opened relationships and avenues of persuasion with Education faculty members who were willing, or who were told, to work with me. I framed my work as collaborative and social, because our relational conversations turned into designs that were used in teacher education classrooms, hopefully making an impact. Nascent concepts of storytelling eventually led to my doctoral work, deconstructing a design teams' design conversations as a socially transformative process (1994). Although I was successful mobilizing my scholarship (i.e., publishing) over time, I was definitely an outsider in the educational technology world. I wrote about instructional designers' identity and social agency, moral complexities of institutional culture, and how female faculty approached and resisted the use of learning technologies. Through the 1980s and 1990s, however, my papers were mostly rejected by the journals to whose audiences I wanted to present a different perspective. Apparently, there was no room for multiple perspectives. Instead, I published in feminist journals, *Curriculum as Inquiry*, *Radical Pedagogy*, *Journal of Transformative Education*, *International Journal of Qualitative Studies in Education*; *Journal of Higher Education*. Reviewers often questioned my subjectivity, reliability, and validity of data, rigor, use of the active voice, and acknowledgment of personal experience as evidence, common criticisms of qualitative research at that time and representative of the science discourse of the field.

The Links Between Universal Design, Constructivism, and Feminist Instructional Design

Quite simply, for me designing from a feminist standpoint is a political act. For instructional designers in institutions of higher education, the context I know best, the delicate, sometimes emotional negotiations between designer and client/faculty member result in decisions taken, and decisions rejected. This relationship is in constant negotiation because the workplace itself is in constant flux, a risky and political place, in which power status is much more complex than what academic rank or titles reflect. For example, for centuries design pedagogy was based on the master-apprentice relationship in that a "design studio master, as keeper of knowledge and process, would put apprentices through a series of design problems to be executed in the vacuum of the studio or atelier" (authors not yet public, 2014). However, with the confluence of the social activist movements of the 1960s, the turn toward constructivist epistemology, and grudging acceptance of qualitative methodologies in the "hard sciences," alternative design scholarship and practice, increasingly offers instructional designers a lens through which we can "understand how unequal power relations are embodied in, and result from, mainstream design practice and products" (Nieusma, 2004, p. 13).

Theorists of feminist pedagogy describe the feminist classroom as a place of protracted struggle, concerned with relationships, and accepting of multiple and conflicting voices. The feminist classroom honors the personal experiences of teacher and learner, and tries to integrate and reconstitute these experiences in the curriculum and pedagogical design. In the end, knowledge is co-created and reciprocal. Value-neutrality is challenged for the illusion it is (Orner, 1992; Luke, 1992) "We live in imagined communities and identify with a group… (That) is as important to one's self-identity as the sense of being unlike", (McCarthy, 1995, in Gubrium & Koro-Ljungberg, 2005, p. 708). Although our knowledge is grounded in these communities and is accepted as "real," objective, and "the truth" arrived at by rigorous scientific examination, we are confronted everyday with the possibility that it may be fluid, has a cultural and social context, is created and recreated through relationships, conversations, language, and action. This is as true for instructional design as it is for the disciplinary communities (that believe they have long established) a lasting social consensus that is the product of continual legitimation (I'm talking to you, astrology. So, Pluto is no longer a planet?). Social constructivists acknowledge that meaning derives from the social relationships within language functions…"words acquire meaning through social use, in context, and within the rules and constraints of any particular discourse" (Gubrium & Koro-Ljungberg, 2005, p. 704). It is obvious to me that poststructuralism and social constructivism are well-aligned conceptually and in practice.

What about universal design (now often called "inclusive design"), borrowed from architecture and adapted for, among other uses, user-interface design, fashion design, product design, instructional design, game design, and transportation design? Universal design is a wonderful example of the political, as the disabled community took social action to enhance their access to the environment. Universal design, feminist design, constructivism, *Design for All*—they all represent the agency of the formerly marginalized, and have all intersected in sociocultural concerns about language and its referents, human diversity, social inclusion, ethical practice, and multivocality. All *start* with the authentic voices of, and the participation of the community in design. So, more than a technique, each reflects an epistemology located in difference rather than normalization. For example, as McDowell (2007, p. 22) points out gender, among other characteristics, is relational and contingent, fluid and contingent, and constructed and maintained through everyday actions and social discourses.

One Last Story: The Role of Experience, Value, and Change in Instructional Design

In a multi-year narrative inquiry (2004–2007) with my colleagues Rick Schwier (University of Saskatchewan) and Rick Kenney (Athabasca University) we explored the identities of instructional designers as agents of social change. One of our research participants, an instructional designer in a large university's centralized academic support unit, had worked for approximately two decades with immigrant service organizations, community work programs, and international language programs, including several years at a community college teaching English to political refugees. She described her career trajectory as being based on her "lower middle-class background." I want to end with this excerpt because it encapsulates the argument I hope I have made, to wit: Feminist instructional design is a reflexive critical practice in which designers are agentic, relational, political actors who are influential in social change.

> I think that you do pick up certain values… become socialized to a certain place… I worked with people who had a very radical orientation to education, were quite active in a number of political movements. . . I think it certainly has molded me in a lot of ways or awakened my awareness to larger issues because when you talk about teaching in *that* context, you're…talking about issues…of social justice. How do you orient a person from a different culture into this new culture…there are just so many complex things…and it's quite interesting for me to come here and work with professors…who are very knowledgeable in their area but…it's hard for them to convey…the significance of that content…within the wider context of the world…. It's more my informal education through working with people who were very, very committed educators…who really walked the talk of what they believed…who were very much into…. Freire…that has been… a consciousness that has evolved for me in the past twenty years… I kind of wonder, "You know, I still have the same values or was it an accident that I ended up there?"…. I think the fact I was 21 when I started…. If I had done a degree and then gone on to get my masters in instructional design and then worked in an academic environment I'm sure I would have very different perspective. I don't know how different because I think there are also other values that I bring from my early life, to that mixture, but I think certainly that would be an issue.

Implications for Graduate Education and Practice

Lindemann Nelson (2001) casts discourse and narrative as both analytical and practical tools for moral and ethical theorizing. A counterstory to the master narrative of the "masculinist scientific scholarship and practice of instructional design" may be constituted of many parts, but the point of telling it is to keep the master narrative from "edging you out or forcing you in by countering them with identity-constituting stories that lessen the constrains on a person's moral agency" (p. 186).

How many opportunities do we take to share our counterstories, challenging the moral understandings of the "found community" of instructional design? If we have been criticized for "designing for ourselves" should we not understand our identities as designers? I believe that this kind of sustained critical reflection at micro- and macrolevels is essential for designing learning environments that are inclusive. For example, I might be very uneasy about learning assessment approaches in online courses. Why? Perhaps a conversation with peers about personal experiences with assessment reveals no exposure to formative assessment, or essay writing as the only available approach, or 100 % final multiple-choice examinations. From a feminist agentic point of view, these decisions cast learning as a zero-sum game, an exercise in internship in the powerful master narrative of the discipline, an experience of exclusion, even contrary to my learning culture. Perhaps the assessment tools available in the learning management system are very limited. How can they be subverted, or complemented?

I have wondered why we insist on the inevitable "History of the Field" course in graduate degrees. Might these kinds of courses continue to revere the Western scientific cognitive foundation of instructional design, and its staunchest practitioners? Can we undertake a deconstruction project that socially and historically situates instructional design pioneers in order to move forward with new ideas? As our community confronts change, how can we overcome the inertia presented by legacy curricula? The studio design approach is emerging, designerly thinking and practice has become a valuable discourse; debate has begun about the academic level of instructional design study, i.e., undergraduate vs. graduate.

Guggenheim Museum Bilbao, by architect Frank Gehry, is described as a "fusion of complex, swirling forms and captivating materiality that responds to an intricate program and an industrial urban context" and "not only changed the way that architects and people think about museums, but also boosted Bilbao's economy with its astounding success." The "Bilbao Effect" (Pagnotta, 2013) is the "phenomenon of a city's transformation following the construction of a significant piece of architecture that continues to challenge assumptions about the connections between art and architecture today." The building, seen by over 10,000,000 visitors and studied extensively by novice and expert architects, is precedent-setting as "a signal moment in the architecture culture (representing) one of those rare moments when critics, academics, and the general public were all completely united about something" (Trynauer, 2010, p.). Not without controversy (e.g., over its "gentrification effects"), Gerry's forms are almost instantly globally recognizable, although apparently he resists being associated with one "school," such as deconstructivism. "I started with this fish schtick. . . and started drawing the damn things, and I realized that they were architectural, conveying motion even when they were not. . . Most architects avoid double curves, as I did, because we didn't have a language for translation into a building that was viable and economical. I think the study of fish allowed me to create a kind of personal language." Gehry's concept of "the organization of the artist" is a counterpoint to the "marginalization of the artist," i.e., the design implementation depends on the artist staying in control throughout the process, rather than being driven by business or political interests. This concept was later adopted by Steve Jobs as a design principle.

Gehry's formative years exemplify the significance to designers of identity work. Born in 1929, he grew up in Toronto, Ontario, where his grandfather owned a hardware store. Gehry and his grandmother would use found objects (e.g., corrugated steel, scraps of wood) to build tiny cities; his mother regularly exposed him to the art world. As a young adult Gehry tried many jobs, such as radio announcing and truck driving; dissatisfied, he reflected on his relationships and embedded youthful experiences remembering that he loved going to museums, looking at paintings, listening to music, and drawing. "Those things came from my mother, who took me to concerts and museums. I remembered Grandma and the blocks, and just on a hunch, I tried some architecture classes" (Frank Gehry Interview, 1995). Gehry always works with models, using pleated cardboard, crushed paper-towel tubes, a Perrier bottle. "I move a piece of paper and agonize over it for a week, but in the end it was a matter of getting the stuff built," he tells. "The computer is a tool that lets the architect parent the project to the end, because it allows you to make accurate, descriptive, and detailed drawings of complicated forms" (Trynauer, 2010, np).

Similarly, Apple's Jonathon (Joney) Ives grew up in a design family; his father, Michael, worked with the British government to develop and set the standards for design education. Early on, father and son designed useful artifacts, such as a toboggan, together, always starting with a design sketch. Ives studied chemistry and sculpture, graduating from Newcastle Polytechnic in 1985 with the reputation for being "passionately detail-oriented, creating dozens of models of hearing aid to be used by deaf children and their teachers" (2014, p. 4). Ives describes Apple's design process as almost abstract, devoted to the pure idea, i.e., "Good design defines the market; ideas are king" (p. 5). Sullivan observes that in contemporary culture hits and likes threaten to overtake content in value, and the purity of an idea takes on increasing currency. Ives responds, "I think now more than ever it's important to be clear, to be singular, and to have a perspective, one you didn't generate as the result of doing a lot of focus groups," but instead having "Fascinating conversations" with his team about ideas and prototypes (p.6). In both these stories, the designer's experiences and values, interacting with context, define a signature pedagogy that is iconic, recognizable, deconstructable, relational, perhaps transformative. Is it replicable? Is it teachable? In my view, what matters more is both have influenced their disciplines and the broader culture because they are epistemologically grounded. Although I may recognize a David Jonassen-influenced problem-based design, I'm not sure I would be able to point to many other design "signatures" in our field. Is that partly because many are hidden behind secure firewalls, or mostly because designers are invisible, voiceless, and without social power in higher education? Does a MOOC represent signature pedagogy; what precedents will MOOCS contribute to design language?

In recent years, peer review, the master narrative of academe, has come under some scrutiny. Peer review, editorial boards, and chosen reviewers may act as disciplinary gatekeepers that edge out different perspectives. Do we *really* have a forum (e.g., a journal) that encourages alternative design thinking and practice? A found community in which it is safe to challenge the power and still get tenure? Or must unruly scholars continue to publish or be heard in communities with no power to create counterstories? In other words, *not* heard in the community that needs to consider other voices.

We need to begin to make room for alternative views and practices, i.e., the scholarship of instructional design (Cross, 1999, 2007; Tracey & Boling, 2013). For example, our colleagues are challenging instructional design as an objective, individual pursuit, and the use of theoretical models to guide practice (Gibbons & Yanchar, 2010; Boling et al., 2011); urging reflective practice (Tracey & Hutchinson, 2013; Tracey, Hutchinson, & Quinn Gryzbyk, 2014); accepting qualitative research methodologies and signature pedagogies (Boling & Smith, 2009; Boling & Smith, 2010), partnering designer identities/values with projects of (for example) social value, and so on.

Finally, for this chapter, I urge my colleagues to seek out the practice of our global communities. We tend to read only those accounts available in English, most of which reflect our worldview back to us (which we then replicate as if the whole world should do it *this* way). Are we in danger of becoming the Ugly Instructional Designer?

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The Kiowa Language and Culture Revitalization Program: Designing a Community-based Learning Model for an Endangered Language

Angie Calton, Xun Ge, Melody Redbird-Post, and Moge Wang

Abstract The Kiowa Language and Culture Revitalization Program is a community-based learning model designed to help language learners construct knowledge and practice an endangered language in situ through networks of community members, protocols, scaffolding, and tools. In this model, tribal members act as linguistic and cultural resources, and teachers use specially designed tools to elicit knowledge from tribal elders and to build knowledge of language and culture within the community. The design of the learning model is intended to serve as a framework for a variety of communities responding to the prospect of language extinction.

Keywords Community • Culture • Language • Instructional design • Community-based • Tribe • Process • Tools • Products • Procedures • Roles • Language immersion • Early childhood

Tribal peoples across the United States are endeavoring to revitalize their heritage languages and cultures. Struggling with the effects of colonization and assimilation, the Kiowa people have endured language loss since the late 1890s through various mechanisms, such as religious missionary efforts, forced boarding school attendance, and governmentally sanctioned, militarily backed cultural eradication campaigns.

Located in rural, southwestern Oklahoma, the tribal headquarters of the Kiowa Tribe of Oklahoma is situated within the historical boundaries of the Kiowa-Comanche-Apache Reservation. According to a 2012 survey of the status of the Kiowa language, the Kiowa Tribe of Oklahoma contains fewer than 12,000 tribal members, of which 50 % are under 18 years old, fewer than 40 tribal elders are fluent speakers, and only about .003 % of the population can speak Kiowa fluently (Drake, 2012). The fluent speakers that remain are well past retirement age and have

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no formal training in teaching the Kiowa language. Thus, without intervention, the Kiowa Tribe faces permanent and irrevocable loss of its language and major aspects of its culture since language carries culture (Redfield, 1941).

Early efforts to stem language loss were led by Kiowa tribal member Parker McKenzie, who worked with anthropologist John Peabody Harrington in the 1920s to develop a written orthography for his tribal language (McKenzie & Meadows, 2001). Until that time, the Kiowa language had never been written, depending instead on the oral transmission of the language from generation to generation. Since then, several orthographies have been developed, but none have been officially adopted. In addition, efforts to teach the language in formal classroom settings and to preserve the language through documentation have also been undertaken in recent years. However, the ability to use the language in context and to put words together naturally in a sentence has not been part of the curriculum of the tribally-run education system (Kiowa Tribal Museum OMAP Report, 2012).

Currently, the Kiowa language is considered a moribund language since there are no fluent child or young adult speakers of Kiowa. Many young adult Kiowa tribal members are separated from fluent speakers by two generations. Middle-aged Kiowa tribal members have basic or beginning knowledge of Kiowa but are reluctant to use the language publically due to the nuances in pronunciation that are required for appropriate and proper speech. *Ethnologue*: *Languages of the World* (Lewis, Simons, & Fennig, 2014) provides a comprehensive catalog of all of the world's known living languages. It classifies Kiowa as a dying language since its only fluent users are older than childbearing age, making it too late to restore natural intergenerational exposure to the language through the home. Therefore, a mechanism outside the home would need to be developed.

Roy (2007) contends that the dire state of Native American endangered languages will require entire communities to collaborate towards the common goal of language revitalization, putting aside politics and personal differences. Regarding the Kiowa language, specifically, Roy states that since so many remaining Kiowa speakers are elders, the path to language revitalization lies with focusing on educating the children and working towards creating new Kiowa language speakers at a very young age.

While there are many possible approaches to language revitalization, the research has shown that the most effective method of producing language users has been through the implementation of language immersion programs, especially with young children and through multigenerational interaction with fluent speakers (Hinton, 2011). When it comes to immersion programs as a method of language revitalization, there is a very small research base, mainly focused on international efforts, such as the Maori in New Zealand or the dual language learning programs in the United States. Early childhood immersion programs in Canada among First Nations have been described as integral to indigenous language and culture revitalizations, as well as promoting the well-being of the learners (Preston, Cottrell, Pelletier, & Pearce, 2012). Immersion schools have also been found to produce positive academic outcomes as well as enhance the cultural identity of participating learners (Gokee-Rindal, 2009).

The Kiowa Tribe Child Care Program

The Kiowa Tribe Child Care Program is the first tribal program to propose language immersion as a comprehensive solution to the issue of Kiowa language and cultural revitalization. The Kiowa Tribe's Kiowa Child Care Center is operated via a tribal Child Care and Development Fund grant awarded by the federal Department of Health and Human Services' Office of Child Care. As a state-licensed, tribally operated child care facility, the Kiowa Child Care Center emphasizes high-quality, evidence-based best practices within the context of both the Kiowa language and Kiowa culture. Ages served include infants, toddlers, 2–5 year olds, and school age children up to age 12 in 3 classrooms for a total of 34 participating children. This facility is a prime location for implementing a Kiowa language and culture revitalization program due to the fact that 98 % of child participants are of Kiowa descent. Teachers at the Kiowa Child Care Center are also of Kiowa descent.

Even though tribally-operated childcare facilities present an opportunity for language revitalization efforts, Preston et al. (2012) argues that, for endangered languages, there are very few pedagogical resources for teachers of endangered languages. Many tribes in the United States have sought to find approaches that fit not only their basic needs but also reflect their particular cultural and community context. Consequently, smaller tribes with a small group of language speakers must develop new strategies for instructing language teachers in the target language.

Creative, innovative language teaching and learning strategies must be implemented due to the lack of pedagogical resources available in the endangered language of interest. With fluent speakers who are elderly, language revitalization programs are dependent on teachers who are also second-language learners of the endangered language. Thus, effective language revitalization programs should include a professional development component that allows ample opportunity for the second-language-learner teachers to develop their language and teaching skills. Hinton (2011) proposes that in order for endangered languages to be revitalized, the main goal should be the creation of a language community.

A primary goal of the collective Kiowa tribal community is to sustain and renew the Kiowa language so that future generations will be fluent speakers. Elders are concerned that the language will become extinct and the general consensus as to how to avoid total language loss is to create fluent speakers of Kiowa, starting with the current generation of children. Hinton (2011) reflects that such a goal is complex, long-term, and encompasses generations of individuals who will advocate for the revitalization of the endangered language. Expectations of a successful language community include endangered language learners continuing to advocate for the language's survival by incorporating the endangered language into their daily lives over time and across generations. Furthermore, since Kiowa is the ancestral language of the learners, there is an intrinsic motivation for Kiowa tribal members to become fluent speakers of this endangered language. For some, it is a personal desire to regain a sense of their native identity and belonging to a community. For others, it is a political act, part of a desire to assert cultural autonomy or sovereignty (Hinton, 2011).

In programs that are well-developed and efficiently administered, young children are immersed in the target language beginning in the early years of a child's life, which greatly increases the likelihood that those children will become fluent speakers of the target language. For Hinton (2011), the primary goal of a language revitalization program is not only to save the language from extinction and bring it back into regular use, but also to help a community meet its broader goals. For example, learners may be motivated by a desire to reclaim or build a sense of identity, reinforce a sense of belonging to a minority culture, resist assimilation, take a political stance about cultural/linguistic autonomy, or gain access to spiritual /cultural enrichment. Eventually, those learners may become language activists, transmitters of the language to future generations (through teaching or parenthood), or help form a language community. A language revitalization program prompts community members and learners to reflect on their community and its place in the world, as they are required to consider the influence that the dominant language (English) may have on its own language or how to adapt and modernize the target language to make it functional for practical daily use. As a result, language teachers in this context need to have responsive and evolving strategies (Hinton, 2011).

The primary goal of the collective Kiowa tribal community in southwest Oklahoma, as evidenced by planning studies and community member surveys, is to implement Kiowa language revitalization programming in order to bring the Kiowa language back into daily use by Kiowa tribal youth. The Kiowa Language and Culture Revitalization Program will set out to implement a sustainable, authentic language revitalization program starting from early childhood education within the context of tribal early childhood language immersion. In order to achieve this, all members of the community will need to be actively involved.

Planning studies were conducted during the months of September 2013–March 2014 in the form of surveys, interviews, and meetings with community members. Expanding on the 2009 Kiowa Language Assessment Survey and Report (Native American Studies Department, 2009), the surveys conducted by the Kiowa Tribe Child Care Program staff in 2013 focused on what the Kiowa tribal elders, community members, and Kiowa families valued and viewed as important to consider when developing Kiowa language and cultural activities for the youth. The responses and analysis revealed the importance the arts play in the language and culture of the Kiowa people. Songs, prayers, dance, literature, and the visual arts provide rich opportunities for contextualized language exposure.

A Community-based Learning Model

The learning model designed to achieve these goals is driven by a constructivist approach, which maintains that knowledge is individually and socially constructed based on how learners' interpret their experience of the world (Jonassen, 1991).

This approach is fostered through participation in a tribal learning community, which meets the criteria outlined by Bielaczyc and Collins (1999):

- Diverse expertise is represented within the community.
- The goal of advancing collective knowledge is shared by the community.
- There is an emphasis on learning how to learn.
- There are ways to share what is learned.

Jonassen and Rohrer-Murphy's (1999) Activity Theory Design Model, which focuses on the interaction of human activity and the mind within its relevant environmental contexts, has also inspired the design. Rather than focusing on knowledge states, our learning model focuses on the activities in which individuals (learners) are engaged, the nature of the resources they use in those activities, the social and contextual relationships among the collaborators in those activities, the goals and intentions of those activities and the objectives and outcomes of those activities, and the tools the community members use to accomplish their goals.

Within any learning community there is a complex interplay between learner, community, resources, and contexts. Language is not just the medium of culture but also an aspect of culture. It adaptively responds to represent evolving memes and to express subcultures (based on gender, class, age, status, level of education, geography, etc.) within the broader culture. The community and its resources help mediate between the learner and the language and culture. The learner is engaged in the activity of revitalizing the Kiowa language and preserving its culture through knowledge construction. The role of the learner may be fulfilled by any of the community members in the social environment. In addition to acting as the learner, they may also serve as a resource for another community member (Fig. 1).

For example, a "teacher" may be considered a "learner" while she is involved in improving her language skills through interactions with tribal elders. However, once she begins to interact with the children, she becomes a language and cultural resource. In the same sense, the child may be a "learner" working with a teacher to construct new knowledge but in the next moment, she may be mentoring younger or more novice "learners," or modeling language for a parent or caregiver "learner." So, at any given time, depending on the interaction and activity, any community member may jump into the role of learner, or serve as a resource. This creates a highly flexible and dynamic system.

The connected nature of the model means that individuals involved in a particular activity are simultaneously members of other task groups. These individuals and community members naturally have different products, processes, performances, social dynamics, and tools. For this reason, the efforts and outcomes of various members are inextricably intertwined, making this complex and interactive learning system truly collaborative.

For example, the product of the elder–teacher interaction may be a set of materials that will serve as a scaffold for the teacher–child interaction, which may culminate in a performance that will eventually model language for the child–parent interaction. From this evolving scenario, it becomes clear how interdependent

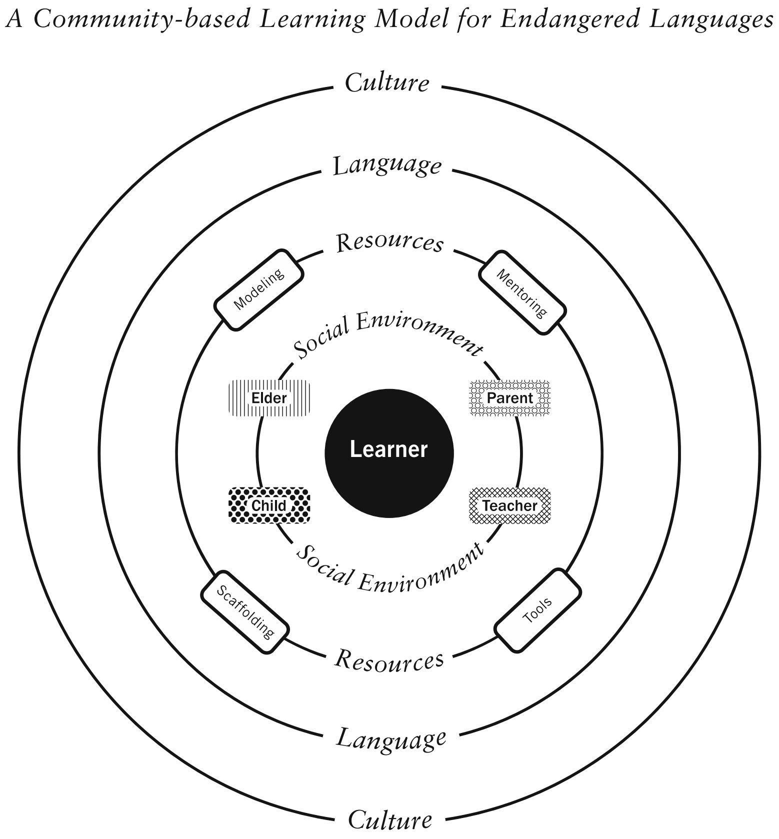

Fig. 1 A community-based learning model

the community members' roles, functions, and activities are in building shared knowledge (Fig. 2).

The flowchart below illustrates the relationships, processes, and products involved in a particular learning cycle. Recently, teachers observed the popularity of the Ylvis song "What Does the Fox Say?" among the children in the Kiowa Child Care Center. The teachers felt this song could form the basis of a set of engaging learning activities for the children. As a group, the teachers outlined learning objectives related to the song. They also identified possible target language and a set of materials they would need to create in order to support those objectives. During their regular meeting with tribal elders, the teacher adjusted the lyrics of the song to better reflect the specific Plains animals that are culturally significant to the Kiowa. They elicited from the elders the target language needed in order to sing the song in Kiowa. However, the elders were not able to supply or model all of the target language needed for the project, and the teachers had to find

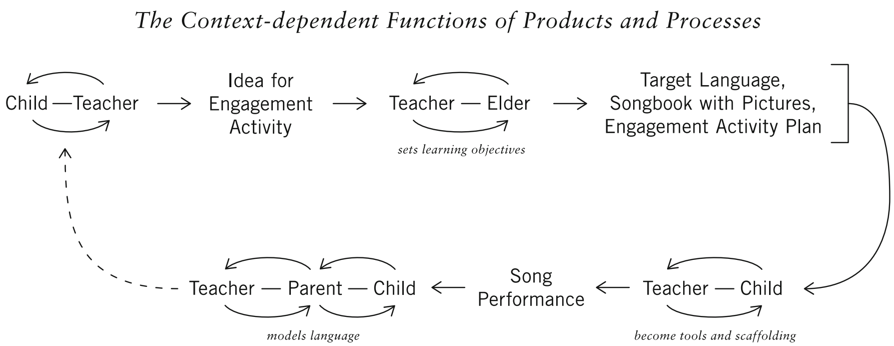

Fig. 2 The context-dependent functions of products and processes

other community members to help fill in the gaps and to check their accuracy. This elder–teacher process resulted in a set of learning objectives, a list of target language, learning materials (such as flashcards, mp3 audio file, language reference, and songbook) and an activity plan. These "products" were the outcome of the elder–teacher learning process. However, eventually these products were used to scaffold the subsequent learning process between the teachers and children. The materials were used to help present language in context, clarify meaning, and practice the lyrics of the Kiowa version of the song "What Does the Fox Say?" The outcome or "product" of the teacher–child interaction was a successful public performance of the song. However, through at-home practice and the public performance, the child models and/or recycles the target language for their caregivers and the community at large. The child or parent may want to add a verse to the song with an animal of their own choice, and ask the teacher, elders, or other community members to help them find the language they need.

These interactions, products, and processes can be applied to any kind of activity, from giving instructions in Kiowa on how to make and play a traditional hoop game or how to dry meat, to using Kiowa for routine class management tasks, to lunchtime routines and with class helpers. The curriculum is not predetermined; rather, it is constantly negotiated from within the community.

In addition to regular interviews, surveys, and meetings with the parents and community, a set of observation and assessment tools have been developed to support teachers in creating original engagement and activity plans. These cognitive tools enable teachers to observe and document children's interests, skills, abilities, as well as their needs, all of which are taken into consideration when teachers develop their weekly plans and corresponding activities.

Once the community has decided *what* to learn, the teachers must begin to consider *how* to learn what they need to know. The figure below shows the possible types of activities that are likely to occur between Elder–Teacher and Teacher–Child interactions. Notice how the roles and activities of the teacher shift depending on whether they are interacting with elders or children (Fig. 3).

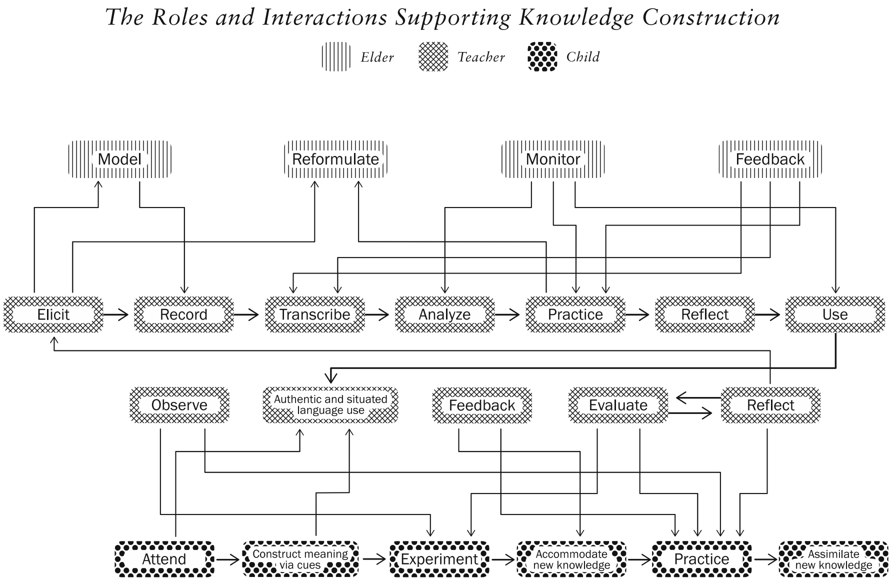

Fig. 3 The roles and interactions supporting knowledge construction

In the Elder–Teacher interaction, the tribal elder will serve as a language and culture resource for the teacher, who will act as the learner. The teacher will need to be able to break down the component skills/target language related to the learning objectives they have outlined for their interactions with the children. As the carrier of language, culture, wisdom, and history, the elder will serve as a language model and mentor, who will help reformulate awkward utterances or elaborate on the teachers' prior knowledge. The teachers will elicit, record, analyze, practice, reflect, and use the target language or skill. Initially, they will be provided with tools, technology, and protocols to scaffold their learning. A sample of the Elder–Teacher interaction can be found below (Table 1).

In the Teacher–Child interaction, the teacher will serve as a language and culture resource for the child, who will act as the learner. The teacher will introduce the target language in a context and will continually observe, evaluate, and reflect on the children's progress and how their efforts as teachers have either helped or hindered that progress. Those insights will be fed back into the Elder–Teacher interaction, and will start a new learning cycle for the teacher as "learner."

A host of other well-structured and ill-structured interactions, such as Child–Child, Child–Parent, Child–Community, Elder–Child, etc., can enable a variety of learners to co-construct, share, and apply knowledge in authentic and meaningful ways. There are opportunities to motivate the community by extending learning beyond the intentional environment of the Kiowa Child Care Center to seasonal ceremonial events, knowledge demonstrations at community venues, summer language camps, language fairs, powwows, church gatherings, family reunions, and at home during family interactive activities.

Table 1 Elder–Teacher: sample protocols and tools

Stage	Tool	Description	Sample dialogue
1. Identify objectives and elicit language	Language elicitation worksheet	• The teachers sit in a circle around a laptop or other recording device	*Head teacher*: This week we will be focusing on family. Let's think about the types of language we will need to talk about families, and the kinds of activities we can do with the students. Work in pairs to come up with an activity and target language. (after 5 min of pair work)
		• They think about the lesson theme and generate a list of target language, knowledge, skills, and/or attitudes they would like for the student to achieve. This can be generated individually (silently), or brainstormed together as a group	*Teacher 1 and 2*: We want the 5–8-year-old students to be able to introduce members of their families appropriately. We plan to do this by telling the story of Robby the Rabbit and his friend Hopper. Here is the target language we would like to use
		• They can document the language on the lesson plan template	• *Mother/father*
			• *Grandmother/grandfather*
			• (*big*) *sister*/(*little*) *brother*
			• *Aunt/uncle*
			• *My friend*
			• *This is my…*
			Nice to meet you./Nice to meet you, too

(continued)

Table 1 (continued)

Stage	Tool	Description	Sample dialogue
2. Record target language	Audio recording device	• Once they have determined what the target language and lesson objectives will be, they can try to tell the group (in Kiowa). If teachers have the language ability, they should try to do this in Kiowa	*Elder*: In Kiowa, "aunt" is *tsaw-yee or khaw*. "Tsaw-yee" is used when talking about your father's sister, "khaw" is used to talk about your mother's sister. (The teachers listen and repeat. Teacher 1 records these sentences. The elder records these sentences)
		• If the utterance is wrong or unnatural, the Elder can invite another teacher to correct it. If one of the peers cannot help, the Elder can reformulate the unnatural utterance. If the teacher is unable to say any part of the utterance in Kiowa, they tell the group what they wish to say using English. Can anyone translate? If not, the tribal elder will translate their English into Kiowa. As this process is going on, all teachers are encouraged to "overhear" their peers' struggle to communicate	*Teacher 3 and 4*: We want the students to make masks so they can act out the story. We want to demonstrate how to make the masks while using Kiowa to give the instructions. Here is the language we think we'll need ...
		• Once the target language has been modeled and practiced, the teacher (or Elder) will record the correct utterance on the recording device	• *Mask*
		• Another teacher will have a turn and more language will be added to the recording	• *Paper plate*, *yarn*, *scissors*, *pipe cleaners*
			• *Whiskers*, *ears*
			• *Cut*, *draw*, *color*, *glue*, *punch holes*, *tie*
			Elder: Listen to me (elder demonstrates the target language), *put your fingers on top of your head*. (teachers repeat). Now listen (elder demonstrates) *Draw your character's face on the paper plate to make a mask. Cut out rabbit ears. Glue the ears on the paper plate. Cut the yarn*, *Punch holes in the sides of the mask* (The teachers listen and repeat. Teacher 4 records these sentences. The elder records these sentences)

3. Transcribe recording	Transcript and language analysis worksheet	• Teachers listen to the tape and transcribe the target language	*Head teacher*: Let's listen to the recordings. As we listen, write down what you hear. We will listen to each utterance three times. (after writing down utterances) Teacher 1, please write the first utterance on the board. Teacher 2, please write the second utterance on the board, etc.
		• The Elder may need to provide a lot of assistance and support in the beginning. Gradually, over time, the Elder will intervene less and less until the group is self-sufficient	Elder, can you check us?
			Elder: Sure, there are only a couple of mistakes. (Elder corrects on board and explains mistakes)
4. Analyze language	Transcript and language analysis worksheet	• Teachers and Elders work together to analyze the language. Are there any sentence patterns? What vocabulary or verb forms/tenses were used and which were not, why?	*Head teacher*: What patterns do you notice from these sample sentences?
		• In the beginning the Elder will need to guide this process. They can focus on common mistakes. But as the teachers improve, they will need to be totally involved in the process, choosing what to analyze	*Teacher 3*: tdawn-aydle, tdawn-shaw, tdawn-adle ("big" and "older" seem similar)
			Teacher 2: So, it seems that we need to change the way we say "grandma" if we are talking to her directly. But if we are talking about grandma we need to show whether she is our mother's mother or father's mother
			Elder: Yes, that's right

(continued)

Table 1 (continued)

Stage	Tool	Description	Sample dialogue
5. Reflect on language and instructional intervention	Personal error worksheet language reflection worksheet	• After all the target language has been recorded, the teachers reflect on the lesson they have prepared to teach. They can review the recording to remind them of all the language	*Head teacher*: What do you think will be the most challenging about using this language this week? For us? For our learners?
		• Together as a group, they should identify what might be easy or challenging for their students or for them as teachers of Kiowa	*Teacher 1*: I think it might be confusing that there are three ways to talk about "grandma"
		• As a group they think of strategies and possible solutions (This part is not recorded)	*Head teacher*: What can we do to help make the meaning clear for our learners?
			Teacher 4: I think we could use images to show the difference when we present them. Perhaps we could use a story, and use characters to help contextualize those differences
			Teacher 3: But we can also give extra practice by explaining "my mother's mother is my grandmother". "My father's mother is my grandmother". This can give our learners extra practice
6. Practice	Peer or Elder personal error worksheet	• Time permitting: the teachers can pair up to run through the lesson or target language they intend to teach	*Head teacher*: Now Teacher 1 and Teacher 3 work together, and Teacher 2 and 4 work together. Try to lead your partner through your plan using the target language (Elder monitors and supervises)
		• The Elder can monitor this activity and provide feedback or error correction at the end of the activity	*Head teacher*: What do you think you need to practice? Be sure to take a copy of the recording with you as you leave
		• The teachers can provide peer correction and feedback when necessary	
7. Reflect	Activity reflection worksheet	• After leading students through an engagement activity, the teacher uses the Reflection worksheet to analyze the strengths/weaknesses of the encounter and what to do differently next time	

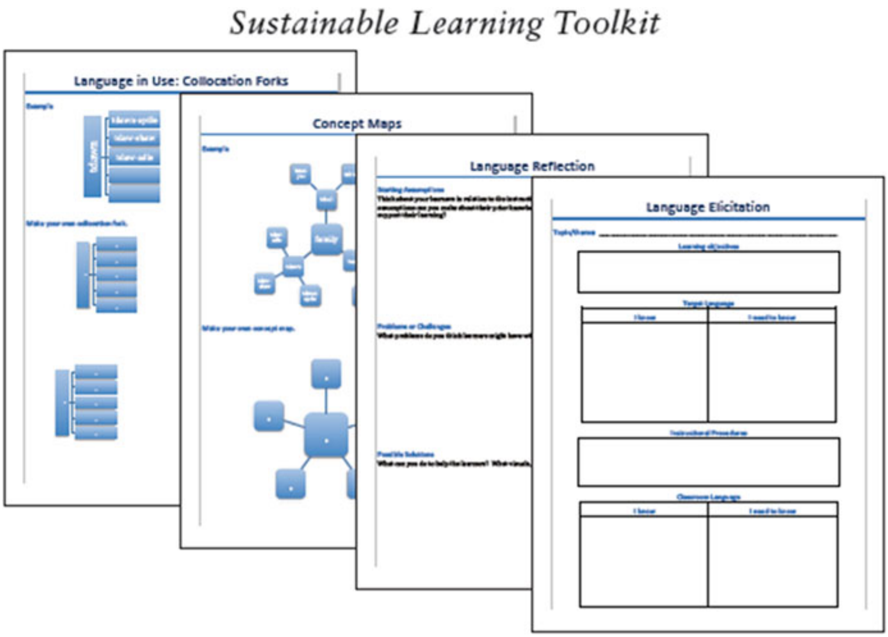

Fig. 4 A sample of materials from the sustainable learning toolkit

A variety of physical and cognitive tools have been developed to elicit the language/culture, mentor learners, or scaffold learning for each of the interactions. According to Jonassen and Carr (2000), cognitive tools scaffold important processes of articulation and reflection, which are the foundations of knowledge construction. They empower the learners to think meaningfully and to take ownership of their knowledge, rather than reproducing knowledge passed to them by teachers. They can be used to facilitate knowledge acquisition, integration, organization, and representation. These tools include things like semantic organizers, procedures, methods, workflows, metacognitive instruments, conversational supports, knowledge building templates, and more (Jonassen & Carr, 2000) (Fig. 4).

As the teachers grow more confident, they can begin to direct their own learning process. They can decide whether to keep, adapt, or discard the prepackaged supports or create their own. They will choose whether to take notes or make a video of elders modeling language. They will determine whether to analyze language by noticing patterns of usage from sample sentences or by deconstructing sentences into various parts of speech. They will choose whether to practice through drills, dialogue building, or free roleplay. By leaving learning open-ended, teachers will have the opportunity to make discoveries about the Kiowa language and learning in general.

Plan for Future Implementation

The Kiowa Child Care Center has already begun experimenting with the framework and cognitive tools. However, at the time of writing, the stakeholders are discussing how to best fully implement the learning model given current resources. The Kiowa Language and Culture Revitalization Program has identified three broad goals for implementation.

Goal 1: By the end of Year 3, train a minimum of five teachers via the implementation of a teacher training program using the community-based learning model detailing the interactions between teachers of Kiowa language and Kiowa elders who are fluent speakers with a minimum of two 1-h elder mentorship sessions per week, where teachers will elicit the target language necessary for creating engagement activities with the children.

Goal 2: By the end of Year 3, implement Kiowa language immersion via 3-h sessions led by teachers and based on information and resources constructed during the Elder–Teacher Mentorship sessions.

Goal 3: By the end of Year 3, design, develop, and complete a minimum of three sets of Kiowa language learning materials that each encompass a unified theme as well as correlate with teacher activity plans and the children's developmental abilities, and are available in print, audio, video, or digital formats for use in Kiowa language immersion sessions and during parent–child interactions outside of the traditional classroom setting.

Evaluation

Since the curriculum is not predetermined and can evolve according to the interests and needs of the community, the evaluation will focus on gains in overall language proficiency and cultural awareness, rather than achievement of a predefined set of objectives. The learners will be evaluated on their ability to communicate using the target language and/or appropriately respond in a range of authentic situations. Their development will be determined by (1) Administering Pretest and Posttest of learners' proficiency levels using locally designed, collaboratively developed Kiowa language assessment tools that will measure Kiowa language speaking and listening skills at the beginning and the end of Year 1, and by Year 2, the Pre/Posttest measure will have been expanded to include valid assessment of Kiowa language reading and writing skills once a consistent Kiowa language orthography has been developed, finalized, reviewed, and identified as ready for use by all collaborative stakeholders of the Program. The language proficiency and fluency levels will be guided by the American Council on the Teaching of Foreign Languages (ACTFL) Proficiency Guidelines 2012, which delineate proficiency levels as Novice, Intermediate, Advanced, Superior, and Distinguished across four domains that include speaking, listening, reading, and writing. (2) Additional insight into developing reliable proficiency measures can be given by a review of the Common European Framework of Reference for Languages—Learning, Teaching, Assessment grids for language proficiency assessment development (Council of Europe, 2001). It is used to describe the linguistic, sociolinguistic, and pragmatic competencies of learners of foreign languages and serves as a reference for many international language proficiency exams. (3) PrePost test measures will be completed and conducted for both the adult participants as well as the child participants by the end of the program Year 1.

All participating children will be assessed upon their entry into the program, or for currently enrolled children at the Kiowa Child Care Center, assessed for the Pretest measure by the end of the program Month 1 using the locally developed and collaboratively designed pretest/posttest measure for Kiowa language speaking and listening proficiency adjusted to be developmentally appropriate for children ages 1–12 years old. Participating children will also be assessed at the end of each program year using the posttest measure. All participating childcare teachers will be assessed using an age-appropriate pretest/posttest measure by the end of Month 1. Participating teachers will then be assessed using the posttest measure at the end of each program year. Learners are expected to progress to the next proficiency level after 200 h of active engagement with the language and culture. At the end of each program year, based on the results, participants are encouraged to set goals, negotiate the processes used to achieve those goals, reflect on performance, and refine practice.

Summative evaluation at the conclusion of Year 3 of the Kiowa Language and Culture Revitalization Program will be conducted. Surveys, field observations, interviews, and other data from all 3 years of the program will be collected and analyzed in order to gauge an overall perspective of the status of the Kiowa language. *Ethnalogue*'*s* Expanded Graded Intergenerational Disruption Scale (Lewis et al., 2014) will be used to benchmark the program's success in reversing language shift in the wider community. This scale, also known as the EGIDS, is an 11-point scale used to describe the vitality and reach of the world's living languages, with 10 indicating extinct languages and 0 indicating languages used as a lingua franca. The status of the Kiowa language is currently ranked at level 8b (nearly extinct). The goal is to move the language down the scale to a more safe and secure status.

Implications

How can learning be supported in a community where qualified instructors and subject matter experts are scarce, conventional learning materials do not exist, and institutions of learning have been regarded historically with suspicion due to past programs of cultural assimilation? Revitalizing endangered languages and cultures presents a unique challenge for instructional designers. We set out to create a self-directed, self-sustaining constructivist-learning model that equips community members with effective tools and procedures, enabling them to identify and fulfill the needs of their specific community. In many ways, by aiming to help community members become autonomous learners, this community-based model mirrors the instructional design process in that it seeks to help members determine *what* to learn and *how* to learn it.

In reflecting on the development of this learning model, the boundary between the designers and the design is called into question, as the designers become incorporated into the design through modeling and scaffolding the instructional design process, and mentoring the community to become self-determined designers in their own right. Likewise, the barrier between "teacher" and "learner" reveals itself to be very thin, if nonexistent. In this learning community, teachers learn from tribal elders about their heritage language and culture. Tribal elders learn *about* their language and the learning process through tough questions and language elicitation sessions. Children learn from their peers while parents learn from their children.

The Community-based Learning Model provides a framework in which to understand and explore one's role(s) in the process of reclaiming and constructing knowledge. The recommended procedures and cognitive tools are designed to support members in carrying out those roles. However, as the community builds confidence and expertise, gains a deeper understanding of the target language and the learning process, and reflects on their practice and shared goals, they may decide to add to, modify, replace, or even abandon the original set of procedures and cognitive tools in order to better respond to the community's evolving needs, interests, and skills.

If we were to visit the Kiowa Child Care Center in 5 years, we might find the original Language and Culture Revitalization Program has transformed into something unrecognizable, as community members take more ownership over the processes and tools. This places the community members in the role of instructional designers, requiring them, rather than outsiders, to monitor and evaluate the group's processes and outcomes, encouraging a community-wide conversation about what is working or what is not working, and modifying or strengthening the approach based on observations and other evidence. This begs the questions, To what extent could the practice of instructional design itself facilitate learning? Could the activities and processes that have traditionally been used to help designers create instructional materials or sequence content be mined for their own instructional potential?

Taking ownership of this ongoing and ever-evolving process by fully engaging in the struggle to reclaim lost knowledge and striving to co-construct a relevant and vibrant language and culture is just as valuable as the eventual intended language acquisition. This active participation has the potential to energize the community and sustain its interest in the collective mission and its continued advocacy of the group's goals. This is true, whether the learning community is focused on reversing language and culture shift or some other endeavor.

The Community-based Learning Model is intended to provide a generalizable framework that can be adapted for a variety of communities, yet it is customizable enough to accommodate specific contexts. The framework could be used amongst refugee or immigrant communities to help preserve or express identity, to counteract pressures exerted by the dominant culture, or to act as a bridge between the native and adopted languages and cultures. The framework could also be used by more established communities to revitalize creoles and strengthen microcultures.

However it is used, the learning model leads to a fundamental rethinking of the role of an instructional designer. While two other chapters in this book (Exter, Dionne, & Lukasik, 2015; Stefiniak, 2015) discuss the importance of flexibility in learner-centered designs, and suggest it is essential to plan for learners to have limited input at various stages of the design process (often predetermined by the designers), perhaps designers should relinquish even more control, and completely hand over the reins to the learners while coaching them on instructional design principles and practices. In this framework, where the community members are subject matter expert(s), learner(s), teacher(s), and instructional designer(s) rolled into one, the designer's job is to work in service to the community to help it articulate and research a problem, define its goals and determine how to evaluate whether those goals have been adequately met. The designer can help the community to identify sources of relevant expert knowledge and by modeling ways to leverage that expertise through protocols, cognitive tools, and other resources that help make learning explicit. The designer can encourage the community to regularly revisit and revise their systems and procedures to better tune them to their stated goals and learners. In addition, the designer can help members identify the various roles they may play in the community, the nature of their interactions with other community members, and the processes and products involved in those interactions.

While the designer can provide initial procedures, cognitive and metacognitive tools to support the community, the community must ultimately learn to direct and sustain itself, and recorrect its course when necessary. In essence, the instructional designer must equip the community with the basic tools of instructional design and provide ongoing support and coaching as needed or requested.

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Examining Learning Experience in Two Online Courses Using Web Logs and Experience Sampling Method (ESM)

Sanghoon Park

Abstract Web mining and visualization techniques are used to discover the underlying patterns of online learning experience. Yet, the analytics are often limited to merely behavioral data lacking other critical dimensions that form an important part of the learning experience such as learners' cognitive involvement and emotional experience. Therefore, it is critical to find a method that can capture a holistic online learning experience while a learner progresses in an online course. This chapter introduces the Experience Sampling Method (ESM) that can be used to supplement Web Log Analysis (WLA) by collecting data on learners' cognitive involvement and emotion in each learning task. Then this chapter reports a case study of utilizing the ESM and WLA to examine online learning experiences in a discussion-focused online course and a design-/development-focused online course. Lastly, a visualized learning experience dashboard is presented to show an individual learner's learning experience based upon the three dimensions of learning experience.

Keywords Learning experience • Web log analysis • Experience sampling method • Visualization • Online learning

Introduction

The number of online programs in higher education across the nation has been growing fast. Recent research shows that more than a total of 7.1 million students are taking at least one online course as of 2012, with an increase of 411,000 since 2011 (Allen & Seaman, 2014). Sixty-two percent of higher education institutions are now providing complete online programs across almost all disciplines (Allen & Seaman, 2014). The number is expected to grow exponentially as online learning

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has become a widespread platform for providing formal learning experience at the higher education level (Harasim, 2012; Moller, Foshay, & Huett, 2008; Shea & Bidjerano, 2014).

With the increasing need for online learning, more and more universities are striving to meet a huge demand for high-quality online courses. As a result, e-learning systems or learning management systems (LMS), are expected to provide students with optimized learning experience throughout the course (Mahajan, Sodhi, & Mahajan, 2014). Many current LMS such as CANVAS or Moodle offer various sets of learning analytics to help analyze learning experience, such as course log history, number of views for each page, number of comments, punctuality of assignment submission, and other technology usage.

Web mining and statistical techniques can be applied to analyze the data and produce valuable information on learning experience. However, the analytics are often limited to only behavioral data lacking other critical data such as students' personal attributes, including cognitive process, motivational experience, and emotional experiences that form an important part of learning. Therefore, it is critical to systematically approach "learning experience" from two aspects of experience. One is behavioral experiences like Web logs that are automatically recorded in the learning management system, and the other is psychological experiences that can be measured throughout the course for each learning event. By combining two such dimensions of learning experience, we are capable of analyzing each individual learner's experience in online learning and further providing the most optimized learning experience.

Literature Review

Learning Experience in Online Learning

Online distance learning has been highlighted to learners as a reliable alternative to face-to-face education (Brady, Holcomb, & Smith, 2010; Harasim, 2012; Velestianos & Navarrete, 2012). According to Allen and Seaman (2014), over 20 % of all higher education institutions claim that online education is critical for their long-term strategy. A total of 41 % of chief academic officers, however, reported that retaining students was a greater problem for online courses than for face-to-face courses. Both the wave of the popularity of online learning and the concern for the retention of students have brought the advance features in LMS, such as learner analytics or learning analytics. Learning analytics is concerned with the collection and analysis of learning experience data in order to inform and improve learning processes and outcomes (Siemens et al., 2011). It can be explained in two different levels, macrolevel and microlevel (Ferguson, 2012). The macrolevel learning analytics involves administrators and policy makers having the opportunity to use the analytics data to make programmatic or legislative decisions. On the other hand, the microlevel learning analytics are for learners and teachers to have the opportunity to make more local decisions about the current learning events they are involved in (Clow, 2012; Wise, Zhao, & Hausknecht, 2014).

Consequently, researchers have been exploring various analytic strategies to present an effective and efficient learning content, to promote interactions, and to support learners' affective status such as emotion and motivation in LMS. The overall goal of such content design, interaction design, and motivational design has focused on providing learners with the most optimal level of learning experience during the course of online learning.

The word "experience" and the idea of "user experience" are often used in designing and developing interactions between users and products (Forlizzi & Ford, 2000). Forlizzi and Ford further explained "experience" in three different ways: experience, an experience, and experience as story.

In general, an online course is offered through a packaged set of learning experiences that the course instructor or instructional designer designed, developed, and uploaded on the LMS. We often refer to it as teacher-led learning experiences because students usually have no input into the content design and development process (Cowan & Butler, 2013). Through the intended learning experiences that are designed to achieve a certain leaning goal, online learners experience different levels of "experience" through the mixture of smaller experiences as described in Table 1. For example, when a student completes a textbook reading and discussion assignment, he/she first reads the assigned textbook chapter; writes a review/summary of the reading, or shares their ideas with others on discussion board; and reads others' discussions to understand different perspectives and viewpoints. Each smaller experience contains a certain level of different "experiences" that are "experience" as in interacting within a learning environment, "experience" as in opening oneself to comments from peers, and "experience" as in communicating his/her own comments to other peers.

To be successful in online learning, learners need to be prepared for the learning experiences, take the necessary steps to go through the designed learning experiences, manage and evaluate the learning, and provide self-feedback and judgment, while simultaneously maintaining a high level of motivation (McLoughlin & Lee, 2010). In other words, the direction and the depth of online learning that learners are ready to regulate to a far greater degree determines online learners' successful learning experience (White, 1994). It is also believed that greater participation in course communication results in online learners' experience in higher cognitive learning (Paskey, 2001), and an appropriate level of interactions is linked to higher satisfaction and performance (Borokhovski, Tamim, Bernard, Abrami, & Sokolovskaya, 2012; Meyer, 2003). Therefore, learning experience in online learning needs to be investigated through multiple aspects, including learners' cognitive experience, learning-related emotions, and behavioral participation in the course. As Veletsianos and Doering (2010) argued, it is imperative to understand online learners' long-term experience throughout the semester rather than examining short-term learning experience because of the long-term nature of online learning programs. As the overall "experience" in online learning is made up of an infinite number of smaller

Table 1 Three ways of understanding the concept of "experience" (Forlizzi & Ford, 2000)

	Cognitive experience	An experience	Experience as story
Concept	• The constant stream that happens during moments of consciousness	• Experience that has a beginning and an end, and changes the user, and sometimes, the context of the experience as a result	• Stories are the vehicles that we use to condense and remember experiences, and to communicate them in a variety of situations to certain audiences
	• Experiences that require us to think about what we are doing		
Example	• Interactions with new products, interactions with confusing or unfamiliar products and environments, or tasks that require attention, cognitive effort, or problem-solving skills	• Witnessing a story that allows us to feel powerful emotions, assess our system of values, and possibly make changes in our behavior	• Experience as story plays an important role in events as diverse as legal testimony and fantasy gaming
		• Powerful selection of stories leading us through an experience as we read them	• Relevance for sharing user findings with a design team of various disciplines
Related theory	• Richard Carlson's theory of consciousness known as Experienced Cognition	• John Dewey referred to in his book *Art as Experience*	• Roger Schank
			• an AI researcher

experiences that are related to learning contexts, learning content, and peer learners/instructor interactions, a series of the short-term learning experiences needs to be combined to draw a big picture of "online learning experience" within a given course.

One of the most commonly used methods in analyzing users'/learners' experience is to use Web log data. The Web Log Analysis (WLA) can provide valuable information and insights on how the online learners utilize the online course site by retrieving sets of user data (Mahajan et al., 2014). Yet, it is often limited to only behavioral data, and there is a need to supplement the Web log data with other learner-oriented psychological experience data, such as cognitive involvement and emotion. In the sections below, suggested are two methods that are reciprocally supplemental when investigating "learning experience" in online learning. WLA is suggested as a method to collect and analyze online learners' behavioral pattern data, and Experience Sampling Method (ESM) is suggested as a way to further explore online learners' cognitive involvement and emotion.

Web Log Analysis

Web log files contain the list of user actions that have occurred during a certain period of time (Grace, Maheswari, & Nagamalai, 2011). Many LMS, including Blackboard and CANVAS, are now offering a learning analytics feature in their platform. The vast amount of user information can be used to find an answer to questions such as How many times per day and how often students log in, how many times and how often do they post on discussion boards, how many times and how often do they interact with their classmates or course instructor, how many students submit assignments on time or late, and how are their grades? The data can be presented in the form of class as an analysis unit or by each individual learner. Two example screens are presented in Figs. 1 and 2. Figure 1 shows a screen capture of CANVAS LMS analytics that visually presents the number/type of class activities, class participation, the number/type of communications with the course instructor,

Fig. 1 Example screen capture of learning analytics data on the individual learner level (CANVAS LMS)

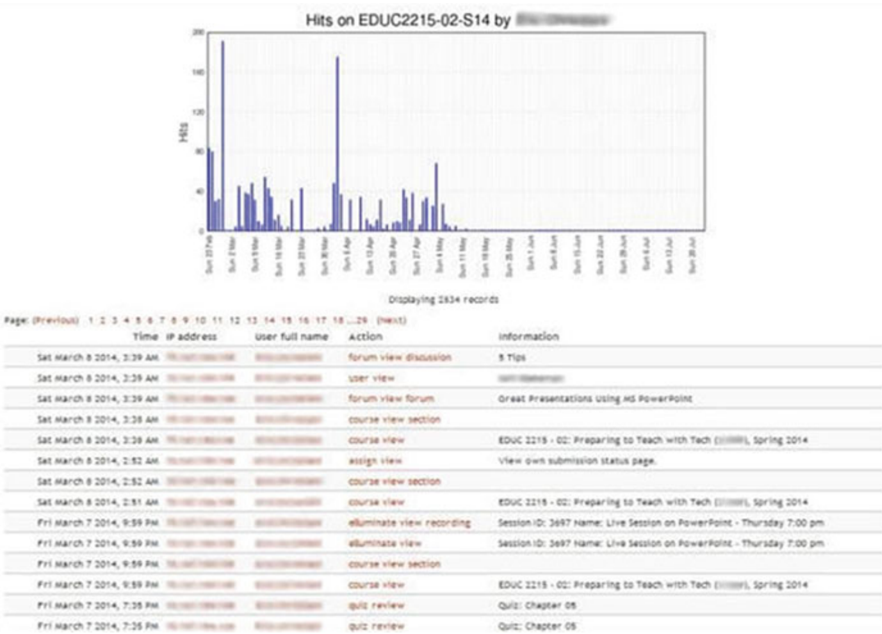

Fig. 2 Example screen capture of learning analytics data on the individual learner level (MOODLE LMS)

the punctuality of assignment submission, and grades for each assignment for each individual student.

Moodle LMS, on the other hand, provides the list of course activities for each individual student in the chronological order. Thus, the course instructor is able to view behavioral actions taken by each student while he/she is taking the course (Fig. 2).

As described earlier, learning analytics at a macrolevel can aid school administrators to improve institutional efficiency in online learning. Also it can help course instructors identify struggling students, enhance course efficiency, and further successful completion rates at a microlevel. Many previous studies show the benefits of analyzing learners' Web log data to understand learner behavior in the online learning system. For example, Hellwege, Gleadow, and McNaught (1996) found a behavioral pattern showing that learners access the most recent lecture notes first when using a geology Website, then viewed a couple of key slides before returning to a previous lecture. Also, after analyzing a long file for learners, Sheard, Albrecht, and Butbul (2005) found that knowing when the student accesses various resources can help educators understand student's preferred learning patterns. Later, Vanijja and Supattathum (2006) reported the results of log data analysis in terms of usage pattern among various e-learning courses. With regard to using log data to investigate learning effectiveness, Peled and Rashty (1999) found interesting results that the most popular online activities were, in general, passive activities such as focusing on getting information rather than contributing activities. Dringus and Ellis (2005) analyzed asynchronous discussion form of usage data to evaluate the progress of a threaded discussion. Valsamidis and Democritus (2011) examined the relationship between a student activity and their grades in e-learning and found that the quality of learning content is closely related to the students' grades and the instructors should improve their courses in order to increase students' learning experience.

While Web log data can provide online learners' personal information (such as profile, assignment scores, and interaction data) and behavioral experience data (such as reading, writing, taking tests, performing various tasks, and communicating with peers/instructor) (Mostow et al., 2005), their cognitive experience (such as whether they invested their learning efforts into a certain learning task during the course) or affective experience (emotions aroused in response to a certain learning task during the course) is often unclear.

Experience Sampling Method

ESM is a means for collecting information about both the context and content of the daily life of individuals, and it affords an opportunity to "examine fluctuations in the stream of consciousness and the links between the external context and the contents of the mind" (Hektner, Schmidt, & Csikszentmihalyi, 2007, p. 6). A researcher begins the ESM method by asking individuals to provide written responses to both open-ended and closed-ended questions at several random points throughout each day of normal week. Then each individual is prompted to respond using a predesigned signaling strategy. According to Hektner et al. (2007), the questionnaire can be tailored to meet the researchers' interest and goals, but in general, questions often include physical context, social context, activities, thoughts, feelings, and cognitive/motivational self-appraisals. ESM especially allows a researcher to capture the individual's representation of experience as it occurs. Therefore, it is well-suited to measure dimensions of experience that are likely to be context-dependent.

In experience sampling studies utilizing ESM, three signaling schedules exist: interval-contingent sampling, event-contingent sampling, and signal-contingent sampling (Hektner et al. (2007). Interval-contingent sampling refers to a signaling schedule where study participants complete self-reports at the same time every day or at regular intervals. Event-contingent sampling instructs participants to complete a self-report following a particular event of interest. In signal-contingent sampling, participants are signaled at random times over the course of study period. While signal-contingent sampling is most widely used in ESM studies, event-contingent sampling is popular in studies interested in understanding children's experiences in schools because participants are able to focus more on the particular context of interest (Hektner et al., 2007; Turner et al., 1998; Uekawa, Borman, & Lee, 2005). Participating students can provide reports to the researcher only after a particular event of interest has occurred, and the experience can be compared with other students' experience in the same or similar situation. Interval-contingent or signal-contingent sampling does not consider “the event of interest” as a data collection point because participants are signaled at regular intervals or even at random times.

When an ESM study is designed, the researcher must decide the number of days when study participants will be asked to report on their experiences and the appropriate signaling schedule. Both the duration of the signaling period and the frequency of signals can be fully tailored to the purpose of the researcher. Previous studies reported as few as 3 days (e.g., Hurlburt, 1979) and as many as several weeks or even months (e.g., Feldman Barrett, 1998).

As discussed in the previous section, Web log data can provide vast amounts of online learners’ behavior data. However, other aspects of learning experience like learners’ psychological experiences are not captured in the Web log data. Alternatively, we can implement ESM in research on online learning experience to supplement Web log data by providing information on learners’ cognitive involvement and emotion when they occur. To begin with ESM in online learning experience research, first, the scope of the target event needs to be determined. After the target event is defined, the corresponding learning activities and learning experience are also defined and can be measured at certain events throughout the semester by using the event-contingent sampling strategy. Second, a set of questions asking about particular aspects of learning experience needs to be designed. It can include the various types of questions Hektner et al. (2007) suggested, yet it would be ideal to focus on learners’ cognitive and emotional experience. Third, previous studies have suggested that event-contingent signaling strategy would be the most appropriate schedule in online learning experience research. After collecting online learners’ cognitive involvement and emotional data using ESM and their behavior data using Web Logs and analytics, we can better understand the learning experience in online learning.

In this chapter, the researcher utilized ESM to collect online learner’s cognitive and emotional data and also used Web logs to collect behavior data in two differently structured online courses, a discussion-focused class and a design-/development-focused class. The learning experience analysis for each individual student was conducted at a mircolevel learning analytics in a visualized dash board. Also, the overall learning experiences between the two differently structured online courses were compared with each other.

Method

Setting

Twenty-two graduate students enrolled in two 8-week-long online courses participated in this study. Twelve students were enrolled in a “Program evaluation” course (Course One) focusing on textbook reading and discussion activities while ten students were enrolled in the other course, “Instructional multimedia design and development” (Course Two), which mostly required in-depth hands-on activities in developing several multimedia projects. Because two students dropped from each course, data reported in this chapter concern 18 participants, 10 (4 male and 6 female) in Course One and eight participants (all female) in Course Two, with a mean age of 32.60 years (SD=5.76) and 35.25 years (SD=9.66) respectively. The average number of online courses that participants in each course previously had taken were 11.40 (SD=4.88) and 11.38 (SD=12.28). These were not significantly different. However, it should be noted that the number of students who have not taken more than ten online courses previously was higher in Course Two (five participants) than in the Course One (three participants). Fifteen participants were teachers, including five in elementary school, five in middle school, five in high school, one administrative assistant, one curriculum director, and one instructional designer.

In this study, two online courses were purposefully selected as a unit of analysis. The first course was "Program evaluation," which mostly involved book chapter readings, weekly discussion posting, quizzes, and a final evaluation plan. Students enrolled in this course were expected to read the textbook, participate in weekly discussion activities, and complete a program evaluation plan. The other course selected as a unit of analysis was "Instructional multimedia design and development," which consisted of a series of hands-on activities during the semester, with the final project of Web-based multimedia unit development. Students were required to review journal articles on multimedia design during the first week of the semester and participated in several multimedia development projects for the remainder of the semester. These two courses were purposefully selected because of their differences in terms of the course objectives, required class activities, and the type of course projects (Table 2).

Both courses were delivered via Moodle LMS and met the Quality Matters (QM) standards. Moodle (Moodle, 2014) is an open-source LMS to help educators create online learning courses. It has been used as a popular alternative to proprietary commercial online learning solutions and is distributed free under open-source licensing (Romero, Ventura, & García, 2008). Moodle has been installed at universities and institutions all over the world (Cole, 2005). QM specifies a standard set that is designed to certify the high quality of online courses (www.qualitymatters.org). Both courses analyzed in this study achieved more than ten points higher than acceptable levels after the rigorous review process.

As the study explored online learners' experience within two different online courses, it is critical to note the different course activities and requirements between the two courses. The target event to be used in the study was "weekly assignment/project" and corresponding learning activities, course title, and learning objectives are described in Table 2.

Instruments

In order to measure behavioral learning experience, the researcher collected archived Web log data from the learning management system. Web log data included three sets of behavior data: (1) Number of viewing activity (Course viewing, Forum

Table 2 Comparison of course structure and design between two online courses

	Course one	Course two
	Discussion-focused course	Design/Development-focused course
Course title	Program evaluation	Instructional multimedia design and development
Course objectives	By the end of the course, students will recognize and interpret evaluation models in the following levels: satisfaction, knowledge, behavior, and result. Students will learn how to recognize and interpret various evaluation models that gather quantitative and qualitative data and that include the diversity of the faculty/student bodies and the dispositions. Students will adapt established evaluation models to accommodate technology employed in teaching and learning. Further, students will apply different data-gathering strategies to distance education settings and to traditional classroom settings in which technology is a significant element	This course provides an in-depth focus on the design and development of multimedia instructional materials. Emphasis will be placed on the design of technology rich learning environments that support meaningful learning. Discussion topics include instructional design and multimedia development, multimedia design principles, step-by-step design and development process along with hands-on activities in instructional multimedia tools such as PowerPoint, Audacity, Photostory, and Web authoring tools (Dreamweaver. Pagebreeze, and/or Google sites, WordPress, etc.)
Main activities (Significant learning event)	[Week 2]	[Week 2]
	• Evaluation models, process, examples analysis (*Textbook reading*, *article review*, *document review*, *online discussion*)	• Article reviews on the use of audio in multimedia learning/graphics/pictures in multimedia learning (*Article review*, *online discussion*)
	• Technology plan analysis (*Document review*, *online discussion*)	• Audacity instructional unit development and Lesson/training plan design (*Hands-on activity*)
	[Week 3]	[Week 3]
	• Theme 2 (Chap. 1) reading and discussion (*Textbook reading*, *article review*, *online discussion*)	• Photo story instructional unit development and lesson/training plan design (*Hands-on activity*)
	• Theme 3 (Chaps. 2 and 3) reading and discussion (*Textbook reading*, *article review*, *online discussion*)	
	• Quiz I (Chaps. 1,2 and 3)	
	[Week 4]	[Week 4]
	• Theme 4 (Chap. 4) reading and discussion (*Textbook reading*, *article review*, *online discussion*)	• Personal website development using a web-authoring tool (*Hands-on activity*)

	• Theme 5 (Chap. 5) reading and discussion (*Textbook reading*, *article review*, *online discussion*)	• Final project (Instructional web-based learning module) topic statement (*Hands-on activity*)
	• Quiz II (Chaps. 4 and 5)	• Web-authoring tool tutorials (*Hands-on activity*)
	[Week 5]	[Week 5]
	• Theme 6 (Chaps. 6 and 7) reading and discussion (*Textbook reading*, *article review*, *online discussion*)	• Instructional web-based learning module proposal/storyboard/site map design (*Hands-on activity*)
	• Theme 7 (Chap. 8) reading and discussion (*Textbook reading*, *article review*, *online discussion*)	• Web-authoring tool tutorials (*Hands-on activity*)
	• Quiz III (Chaps. 6, 7 and 8)	
	[Week 6]	[Week 6]
	• Theme 8 (Chaps. 10 and 11) reading and discussion (*Textbook reading*, *article review*, *online discussion*)	• Instructional Web-based learning module: Initial version development (*Hands-on activity*)
	• Theme 9 (Chaps. 13 and 14) reading and discussion (*Textbook reading*, *article review*, *online discussion*)	• Web-authoring tool tutorials (*Hands-on activity*)
	• Quiz IV (Chaps. 10 and 11)	
	[Week 7 and 8]	[Week 7 and 8]
	• Evaluation plan progress report	• Usability testing report (*Hands-on activity*)
	• Final evaluation plan	• Instructional web-based learning module completion and lesson/training plan design (*Hands-on activity*)

viewing, User viewing), (2) Number of online discussion activity (Discussion viewing, Discussion posting, Discussion responding, Discussion updating), and (3) Number of assignment/project activity (Quiz, Resource viewing, File uploading). Also collected were students' profile information, attendance record, and performance data for each weekly assignment.

To measure psychological learning experience, the researcher utilized the EMS, a procedure providing valuable information on individual experience based on contextual and experiential aspects of daily life through repeated self-reports completed by individual members during the unfolding events and situation (Bassi, Ferrario, Ba, Fave, & Viganò, 2012). Unlike a single administration survey such as cross-sectional surveys, ESM increases accuracy and minimizes retrospective biases by providing information on both contextual and experiential variables and further can reveal dynamic learning progress (Ebner-Priemer & Trull, 2009). The researcher used an event-contingent sampling strategy to assess each learner's perceived psychological learning experience during the course. Each student was prompted to answer a set of questions that appeared on a pop-up window immediately following a critical learning activity once a week. The questions were repeated each week immediately after the predetermined critical activities. Students in both courses completed six sets of a repeated questionnaire for weeks two through eight. As the questionnaire needs to be simple but comprehensive to measure learners' cognitive involvement and set of emotions, each questionnaire used one item with 1–9 likert scale ranging from "very very low" to "very very high." Items included were (1) invested mental effort: "While completing this week's learning activity (lesson content and assignment), I invested…" (Paas & van Merriënboer, 1994); (2) perceived prior knowledge: "My level of prior knowledge/skills before completing this week's learning activity was…"; (3) perceived task difficulty: "Overall, completing this week's learning activity was…" with 1–9 likert scale ranging from "very very easy" to "very very difficult" (Tedesco & Tullis, 2006); and (4) academic emotions: interest, confidence, frustration, and excitement: "It was interesting to work on this week's learning activity," "I felt confident while working on this week's learning activity," "I felt frustrated while working on this week's learning activity," "It was exciting to work on this week's learning activity" with 1–9 likert scale ranging from "very very untrue" to "very very true." The invested mental effort score and the assignment performance score were then used to compute the cognitive involvement score (Paas, Tuovinen, Merriënboer, & Darabi, 2005). The average time taken to complete each weekly questionnaire was less than 2 min. Two open-ended questions were asked at the end of the semester to understand students' thoughts about what they most liked in the course, what they least liked in the course, and why.

Results

Learning Experience Analysis

An example of learning experience analysis from three aspects—cognitive involvement, emotion, and behavioral activity pattern—is presented in Fig. 3. The learning experience analysis dashboard consists of five different areas. First, the area

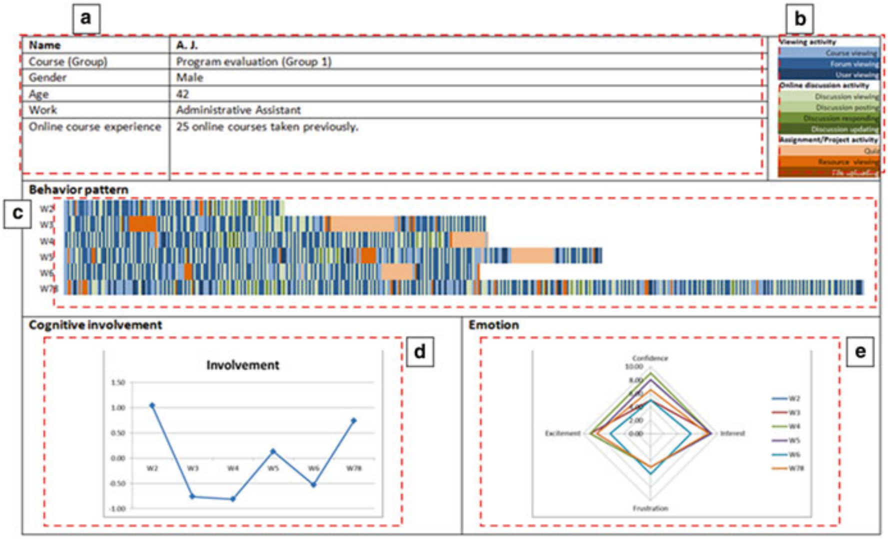

Fig. 3 Example of a student's learning experience from three aspects: cognitive involvement, emotion, and behavioral activity pattern

designated with the letter "A" represents student's information. Specifically, name, gender, age, workplace, previous online learning experience, and currently enrolled online course are presented in this area. The "B" area provides a legend for behavioral activities. The "C" area is where student's behavioral pattern and occurrence are presented. Cognitive involvement per each week is presented in the "D" area, and lastly, student's emotions per each week are presented in the "E" area. Whether a student is in progress or has completed a course, the learning experience dashboard created by using the Web log data and ESM data is capable of offering the microlevel of learning analytics for learners and teachers to make more local decisions about the current learning events (Clow, 2012; Wise et al., 2014) such as the following scenario.

Learning Experience Analysis Scenario *A.J is a 42-year-old male student in the Master's program. He has taken 25 online courses previously and is currently taking an online course: Program Evaluation.*

Behavioral pattern: A.J. spends a lot of time online as indicated by the size of each pattern shell. If not much time is spent for online activities, the size of pattern shell will be wider than the currently presented one. By visually investigating the colors of behavioral patterns, we can tell that A.J tends to participate in viewing-related activities first, and then discussion-related activities, and finally assignment/project related activities.

Cognitive involvement: A.J. started the semester with a high cognitive involvement, yet it went down below "0" in weeks 3 and 4. His cognitive involvement fluctuated as he approached to the end of the semester.

Emotion: Overall, A.J. experienced positive emotions during the semester except in week 6.

With this visualization data, the course instructor is able to decide when scaffolding should be properly offered to A.J. Also, depending upon the level of weekly cognitive involvement and emotions, the course instructor can decide the type of scaffolding (cognitive or motivational) to be provided to him.

Comparison of Learning Experience

Except participants who were excluded from the data analysis due to incomplete course works, a total of 18 online learners' learning experiences were included in the experience comparison. Overall experience data are presented for each set of the experiences of cognitive involvement, emotion, and behavior (Table 3). The researcher compared the three aspects of learning experience between the two courses.

Table 3 Descriptive statistics of cognitive involvement, emotion, and behavioral activities

	Overall learning experience	
	Course one: Discussion-focused course ($n = 10$)	*Course two: Design/Development-focused course* ($n = 8$)
	M (SD)	*M* (SD)
Cognitive involvement		
Invested Mental effort [a]	−0.16 (0.65)	0.20 (0.76)
Performance [a]	−0.41 (0.63)	0.52 (0.37)
Involvement (I)[b*]	−0.40 (0.67)	0.51 (0.68)
Emotion[c]		
Confidence	6.43 (0.82)	6.44 (1.50)
Interest	6.62 (1.41)	7.33 (1.12)
Frustration	4.09 (1.32)	5.10 (1.73)
Excitement	5.73 (1.84)	7.29 (1.42)
Behavioral experience		
Discussion posting	2.55 (0.29)	2.65 (0.39)
Discussion response	4.05 (1.54)	2.71 (2.41)
Discussion viewing	36.15 (16.21)	26.85 (9.60)
Resource viewing	8.85 (1.69)	10.08 (3.04)
File uploading[*]	1.10 (0.33)	2.27 (0.50)
Attendance	27.05 (5.92)	25.88 (7.38)

$^*p < 0.05$

Note: [a]Scores are standardized (*Z* score) to compute involvement score (*I*)

[b]Involvement score was computed using the formula (Paas et al., 2005): $I = \frac{R+P}{\sqrt{2}}$

[c]9 point Likert scale was used

Several analyses were performed, including descriptive analyses (i.e., means, correlations, standard deviations) for the overall experiences of cognitive involvement, emotion, and behavior (Table 3). Then the researcher compared the three aspects of learning experience between the two courses. A series of Mann–Whitney tests (Field, 2013), the nonparametric equivalent of the independent samples *t*-test, was utilized to compare cognitive involvement, emotion, and behavioral activity data between the two courses. The Mann–Whitney test was used in this study because the data did not meet the requirements for a parametric test, and the Mann–Whitney test has the great advantage of possibly being used for small samples of subjects between 5 and 20 participants (Nachar, 2008).

The Mann–Whitney test results indicated that cognitive involvement level (I) for the design-/development- focused course ($Mdn = 0.71$) was significantly higher than the cognitive involvement level for the discussion-focused course ($Mdn = -0.49$), $U = 67.00$, $z = 2.40$, $p < 0.05$, $r = 0.57$, showing a large effect size as it is above the 0.5 threshold (Field, 2013). Students in the design-/development-focused course ($Mdn = 2.08$) were also more involved in the file uploading activity than students in the discussion focused course ($Mdn = 1.17$), $U = 79.50$, $z = 3.53$, $p < 0.001$, $r = 0.83$, showing a large effect size. Other aspects of learning experience between the two courses were not significantly different.

Open-Ended Comments

At the end of the semester, students were asked to provide what they liked more in the course and what they least liked in the course. This activity was an attempt to find out the most (and the least) liked course activities and the nature of those activities. Learners reflected on the semester-long learning experiences before answering the two open-ended questions.

Despite the overall positive experience, students in Course One (discussion-focused course) identified the final course activity, evaluation plan proposal, as a learning activity they liked most. The main reason provided was the immediate value of the activity in the field. Students felt the final project would help them be better prepared when planning for a program evaluation task. Students stated that: "*I most liked creating the evaluation project. The project allowed me to look at my county's tech plan in greater detail than I normally would have*." "*I enjoyed creating the evaluation plan. It is a resource that I can actually use at my school*." "*I liked the final project. I found it to be a practical application that I can use immediately*." Students in the Course One also reported that they least liked reading the textbook and taking quizzes. It appears that although students were aware of the required amounts of reading, class discussions, and quizzes as a regular assessment, they completed the activities to finish the course successfully rather than because they enjoyed the learning experience.

Students in the Course Two (design-/development-focused course) stated that they most liked the project design and development processes. Many reported: "*I thoroughly enjoyed learning how to use the software and then creating my own.*

Storyboard, *Sitemap*, *and Proposal were very useful when thinking and planning out the IMW*." "*I enjoyed learning new techniques and forms of technology to use in my classroom*." "*I loved creating a website. I think it will be the most beneficial component I use in my classroom*.""*I enjoyed audacity*, *photostory*, *and the web page assignments*." To some students, following the tutorials and learning new technologies proved to be a challenge due to the lack of knowledge or no immediate relevance to their career. "A*lthough the Audacity project was interesting*, *I most likely will not use it very much in class*." "*I disliked aspects of the photostory and web page because of my lack of knowledge in working with them*." One student shared that she liked the review activities least although her overall course experience was positive: "*I liked the reviews least. Simply because they were lengthy reads and at least one was a very difficult read for me. But the course is great overall*!"

Discussion and Conclusion

Findings from this study indicate that ESM can be used to measure online learners' learning experience as a supplement to Web log data. ESM was used to capture learners' cognitive involvement and emotion during the 6 weeks of course, while Web log data were used to examine learners' behavioral experience. Due to its unique feature to represent the quality of experience in selective activities for selected groups of people, ESM has a great potential to be used to measure the cognitive and emotional aspects of learning experience that otherwise cannot be captured with the Web log data approach.

The various visualizations represented in this chapter show the differences in online learning experiences between two differently structured online courses: a discussion-focused online course and a design-/development-focused online course. Overall, students in the design-/development-focused course showed higher cognitive involvement throughout the 6 weeks of the study period. Since cognitive involvement is computed using learners' invested mental effort during the target experience (in this study, weekly assignment/project) and learner performance (weekly assignment/project score), high cognitive involvement means that the learner was engaged in an in-depth cognitive process while achieving high academic performance. Also students in the design-/development-focused group reported high frustration but high excitement while progressing through the course.

Using the learner experience dashboard, we can gain deeper insights into the online learning experience design issues. Specifically, the use of ESM has enabled us to investigate learning experience with multiple aspects and therefore can further provide rich information on each learner's progress in an online class.

There are several limitations to this study. First, the experience data collected using ESM and Web logs in this study are limited only to internal data stored in the LMS server. External communication data such as email communications between the course instructor and students or between students and students were not included in the data analysis. Second, the ESM questionnaire was designed to reflect what the researcher considered the most important aspect of learning experience in the two selected online courses. Although researchers are allowed to have the flexibility in designing the questionnaire (Hektner et al., 2007), there is a need for a guideline to inform researchers an effective questionnaire design strategies, especially when employing ESM.

As instructional designers, we can design situations, contexts, or objects that learners can interact with in a learning environment. This study will lead to a new approach to understanding what online learning experience is, what influences such experience, and what the qualities of the learning experience are. Using visualized learning experiences both on the individual and the group level, we will be able to better understand what kinds of experiences can be created, and how experiences should be shifted over time to achieve learning goals. Future research will further explore how ESM can be utilized in measuring online learning experiences in different course structures and formats. Another possible research would be to investigate how to utilize the learning experience data to design appropriate interventions and to help each learner maintain the optimal level of learning experience. Sharing the visualized learning experience via a real-time status indicator on the online course screen could be a good solution to achieve this goal.

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