Computational Thinking Guiding Change in Online Education

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ABSTRACT

As a result of instant access to data, information and knowledge anywhere, anytime, today’s students have rapidly acquired educational opportunities. Online education continues to grow at a pace much faster than face to face enrollments. There is a need for faculty development and training who can teach with technology, design and develop online courses in order to meet the increasing student demand. Faculty barriers to online education include loss of interpersonal student relationships, technology challenges, pedagogical concerns, institutional policy problems and unidentified support or compensation for all associated processes. At the crossroads of problem identification, strategy, and adoption of innovation, Computational Thinking (CT) offers a logical, exploratory, expandable collaborative way of solving a complex problem in a state of change. This paper aims to summarize and synthesize the literature on both CT and faculty barriers to adoption of online education. A further aim is to offer suggestions for collaborative faculty design and development opportunities in exploring their own experience with online education using CT as a framework for problem-solving.

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We cannot solve our problems with the same thinking we used when we created them. - Einstein

Change is rarely welcomed in already existing complex systems. Change creates increased opportunity for error, increased barriers to success and creates upheaval in psycho-social states. Rogers (2003) in his Diffusion of Innovation theory stresses that change is largely a social challenge. Complex social systems undergoing change benefit from a clear strategy for successful implementation of change. However, change is also necessary for growth and development of all systems. Higher education in the last two decades has begun a metamorphosis from face to face (F2F) learning to the exponentially available opportunities in learning online. This new educational delivery system is easily adopted by digital natives who grew up with a world wide web of information at their fingertips. However, designing effective online courses requires the orchestration of many different players for a quality symphonic production. More challenged by the information age are educators whose teaching and learning competencies were developed in a traditional classroom and a very different pedagogical model. “Education has changed dramatically with the Internet and mobile technologies, and educators who continue a strategy of a “sage on the stage” instead of a “guide on the side” are not going to fully engage today’s students.” (Johnson, Wisniewski, Kuhlemeyer, Isaacs, & Krzykowski, 2012, p. 66). Papert’s (2009) review of diSessa’s “Changing Minds: Computers, Learning, and Literacy” reminds us that new technologies bring new levels of literacy. He cautions though “that school cannot get ahead of society and the development of a literacy essentially requires time.” (Papert, p. 242). In order to meet the needs of students of the digital age, the growth and development of face to face faculty will be critical to successful implementation of online course delivery that echoes traditional classroom pedagogy, but also solves problems of the new millennia. This process can be complex, confusing, daunting and promote insecurity.

Clear, concise, problem-solving strategies can provide a framework for organizing and managing challenges in complex systems. Computational Thinking (CT) as first popularized by Wing (2006), “is taking an approach to solving problems, designing systems and understanding human behavior that draws on concepts fundamental to computing.” (p. 33). CT could offer such a framework by categorizing specific problems through the use of algorithms, patterns, parallels and abstraction. While critical thinking can promote a clearer organization of knowledge CT offers a construct for applied problem-solving (Voskoglou & Buckley, 2012). By providing a clear articulation of the problems affecting change from one form to another, strategies for overcoming barriers can be constructed. This paper will aim to provide a review of current literature on applications of CT in higher education and provide a synthesis of the literature focused on
how CT can guide change in online education. A further aim is to provide a framework to support the transitional challenges of F2F learning to online learning for faculty in higher education. This exploration may also serve as an introduction to CT for faculty integrating this style of problem-solving into existing curriculum.

**Literature Review Finding**

<table>
<thead>
<tr>
<th>Author</th>
<th>Population/Problem</th>
<th>Indicator</th>
<th>Comparator</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barr, Harrison &amp; Conery (2011)</td>
<td>Summary of the Surveyed PK-12 Teachers (N=697) from a joint project funded by the National Science Foundation (NSF), in partnership with International Technology Society for Education (ITSE) and Computer Science Teachers Association (CSTA).</td>
<td>To introduce concepts of CT and ascertain a working definition of relevance to teaching</td>
<td>Current curriculum, vocabulary, tools and applications for various disciplines at various levels</td>
<td>Development of a working definition of CT and a framework for application of skills acquired through CT educational opportunities</td>
</tr>
<tr>
<td>Berland &amp; Duncan (2016)</td>
<td>Coded CT of students turns playing the game Pandemic (N=23)</td>
<td>To learn if CT occurs naturally in cognitive processes and how they might be applied to educational opportunities.</td>
<td>One control group and three research groups to explore scaffolding development, rule following, and algorithm design</td>
<td>Students innately used CT strategies with and without intervention. CT could be fostered in learning environments to promote problem-solving skills.</td>
</tr>
<tr>
<td>Czerkowski &amp; Lyman (2015)</td>
<td>Literature review of current trends towards CT and potential application in higher education</td>
<td>To explore the reasons why CT is not yet at fundamental educational opportunity in higher education and suggestions about how CT could be integrated</td>
<td>Comparison of current K-12 integrations of CT.</td>
<td>Establishing partnerships, strategies, resources and research initiatives to support the integration of CT in the various disciplines in higher education will benefit all students in this computer oriented era.</td>
</tr>
<tr>
<td>DeSchryver &amp; Yadav (2015)</td>
<td>Literature Review Course Design</td>
<td>Can computational thinking promote creative thinking?</td>
<td>Creativity, creative thinking and computational thinking with applications for both faculty and student development.</td>
<td>Creative thinking is interwoven into teachable technology at the design and delivery points. Computational and creative literacies promote students prepared for the complexities of future challenges.</td>
</tr>
<tr>
<td>Gonzial (2008)</td>
<td>Literature Review</td>
<td>Can non-computer science students benefit from CT processes?</td>
<td>Computer science and non-computer science students</td>
<td>CT is necessary for students of computer science and other disciplines because it is a necessary skill for 21st-century academics and professions.</td>
</tr>
<tr>
<td>Kostadov (2013)</td>
<td>Simulation</td>
<td>Can the usefulness of CT be simulated and illustrated for a common problem-solving situations?</td>
<td>Statistical computation software application “R”.</td>
<td>“R” allows for the visualization of CT for analysis of problems with random or non-linear solutions. The simulation supports the application of CT processes beyond science and math.</td>
</tr>
<tr>
<td>Masterman, Walker &amp; Bower (2013)</td>
<td>Feasibility Study</td>
<td>Can digital technology tools support faculty in learning design with determinative support?</td>
<td>Four different approaches to three computational design applications.</td>
<td>Faculty assessment of the digital tools yielded the need for a deeper view of pedagogical design. The authors offer thinking using modeling, mapping abstraction, as suggestions to refine and align faculty development opportunities.</td>
</tr>
<tr>
<td>Soh, Shell, Ingraham, Ramsay, &amp; Moore (2015)</td>
<td>Undergraduate computer science students (N=15)</td>
<td>Can computational thinking and creative thinking combined promote expanded problem-solving skills?</td>
<td>Computational creative exercises (CCE) and control group</td>
<td>Higher test scores were correlated with students who completed the CCE courses.</td>
</tr>
<tr>
<td>Voskoglou &amp; Buckley (2012)</td>
<td>Literature Review Classroom experiment (N=90)</td>
<td>Can computational thinking skills support students in problem-solving?</td>
<td>Problem-solving experimental group supported with computers/technology and control group</td>
<td>Critical thinking tools using computation and technology-enhanced student as evidenced by the better problem-solving skill.</td>
</tr>
<tr>
<td>Wing (2006)</td>
<td>Perspective</td>
<td>CT provides a “universally applicable” process that supports learners in all disciplines of all ages.</td>
<td>CT to critical thinking and computer science</td>
<td>CT promotes a human focused process for generating new ways of thinking using abstraction, decomposition, algorithms and heuristics that can be applied to all disciplines, not just computer science.</td>
</tr>
<tr>
<td>Wing (2008)</td>
<td>Perspective</td>
<td>CT is driven by both societal and technological progress as we increasingly rely on computers for everything we do.</td>
<td>A fundamental understanding of CT is critical to students of the technological era we live in.</td>
<td>As computers become more ubiquitous in all human interactions, our relationship with computers will allow us to solve more complex problems in all disciplines. CT will be a mainstream educational requirement of all students thriving in the age of technology and innovation.</td>
</tr>
</tbody>
</table>
A second literature search was performed, again using Academic Search Complete, but this time using key words “faculty development” and “online education”, “online education” and “faculty challenges/barriers”.

Secondary sources include texts, technical journalism and articles found using both Google and Google Scholar.

Table 2. Faculty Barriers and Solutions to Online Education

<table>
<thead>
<tr>
<th>Author</th>
<th>Population</th>
<th>Indicator</th>
<th>Comparator</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ali et al. (2005)</td>
<td>Surveyed Faculty N=65</td>
<td>To ascertain faculty perceptions of competency and assess future needs in teaching online</td>
<td>Bennet’s Novice to Expert Continuum.</td>
<td>Faculty rated highly in concerns for ongoing support. Faculty who had taken online courses had a higher level of perceived competence with online education.</td>
</tr>
<tr>
<td>Allen &amp; Seaman (2012)</td>
<td>Surveyed faculty (N=4564)</td>
<td>Growth of online education</td>
<td>Faculty to Administrators</td>
<td>Faculty have more pessimism than optimism regarding quality and organizational commitment. Administrators have more optimism than pessimism.</td>
</tr>
<tr>
<td>Hoffman and Dudyak (2011)</td>
<td>Experiential review of process</td>
<td>Faculty professional development to address a gap in the knowledge of faculty transitioning to online education and subsequent technology</td>
<td>Traditional faculty roles, responsibilities, and skills with those required for teaching online.</td>
<td>Faculty transitioning from traditional didactic structure need initial and ongoing support in the design, development, administration to meet the professional, organizational and student needs of online education.</td>
</tr>
<tr>
<td>Johnson, Wisniewski, Kuhlemeyer, Isaacs, &amp; Krzykowski (2012)</td>
<td>Experiential review of process</td>
<td>Faculty development boot camp focused on guiding faculty through transitions to online learning</td>
<td>Knowles andragogy in support of adult learners</td>
<td>Faculty anxiety about the implementation of online education and using technology can be mitigated by faculty development programs. However, faculty would benefit from having an introduction to learning theories as well as the technology that can support them.</td>
</tr>
<tr>
<td>Lloyd, Byrne &amp; McCoy (2012)</td>
<td>Literature Review and Survey (N=75)</td>
<td>A disproportionate number of faculty are prepared to meet the increasing demand for online education.</td>
<td>Perceived barriers to faculty development and implementation of online learning and teaching</td>
<td>Perceived barriers include organizational, fiscal, technological, pedagogical and workload related challenges. These perceptions vary dependent upon rank, gender, and experience.</td>
</tr>
<tr>
<td>Ortagus &amp; Stedrak (2013)</td>
<td>Perspectives</td>
<td>How can the demand for online education be met with existing and/or “contingent” faculty</td>
<td>The current state of tenured faculty aligned with the “academic ratchet” of conflicting academic goals.</td>
<td>Participation of tenured faculty through an incentivized and developed approach will be critical to providing quality educational opportunities for students seeking online education.</td>
</tr>
<tr>
<td>Picciano (2015)</td>
<td>Conceptual framework and proposed plan for online education development focused on faculty.</td>
<td>Careful planning of online education may promote better organizational, academic and pedagogical outcomes</td>
<td>Planning model vs disruptive innovation model.</td>
<td>Perspectives on a proposed planning model for engagement with online education at the organizational level.</td>
</tr>
<tr>
<td>Sahin (2006)</td>
<td>Literature Review</td>
<td>How are faculty rates of technology adoption influenced by social systems?</td>
<td>Faculty adoption of technology using Rogers Diffusions of Innovation Theory</td>
<td>Rogers’s theory offers a predictable model for faculty adoption of technology but influenced by experience, training, and organizational support.</td>
</tr>
<tr>
<td>Sharpe Benfield, &amp; Francis (2006)</td>
<td>Contextual Analysis</td>
<td>What strategies promote the implementation of quality online learning for students and development by faculty?</td>
<td>Approaches by several academic institutions.</td>
<td>Strategies for adopting online education include innovator champions, faculty-centered control over innovation projects and support from educational technologists.</td>
</tr>
<tr>
<td>Smidt, McDyre, Bunk, Li, &amp;Gatenby (2014)</td>
<td>What are the specific attitudes of faculty toward online education and how can they be explored while developing new skills?</td>
<td>Qualitative review of faculty after implementation of an online educational experience</td>
<td>Course design and faculty training implications are offered as new opportunities to promote quality online education by faculty with an understanding of role as a facilitator.</td>
<td></td>
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</tbody>
</table>

Data Analysis

Using NVivo 10, twenty-nine articles from the literature search were first categorized into two nodes. The first node contained articles related to CT, the second; articles on faculty barriers and solutions to online education. In the CT node, text queries for abstraction, decomposition, algorithms, patterns, mapping and recursive thinking were explored. In the FBSOE node, text queries included “social”, “pedagogy”, “technology training”, “support” and “policy” using stemmed words to expand relevance. These queries allowed for a closer examination of authors’ ideas on faculty barriers and solutions to development, design and even implementation of online education for themselves and students. For example, when running a text query for “pedagogy” the frequency of the word use in seven journals was displayed. This allows for a more careful analysis and synthesis of the authors ideas. See Figure 1. as an example.
Defining the Problems

The transition from traditional face to face courses to a fully online format involves multiple disciplines at various organizational hierarchal levels and several steps. Lloyd, Byrne, and McCoy (2012) examined faculty perception and involvement concerning online course development and instruction. They found that though student demand for online course offerings was high faculty acceptance of online education remains at about a third of all faculty members. According to Allen and Seaman’s (2013) research in tracking online education trends for the past 10 years, student demand for online education is continually increasing, but faculty acceptance of online education remains low at 32% from a survey of over 2500 colleges and universities.

Faculty acceptance can further be decomposed into specific areas of concern. For example, Lloyd, Byrne, and McCoy (2012) outline the results of their survey of 71 faculty members exploring the barriers to acceptance of online education. In summary, they found interpersonal relationship challenges, organizational policies, training in the technology and financial analysis to be the most heavily weighted factors. These findings echo additional studies citing concerns about pedagogy and faculty support (Allen & Seaman, 2013; Smidt et al, 2014; Alsofyani et al., 2013; Picciano, 2006). Another common concern from faculty in various disciplines is how the same quality educational opportunities are delivered in an online educational forum as opposed to traditional face to face delivery. This concern has been more commonly weighted as an important consideration for faculty members who have never taken an online course (Lloyd, et al. 2012). Digital or computer literacy is critical in not only teaching but functioning in the 21st century. Venkatesh, Thong and Xu (2016) summarized the Unified Theory of Acceptance of Technology (UTAT) and offer a systematic review of the acceptance of technology in banking. Students are digital natives and quickly adapt to educational technology that isn’t always new to them. Guzdial (2008) points out that while the theoretical side of computing may be important to computer scientists, it is the human interaction with the technology that will solve problems. The author adds that “the automated execution of the process is changing how professionals of all disciplines think about their work.” (Guzdial, 2008, p. 25). Because much of our world is now automated and/or supported by computers, thinking computationally will maintain a more current view of teaching, technology and how both entwine with our experiences.

For the purposes of this exploration, each of the five faculty concerns have been synthesized into additional research questions.

Table 3. Perceived challenges from the literature review.

<table>
<thead>
<tr>
<th>Perceived Challenge</th>
<th>Interpersonal Challenges</th>
<th>Technical Training</th>
<th>Pedagogical Concerns</th>
<th>Policy Concerns</th>
<th>Ongoing Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>How is the decreased social connection with students compensated for in successful online learning?</td>
<td>What is the learning curve for most faculty to adopt and adapt to the use of technology in teaching</td>
<td>Can online delivery offer the same educational quality as face to face learning?</td>
<td>Do the organizational policies support both faculty and students in an online delivery?</td>
<td>Does the organization offer support for the workload, recognize contributions (such as gaining tenure), continued faculty development?</td>
<td></td>
</tr>
</tbody>
</table>
Jonassen (2000) defines a typology of problems that can help to begin to categorize the types of problems in an online conversion implementation in instructional design. His 11 problem types include logical problems, algorithms, story problems, rule using problems, decision-making problems, troubleshooting problems, diagnosis solution problems, strategic performance, situated case policy problems, design problems, and dilemmas. Further categorization of the problems faculty face in transitioning to online education can be drilled down using CT. A common problem example is technology implementation at both the macro (organizational) and micro (direct small group interactions) level. At both levels, technological challenges can represent a major barrier to success. For example, not all schools have the technological infrastructure (such as available servers) yet to support conversion of many courses at once. Training and education of many faculty members at once compress time and explode the cost of an implementation. Technology problems are one of the many concerns of implementing online courses. Categorizing the problems as they emerge can offer clarity and with a clearer view of multifaceted problems, the strategy can emerge. In the example of technology problems, the implementation team may be able to parse the problem at the organizational level into categories such as decision-making problems, policy problems, while the small groups may view technology as more of a strategic performance issue with regard to faculty development. Once problems are explored and defined, CT strategies can further zone in on and offer weighted variables to the categorized problems.

Processes

In considering first the perception of challenges faculty are known to have; these known barriers to adoption of online course development and implementation were categorized into 5 main themes. CT can help organize, categorized and strategize ways of overcoming these barriers to progression towards developing, implementing, and offering online versions of their expertise. These methods include create a framework for a faculty development offering orchestrated by a small instructional design team and experienced online education champions who were early adopters.

Human social interactions and behavior cannot always easily be categorized in a linear pattern. Heuristic (rule of thumb) approaches to problem solving can promote insecurity in linear thinkers and compound overlapping problems (Jonassen 2008; Silber, 2007). Considering how people adapt to new technology can be viewed the lens of several applicable theorists. Diffusion of Innovations, the Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology and even Benner’s novice to expert continuum provide a critical path in understanding human adaptation factors in any social change. (Rogers, 2003; Venkatesh et al. 2016; Gardner, 2012) Conceptualizing problems as they emerge in the instructional design implementation process can help keep all team members on the same page. An experienced instructional designer can support both the people and technological changes through a series of well-planned introduction to processes. Having a clearer view of the processes at play can also add clarity to any project. Project managers can help to contain the scope of both the problems and processes during vigorously changing states as well as align interdisciplinary teams (Pan, 2012). DeSchryver and Yadav (2015) stress the importance of iterative thinking as both a creative skill and computational thinking process. In the course, curriculum or program design and development stages; all requires several iterations before they are prepared for prime time.

Understanding the attributes of change can promote effectively managed change processes. Rogers (2003) remind us that human interaction with change depends on the relative advantage, simplicity, compatibility, trialability, and observability. Sharpe, Benfield, and Francois (2006) provide an overview of proposed strategy and leverages for change by examining both the context and culture within their organization. While this provides a high-level view of how processes can unfold, attention to specific human factors in the social context is important for adoption (Rogers), or novice to expert (Benner) processes occur. The experienced faculty hold a wealth of collective knowledge in their field of expertise. Drawing upon this experience, respecting their current role, and placing faculty in autonomous but supported roles might help. However, it is important to acknowledge that a return to an apprehensive role as a learner with new technology and delivery system can be disconcerting for many.

CT Attributes

Forced faculty development can result in further resistance to change. However, allowing faculty to choose the pace of their learning can promote individual competencies and dedication to specific tasks needed to build online education awareness. Roger (2003) offers that late adopters and laggards learn best from those who have already beaten down the path and demonstrated success. By thinking differently about how problems are structured and solutions strategized, learning is grounded in theory but applied to a relevant and useful process. Wing (2006) outlines how and why CT is an important skill set for problem-solving. She offers that CT is a way of conceptualizing the problems to be solved by humans while integrating fundamental skills complemented by computer science. In the case of change management for the problems in online learning transition,
processes can be strategized to overcome barriers by breaking down the problems, finding patterns in both problems and known solutions. Abstracting ideas that form principles can guide solutions and create algorithms or step by step solutions that offer logical clarity.

**Decomposition and Recursive Thinking**

By breaking problems down into smaller components, specific attention can be focused on the type of problem. For example, it is just as important to use the correct collaborative thinking skills to solve a social problem as it is to use the right surgical instrument specific to the surgeon and patient’s needs. Using decomposition to break down the interpersonal concerns cited by faculty can offer clarity in segmenting, sequencing and considering each as parts of the whole. For example, the specifics of faculty who feel there could be a loss of interpersonal interaction with students is heavily weighted in the findings from Lloyd, Byrne, and McCoy (2012). The researchers’ factor analysis decomposes this results further into 5 specific categories of concern related to specific social interaction changes. Each of these areas of concern merits attention and further discussion. Faculty development opportunities to explore these concerns can help inform, motivate and navigate faculty on the diffusion of innovation continuum.

**Patterns**

Human intuition drives pattern recognition. Common patterns begin to emerge in our awareness as we learn any new skill. Modinouneau (2009) discusses how recognizing patterns in problems can promote predictions and strategic solutions. In guiding faculty to developing online learning application patterns may be connected from examples in a sandbox learning environment and then transferred to skill building in developing their own course. Miller and Settle (2011) offer an example of how pattern recognition can lead to an understanding of concepts and problem solving. They discuss how their students learn to find patterns in a web search tree. The authors found that while students didn’t understand the computer coded path in the web search tree, they were able to distinguish a “local” path through recognition of patterns that emerged as they practiced the exercise. In a similar context, faculty learning to develop online courses don’t need to code the course in HTML but rather be able to recognize the patterns in the various structures that make up an online learning management system (LMS) such as Canvas, D2L, Moodle or Blackboard. While each LMS has its own unique proprietary specifics, any pedagogically sound courses content can be patterned into the system. Students also respond to repetitive patterns in course organization within a program, much as most people become accustomed to reading a newspaper from the FrontPage onward. Human pattern recognition is the result of abstraction and recursive thinking (thinking about thinking). We think computationally in several instances each day without distinct awareness.

**Abstraction**

It is the process of abstracting known data, information and knowledge that guiding principles emerge. Silber (2007) outlines the challenges in designing educational opportunities when the design is guided by “ill-structured” or poorly defined problems at the outset of a process. Abstraction focuses on examining the structure of the problem(s) before focusing on the details. “The most important and high level thought the process in CT is the abstraction process. Abstraction is used in defining patterns, generalizing from instances and parameterization” (Wing, 2010, p. 1). A common process in academic course development is development and the use of curriculum mapping. Komenda et al. (2015) discuss the use of curriculum mapping through spatial representations of the curriculum so that interconnections can easily be visualized in graphics using learning analytics, algorithms, and models to fully understand learning outcomes. While higher education curriculum is viewed at the university, program and course level, faculty at all ranks could engage with the curriculum at each level of abstraction, by viewing a map or web of interconnectivity. Voskoglou and Buckley (2012, p. 33) describe abstraction as a way of mapping from a complex representation to a more simple one. Furthermore, Czerkawski and Lyman (2015) describe “Abstraction as a tool that permits the creation of large and complex systems of information by defining and generalizing from simpler components.” (p. 57).

By encouraging different levels of abstraction, Lu & Fletecher (2009) describe that problems can be understood and then resolved more effectively. For example, if the problem of policy concerns is viewed from both the top down and bottom up levels the organizational administrative and student concerns can be addressed. Zooming in or focusing on a specific area of abstraction in a problem can allow for a specified focus and clarity. Much as an “abstract” serves as an introduction to an academic paper, abstracting specific feature of a problem can offer a succinct concentration of a particular issue. “At its most fundamental, CT is the automation of abstractions and it involves the use of computational tools, concepts, or ideas in a significant way to ask new questions or gain new insight into problems in a variety of disciplines.” (Miller & Settle, 2011). Applying this computational tool as a strategy can clarify complexity, and help both define and refine for more efficient resolutions.

**Parallels**

While in computer science, parallelism is used to accomplish many computing tasks synchronously,
parallel thinking lends itself to further define the problems and make sense of them cognitively when more than one task is occurring at the time. Instructional design projects often use both sequential and parallel approaches. Pan (2012) discusses how parallel processes can increase efficiency. For example, Alsofyani, Aris, and Eynon (2013) describe their experience guiding faculty through change using the Technological, Pedagogical, and Content Knowledge (TPACK) model for building competencies in online education. They found that though prior studies have explored a hybrid model of online learning in teaching with technology, a fully online faculty development experience was highly favorably rated by participants (Alsofyani, bin Aris, & Eynon, 2013, p. 121) Similarly, Rienties et al. (2013) examine the impact of collaborative teacher training across different institutions and disciplines outside of their own in a parallel teacher training in technology course. Wing (2008) connects CT and specifically parallel thinking with human vision; both eyes view the same object with only slightly different experience but work together synchronously to send the message of the image to our brain.

One of the barriers to change illuminated by Lloyd, Byrne, and McCoy (2012, p.7) was that many faculty members had never experienced an online course. In consideration of Roger’s Diffusion of Innovations Theory, Sahin (2006) reminds not just of the innovators to laggards trajectory in the adoption of technology, but also how knowledge, persuasion, decisions, implementation, and confirmation are entwined directly with the social system in which change takes place. By offering professional development in a supported online forum faculty can draw parallels between their own experience with the technology and the courses they will design, develop and implement for their students.

**Algorithm Design**

Basic algorithms are designed to consider if “this” occurs then “this” will happen next. This is a basic example of how an algorithm or step by step directions for resolving a challenge can be built. Many healthcare providers are familiar with general principles guiding the step by step process for supporting the birth of a child, growth and development of children, use of medication, resuscitation, and finding cures or at least reduction of the impact of a disease or injury process to promote healing. We use algorithms each day in our thinking in simple human interchanges such as driving. If the light is red, I must stop, if it is yellow, I have choices. Human decision making has many variables. Computers do not yet, but as artificial intelligence emerges into mainstream application it is likely that the algorithms written by humans will manifest in “thinking” machines. With respect to faculty forming algorithms to solve problems, Moldonoveau (2009) discusses how algorithms can provide logical steps, and also several different models in choosing a viable solution. For example, with regard to technical training, not all participants learn technology at the same pace. Offering a step by step approach in an online learning forum that is self-paced can promote faculty awareness of how a student may perceive learning in an online format while building comfort with “if this then this” experience in a learning management system. Czerkawski (2014, p. 36) describes that for deep learning to occur, learners must learn how to learn problem-solving skills that will support further employment competencies in an ever changing market. Adult learners especially experienced faculty may feel uncomfortable with uncertainty as a novice online educator. The use of algorithms to support new learning offers rule-based models of step by step processes. When practiced these step by step processes faculty can develop both skill and confidence in using technology that is new to the user.

**Change Management**

Change management using CT can guide change by patterning human decision points using computer logic, abstraction, recursive thinking, and algorithms. The advantage of using a CT model to guide and promote change in higher education is a clarification of the complexity of the process and consideration for all of the various levels of impact the change will have on an educational system. The ubiquitous shift of face to face courses moving to an online format creates an uncomfortable uncertainty. Lack of professional development funds and opportunities compounds faculty uncertainty about design, development, implementation and ongoing instructional, technical and organizational support for online education and learning pursuits. However, online education is poised to become as popular and useful as online banking. Students, especially adult professional learners require the flexibility and asynchronous access to course content that online learning affords. While traditional classroom pedagogy has its merits, online learning and teaching with technology savvy students requires new pedagogy that incorporates technology, gives learners control over learning opportunities with a more collaborative class and faculty relationship. The days of the “sage on the stage” may be staggered as students seek a “guide on the side”. (“Teachonline.ca, 2012”). There are at least 3 emerging trends in development of new pedagogy for online education:

1. A move to opening up learning, making it more accessible and flexible. The classroom is no longer the unique center of learning, based on information delivery through a lecture.
2. An increased sharing of power between the professor and the learner. This is manifest as a
changing professorial role, towards more support and negotiation over content and methods, and a focus on developing and supporting learner autonomy. On the student side, this can mean an emphasis on learners supporting each other through new social media, peer assessment, discussion groups, and even online study groups but with guidance, support, and feedback from content experts.

3. An increased use of technology not only to deliver teaching but also to support and assist students and to provide new forms of student assessment. (Teachingonline.ca, 2012, para.2)

The shift of a more collaborative teaching-learning model can be especially effective with mature professional adult learners. Faculty serves as facilitators and guides through new data, information, and knowledge. In learning to become online educators, faculty must consider themselves as learners in this emerging role. Figure 3 offers some suggested uses of CT as solutions to some of the barriers explored in the literature.

**Figure 2: Computational Thinking to Guide Faculty through Change**

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**Discussion**

Proposed as a result of the two literature searches and synthesis of the literature is a faculty development exercise using CT as a model for the collaborative participatory design of an online course. The faculty could choose any course subject of interest to them, even something as useful as a faculty orientation to their program. Existing faculty would all be subject matter experts in this area and could all contribute a unique perspective to the design of such a course. Participatory design and development on online course content by faculty promotes both an understanding of the technology, but also maintains a firm grip on the existing expertise and pedagogy of their course content. Technological, Pedagogical and Content Knowledge (TPACK) was first introduced by Mishra and Koehler and “showed that learning is most effective when teachers have appropriate awareness of the complex interplay between pedagogy, technology and discipline knowledge, and integrate these when designing teaching.” (as cited in Rienties et al. 2013, p. 482). Masterman, Walker and Bower (2013) attempt to bridge the gap between faculty development and online education by using digital tools developed for education but with various degrees of support. The authors aimed to expose and inspire opportunities in using technology tools that guide and support pedagogy while promoting collaborative faculty learning and sharing of new information and skills in designing online courses. Furthermore, the authors offer that “The challenge to embedding computational support for teachers’ thinking in a manner that takes into account all these factors is to position it within the design of a program, department, and faculty where it is used by academics on a regular basis.” (Masterman, Walker & Bower, 2013, p. 23).
An initial faculty development opportunity or “boot camp” could be modeled after courses in creative computational thinking organized by Soh, Shell, Ingraham, Ramsay, and Moore (2015). The authors created a series of courses that support both analysis (decomposition, pattern recognition) and reflection (abstraction, algorithm design), but using simple description exercises to promote a new collaborative way to solve problems. They blend instructional design pedagogy based on attention, repetition, connection, with Einstein’s core creative thinking attributes that celebrate the recognition of novelty and ambiguity but a passion for solutions. Smidt, McDyre, Bunk, Li, and Gatenby (2014) explore faculty attitudes towards online course design and teaching, but also offer the framework for development beginning with both open forum face to face discussion, then transfer to an online discussion board to continue the conversation. Smidt et al. support a traditional constructivist view of faculty learning, but their qualitative analysis using NVivo 10 promotes a quantitative view or analysis of text-mined data. This process in itself represents a computational thinking example in abstracting data, analyzing the information, mapping into nodes and then initiating a design that can guide faculty to positive outcomes in learning online education processes. We use computational thinking methods in many aspects of daily life, but don’t recognize the value in the process without it being brought forward to our attention.

What is more important than the process of CT is its application to student learning in an era of technology dependence in every facet of living. Vouskoglou and Buckley (2013) offer that students now will not only need to understand how technology works, but how to create technology to support their personal and professional pursuits in whatever discipline they choose. “CT develops a variety of skills (logic, creativity, algorithmic thinking, and modeling/simulations), involves the use of scientific methodologies and helps to develop both inventiveness and innovative thinking.” (Vouskoglou & Buckley, 2013 p. 29). CT offers faculty not only the opportunity to explore new problem-solving processes but also unleash their own creativity in designing courses, research and various levels of policy that affect long-term visions of their specialty.

Conclusions

Educators are accustomed to organized chaos but organization of CT could offer a collaborative scaffold upon which to build instructional design competencies that can calm chaos. CT offers both a linear logical view of problems but doesn’t sequester creativity or collaborative problem solving. Roger’s Diffusion of Innovations Theory demonstrates that social change is largely affected by fear of risk and unfamiliarity with possibilities. Early adopters can guide late adopters and laggards to the benefits of adopting new ways of thinking but most successfully through a series of developments beginning first with an assessment of current knowledge. As Kaminski (2011) in citing Rogers’s theory; the innovation must have observable benefits, compatible with the learner’s current schema, combined with a scalable scaffold in which to build competency and overcome complexity through repeated experience. CT offers such a scaffold for breaking down the problems into smaller pieces for analysis (decomposition), constructing solid pedagogy (recursion), simplifying problems (abstraction, parallels, and patterns), and planning applicable solutions and policies (algorithm design and automation). As faculty, we readily consider a constructivist view when developing curriculum for our students, but our own learning is often abandoned in a quagmire of academic and administrative responsibilities. Technology now affects every aspect of our life. Maintaining currency and relevance will allow for today’s educators to transfer knowledge using vehicles that are meaningful to students, and aligned with educational tools that promote our own connections to quality learning for those we guide.

References


