21st Century Assessment to Promote 21st Century Learning: The Benefits of Blinking

Valerie J. Shute, Vanessa P. Dennen, Yoon-Jeon Kim, Oktay Donmez, & Chen-Yen Wang

Abstract

What competencies do kids need to succeed in the 21st century, and how do these skills differ from those reflected in current state standards? What is the best way to assess and support new competencies? This paper extends current thinking about educationally valuable skills and instructional system design by identifying and modeling 21st century skills. The first stage (described in this paper) of our multi-stage research involves: (a) conducting an extensive literature review to identify a set of viable and valuable 21st century skills, and (b) modeling each in terms of constituent sub-skills, at a sufficiently refined grain size so that we can measure and diagnose competency levels. The competencies showcased in this paper include: systems thinking, creativity, collaborative learning, and managing social identities. Subsequent stages of this research will include developing appropriate and engaging assessments to extract data on our relevant 21st century skills from students – individually and in groups – during interaction with immersive learning environments. Findings from the second stage will then inform the third stage which will involve adapting existing (or developing new) learning environments that incorporate problems, assessments, and instructional support in relation to our set of important 21st century skills.

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Introduction

Preamble

Once upon a recent time, there was a charismatic woman named Sarah. Her family, friends, and fans all shared nearly-identical values and beliefs about the world (e.g., good guys vs. bad guys). One fine day toward the end of summer, Sarah received a phone call inviting her to be a vice presidential candidate of the United States! Now, a reasonable person receiving such an incredible offer would hold off making a decision for a while, to think it all through. However, one of the values Sarah maintained was that one should "not blink." Indeed, blinking (or as others would say, pausing to think[1]) was an act of cowardice. So she did not blink and immediately said "yes."

As we're writing this paper, the U.S. is just days away from its 2008 presidential election, and it's fair to say that for many reasons, this is a very important (and historic) election. Does the non-blinking woman succeed in becoming vice president? Was her "gut" a better source for making the momentous decision than her brain? What are some of the major ramifications of her decision—in the near and the far term? If she'd talked it out with others holding different perspectives, would that have changed her decision? The point of this preamble is that certain attributes, such as insulating oneself against opposing views, reducing complex issues to black-and-white terms, non-questioning entrenched ideas, and acting impetuously, will likely *not* move us – citizens of the world – in the direction necessary to flourish in the 21st century. So how can we ensure that current and future *worldizens* can learn to systematically and creatively think, communicate, question, collaborate, solve difficult problems, reflect on decisions and solutions to problems, and adapt to dizzying and changing circumstances? Preliminary answers to those questions comprise the basis for this paper.

Purpose

The immediate goal of the research described herein is to identify and model a set of 21st century attributes, or *competencies*, that are currently being ignored in our schools, but we believe shouldn't be – especially with an eye toward the near future of our country and the world. The longer-term goal of our research is to develop, refine, pilot test, and ultimately validate an evidence-based assessment methodology (i.e., *stealth assessment*) embedded

[1] The antithesis to the don't-blink doctrine is Descartes' famous line, *Cogito, ergo sum* (or "I think [blink], therefore I am").

within immersive learning environments (e.g., games, simulations, scenarios, etc.) that can elicit data from learners, make inferences about competency levels at various grain sizes, and use that information as the basis for targeted support.

Our strategy involves a multi-stage approach. The first stage, which began about six months ago and is reported in this paper, involves: (a) conducting an extensive literature review to identify a set of educationally-valuable 21st century skills (e.g., creativity and collaboration); and (b) modeling each of these skills in terms of its constituent sub-skills, at a sufficiently refined grain size so that we can measure and diagnose competency levels. The second stage will involve refining the methodology proposed in Shute et al. (in press), and developing appropriate and engaging assessments (e.g., tasks, scenarios, simulations) to extract important data on relevant 21st century skills from students—individually and in groups—during interaction with an immersive environment. Findings from the second stage will inform the third stage which will involve adapting existing environments (e.g., NSF-funded *Global Warming Simulation*, MacArthur-funded *Quest Atlantis*, the commercial game called *Spore*) or developing new learning environments that incorporate scenarios and stealth assessment, and which fully support students' learning in relation to the important 21st century skills identified in stage 1 via formative feedback, collaboration, and personalized content (Shute, 2008; Shute, Hansen, & Almond, in press).

Before describing our current set of 21st century skills, we examine some of the problems this research is intended to solve. There are actually many obstacles that need to be overcome to make education truly effective for the future and for the masses (e.g., shortage of well-qualified teachers, inadequate financial resources for poor schools, delivery of content in ways that don't engage students, reliance on tests to get numbers instead of insight, etc.). One obstacle that's not usually included in the various lists – but should be – concerns a lack of clear vision about for what exactly we are preparing our kids. We can readily identify trends, such as the *shrinking world* phenomenon as it becomes progressively more interconnected. And we know that in the long run, it's less important to memorize information and more essential to know how to locate and make sense of credible information. But do our schools alter their curricula to accommodate these emergent needs? No. Are we adequately preparing our students for the realities of their future? No. Students are still memorizing and regurgitating facts, and they are graduating high school ill-prepared to tackle real-world, complex problems. We can't directly adjust the wind (the future), but we *can* adjust the sails (competencies). To do so effectively, we need to have a good sense of bearings—where we are, and where we're heading.

Where We Are—The Problems

This section discusses four different problems confronting us as a nation: (a) disengaged 21st century students; (b) an effectively shrinking world (commensurate with increased communication technologies); (c) decreasing competitiveness in the areas of math and science on the international front; and (d) increasing achievement gaps on the domestic front. Each of these will be described briefly.

Disengaged Students

There is a huge gulf between what kids do for fun and what they're required to do in school. School covers material that we deem important, but kids, generally speaking, are unimpressed. These same kids, however, are highly motivated by what they do for fun (e.g., play interactive games). Imagine these two worlds united. Student engagement is strongly associated with academic achievement; thus, combining school material with games has tremendous potential to increase learning, especially for lower performing, disengaged students. This research is intended to lay and firm up the foundation for a viable solution to methodological obstacles that surround such an important unification. The logic underlying the research is as follows. Compelling storylines (narratives) represent an important feature of well-designed games. Well-designed games tend to induce *flow* (Csikszentmihalyi, 1990), a state in which a game player loses track of time and is absorbed in the experience of game play. Flow is conducive to engagement, and engagement is conducive to learning. The problem is that immersive games lack an assessment infrastructure to maximize learning potential. Furthermore, typical assessments are likely to disrupt flow in good games. Thus, there is a need for embedded (or "stealth") assessments that would be less obtrusive and hence less disruptive to flow.

The Shrinking World

The second problem motivating our research is that the world is effectively shrinking (it's a small world after all). One of the main shifts that began at the end of the cold war and has been unevenly accelerating is from a perspective of mutual destruction to one of mutual connectedness. As part of our 21st century existence, we are confronted with *wicked* problems of enormous complexity and global ramifications (e.g., the massive meltdown on Wall Street, nuclear proliferation, global warming, a plastic island the size of Texas in the Pacific, antibiotic resistant microbes, destruction of the rain forests, poverty, new energy sources independent of fossil fuels, etc.). The people who will be making and managing policy decisions in the near future need to be able to understand, at the very least, how research works, how science works, and how peer review works—because solutions are going to be highly technical and highly complex (i.e., blinking is not optional). When confronted by problems, especially new issues for which solutions must be created out of whole cloth, the ability to think creatively, critically, collaboratively, and then communicate effectively is essential. Learning and succeeding in a complex and dynamic world is not easily measured by multiple-choice responses on a simple knowledge test. Instead, solutions begin with re-thinking assessment, identifying new skills and state standards relevant for the 21st century, and then figuring out how we can best assess students' acquisition of the new competencies—which may in fact involve *others* doing this assessment (e.g., community peers), as suggested in Gee's current paper. Moreover, the envisioned new competencies should include not only cognitive variables (e.g., critical thinking, reasoning skills) but also noncognitive variables (e.g., teamwork, tolerance, tenacity, curiosity) as the basis for new assessments to support learning (i.e., assessments *for* learning as opposed to assessments *of* learning). Each of these may be embedded and supported within valued domains—such as mathematics and science.

International Comparison of Mathematics Assessments

The third problem has to do with our country's poor standing in relation to math and science knowledge and skills among the developed countries of the world. In 2004–2005, the United States invested $536 billion in K-12 education and another $373 billion for higher education (U.S. Dept. of Education, 2005). But although the United States is a world leader in education *investment*, nations that spend far less regularly achieve much higher levels of student performance (PISA, 2004). For example, America's 15-year-olds performed below the international average in mathematics literacy and problem solving, according to the latest results from PISA. The test, given in the spring of 2003, assesses the ability of 15-year-old students from various countries (including 30 of the most developed) to apply learning to problems with a real-world context (see PISA, 2004). Students in the following countries outperformed the United States in mathematics literacy in 2003: Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Hong Kong-China, Iceland, Ireland, Japan, Korea, Liechtenstein, Luxembourg, Macao-China, the Netherlands, New Zealand, Norway, the Slovak Republic, Sweden, and Switzerland. These same 23 countries, plus Hungary and Poland, outperformed the United States in mathematics problem solving. U.S. 15-year-olds scored measurably better than their counterparts in only 3 of 30 nations on the new international test of problem solving in math. Moreover, the United States has the poorest outcomes per dollar spent on education. In short, U.S. students are performing poorly on mathematics tasks that involve transfer of learning and problem solving skills. We need to bolster our students' problem solving skills to compete effectively internationally, in the near future.

Widening Achievement Gaps

Shifting attention from the international to the home front, there are also some disturbing differences in mathematics achievement among subpopulations of U.S. students. Despite substantial educational reform efforts directed at poor and minority students across the last two decades, current data show large and growing achievement gaps between ethnic minorities and White students (e.g., Haycock, 2001; Lee, 2002). For example, in 1990, there was a 33-point gap between the scores of Black and White students on the National Assessment of Educational Progress (NAEP) mathematics test at the eighth-grade level. By 2000, the gap had grown to 39 points. Hispanic students were 28 points behind White students in 1990 and 33 points behind a decade later. In California in 2004, fourth- and eighth-grade Black and Hispanic students were found to perform, on average, 3 years behind comparable groups of White students in mathematics. According to Mora (2001a, 2001b), it is reasonable to conclude that for students in California, the achievement gap is most likely due to factors such as language proficiency and its impact on literacy, which relates to accessibility issues. And linking PISA findings and the achievement gap, Bracey (2004) analyzed 2003 PISA data, excluding Asian, Black, and Hispanic students from the sample. When ranking only White U.S. students in relation to students from the other 30 countries, the United States ranked as follows: Reading: 2, Math: 7, and Science: 4.

Where We Should Be Heading

Again, the dual goals of this paper are to figure out (a) *what* attributes to value, assess, and support for 21st century success, and (b) *how* to accomplish the design and development of valid and reliable assessments, toward resolving the big problems noted above. Modeling, assessing, and supporting students in relation to our set of skills is intended to allow students to grow in a number of important new areas, function productively within multidisciplinary teams, identify and solve problems (with innovative solutions), and communicate effectively. See Figure 1 for an overview of the competencies on which we focus our modeling, assessment, and instructional attention. Additional competencies will be identified and modeled as this project unfolds over time.

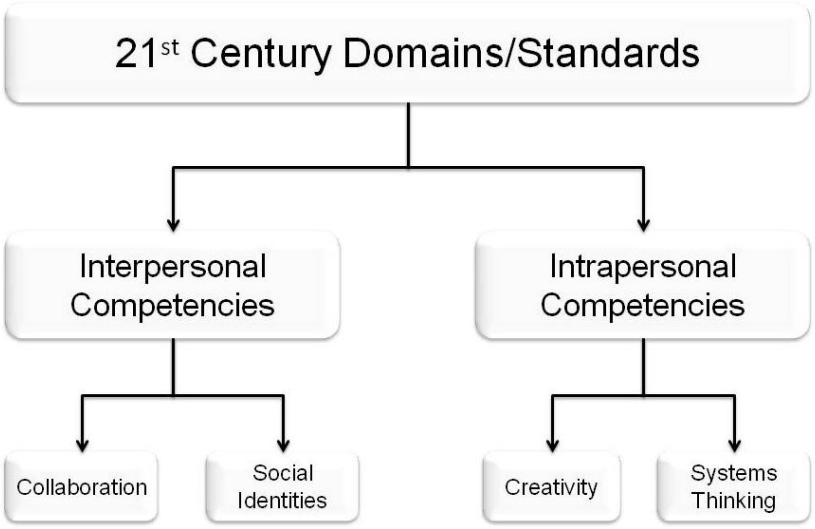

Figure 1. The set of 21st century attributes examined in this paper

To accomplish our goal of developing really good assessments that can also support learning, we begin with the "how" part of the story; namely, an overview of evidence-centered design (ECD) which supports the design of valid assessments. ECD entails developing competency models and associated assessments. We extend ECD by embedding these evidence-based assessments within interactive environments. Afterwards, and comprising the bulk of the paper, we present mini literature reviews relating to the variables shown in Figure 1 as well as their associated models.

Evidence-Centered Design

The whole point of assessment is to make learning – processes and products – visible. Unless you can see, hear, or use other senses to detect a student's learning, it's impossible to know whether learning has occurred. You can't assess what another person knows, feels, believes, etc. unless there is some observable evidence of that learning. Establishing how to make learning visible, however, is difficult. Most of a person's knowledge (and other mental states and traits) is invisible to others, and sometimes even to oneself. Because a person's thoughts cannot be seen, you need to depend on *indicators* that suggest the nature of his or her

knowledge.

Some fundamental ideas underlying ECD came from Sam Messick. According to Messick (1994), "*The nature of the construct being assessed should guide the selection or construction of relevant tasks, as well as the rational development of construct-based scoring criteria and rubrics*" (p. 17). This process begins by identifying what should be assessed in terms of knowledge, skills, or other attributes. These variables cannot be observed directly, so behaviors and performances that demonstrate these variables should be identified instead. This is followed by determining the types of tasks or situations that would draw out such behaviors or performances. An overview of the ECD approach (Mislevy, Steinberg, & Almond, 2003; Mislevy, Almond, & Lukas, 2004; Mislevy & Haertel, 2006) is described below.

ECD Models

The primary purpose of an assessment is to collect information that will enable the assessor to make inferences about students' competency states—what they know, believe, and can do, and to what degree. Accurate inferences of competency states support instructional decisions that can promote learning. ECD defines a framework that consists of three theoretical models that work in concert.

The ECD framework allows/requires an assessor to: (a) define the claims to be made about students' competencies, (b) establish what constitutes valid evidence of the claim, and (c) determine the nature and form of tasks that will elicit that evidence. These three actions map directly onto the three main models of ECD shown in Figure 2.

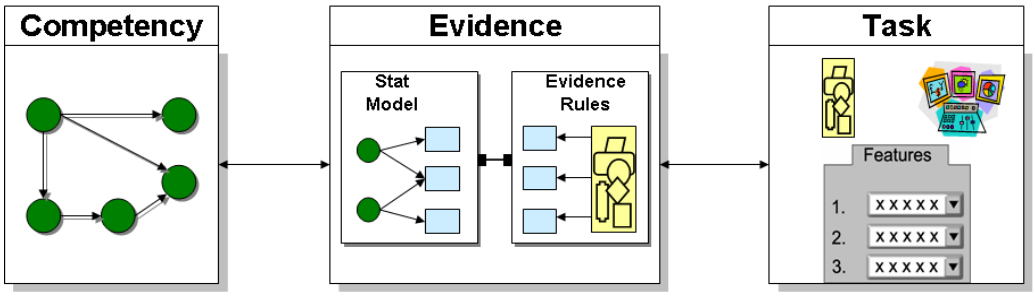

Figure 2. Three main models of an evidence-centered assessment design

A good assessment has to elicit behavior that bears evidence about key competencies, and it must also provide principled interpretations of that evidence in terms that suit the purpose of the assessment. Working out these variables, models, and their interrelationships is a way to answer a series of questions posed by Messick (1994) that get at the very heart of assessment design:

- ***What collection of knowledge, skills, and other attributes should be assessed?*** (Competency Model). This can also be phrased as: What do you want to say about the person at the end of the assessment? Variables in the competency model (*CM*) are usually called "nodes" and describe the set of person variables on which inferences are to be based. The term "student model" is used to denote a student-instantiated version of the CM—like a profile or report card,

only at a more refined grain size. Values in the student model express the assessor's current belief about a student's level on each variable within the CM. For example, suppose the CM contained a node for, "*Can draw a causal loop diagram*." The value of that node—for a student who was really facile at drawing causal loop diagrams—may be "high" (if the competency levels were divided into low, medium, and high), based on evidence accumulated across relevant tasks.

- ***What behaviors or performances should reveal those constructs?*** (Evidence Model). An evidence model expresses how the student's interactions with, and responses to a given problem constitute evidence about competency model variables. The evidence model (EM) attempts to answer two questions: (a) What behaviors or performances reveal targeted competencies; and (b) What's the connection between those behaviors and the CM variable(s)? Basically, an evidence model lays out the argument about why and how the observations in a given task situation (i.e., student performance data) constitute evidence about CM variables. Using the same node as above, the evidence model clearly indicates the aspects of causal loop diagrams that must be present (or absent) to indicate varying degrees of understanding or mastery of that competency. The same logic/methods apply to noncognitive variables as well—stating clearly the rubrics for scoring aspects of creativity, teamwork, etc.

- ***What tasks should elicit those behaviors that comprise the evidence?*** (Task Model). A task model (TM) provides a framework for characterizing and constructing situations with which a student will interact to provide evidence about targeted aspects of knowledge or skill related to competencies. These situations are described in terms of: (a) the presentation format (e.g., directions, stimuli), (b) the specific work or response products (e.g., answers, work samples), and (c) other variables used to describe key features of tasks (e.g., knowledge type, difficulty level). Thus, task specifications establish what the student will be asked to do, what kinds of responses are permitted, what types of formats are available, and other considerations, such as whether the student will be timed, allowed to use tools (e.g., calculators, dictionaries), and so forth. Multiple task models can be employed in a given assessment. Tasks are the most obvious part of an assessment, and their main purpose is to elicit evidence (which is observable) about competencies (which are unobservable).

Assessment design flows from left to right, although in practice it's more iterative. Diagnosis (or inference) flows in the opposite direction. That is, an assessment is administered, and the students' responses made during the solution process provide the evidence that is analyzed by the evidence model. The results of this analysis are data (e.g., scores) that are passed on to the competency model, which in turn updates the claims about relevant competencies. In short, the ECD approach provides a framework for developing assessment tasks that are explicitly linked to claims about student competencies via an evidentiary chain (e.g., valid arguments that serve to connect task performance to competency estimates), and are thus valid for their intended purposes.

Stealth Assessment

For most people, tests are a source of anxiety. Test anxiety can have adverse effects on performance. Fortunately, new directions in educational and psychological measurement allow more accurate estimations of students' competencies, and new technologies let us administer formative assessments during the learning process, extract ongoing, multi-faceted information from a learner, and react in immediate and helpful ways, as needed. When

embedded assessments are so seamlessly woven into the fabric of the learning environment that they are virtually invisible, we call this *stealth assessment*. Such assessments are intended to support learning and remove (or seriously reduce) test anxiety, while not sacrificing validity and reliability (see Shute, Hansen, & Almond, in press). Moreover, stealth assessments can be accomplished via automated scoring and machine-based reasoning techniques to infer things that would be too hard for humans (e.g., estimating values of competencies across a network of skills).

In learning environments with stealth assessment, the competency model will accumulate and represent belief about the targeted aspects of knowledge or skill, expressed as probability distributions for CM variables (Almond & Mislevy, 1999). Evidence models will identify what the student says or does that can provide evidence about those skills (Steinberg & Gitomer, 1996) and express in a psychometric model how the evidence depends on the CM variables (Mislevy, 1994). Task models will express situations that can evoke required evidence. One big question is not about how to collect this rich digital data stream, but rather how to make sense of what can potentially become a deluge of information. Another major question concerns the best way to communicate student-performance information in a way that can be used to easily inform instruction and/or enhance learning. Our solution to the issue of making sense of data, and thereby fostering student learning within immersive environments, is to extend and apply ECD (described above). This provides (a) a way of reasoning about assessment design, and (b) a way of reasoning about student performance whether in gaming or other learning environments.

Now we turn our attention to literature reviews and modeling of our initial set of 21st century skills that we have examined to date as part of this research project: Systems thinking, creativity, collaborative learning, and managing social identities.

21st Century Competencies

Systems thinking

The whole is more than the sum of its parts. ~ Aristotle

Why Systems Thinking Matters for the 21st Century

As noted earlier, rapid changes in today's world have revealed new challenges to and requests from our educational system. Problems facing 21st century *worldizens* (e.g., global warming, racial or religious intolerance, etc.) are complex and cannot be solved unilaterally. Instead, we need to think in terms of the underlying system and its sub-systems to solve these kinds of wicked problems (Richmond, 1993).

A primary task of education is to prepare students to succeed in their future lives. This includes the ability to act competently in complex situations, which is increasingly important in a complex world. To do so, competence in systems thinking (ST) is critical (Arndt, 2006). To illustrate the importance of ST, consider the AAAS Project 2061, intended to help students become literate in science, math, and technology (see http://www.project2061.org/). Project 2061 acknowledges that ST is one of the most powerful ideas in science, and has

recommended beginning the development of systems thinking as early as kindergarten (Rutherford & Ahlgren, 1990).

We now review the literature on ST and conclude this section with a preliminary competency model of ST for use in an assessment for learning system.

Review of the Literature

Definitions of Systems Thinking. Barak and Williams (2007) define ST as the ability to describe and analyze structures and phenomena in natural, artificial, and social environments. Similarly, Salisbury (1996) defines ST as being able to consider all of the elements and relationships that exist in a system, and know how to structure those relationships in more efficient and effective ways. Forrester (1994) points out two beneficial consequences of ST. The first benefit is to provide a general public introduction to the existence and importance of systems. According to Forrester, ST can alert the public to systems in terms of complex causal relations in business and social activities. The second benefit of ST is its constructive role as a door opener to field of system dynamics and other related areas (e.g., econometrics) requiring an understanding complex systems.

In general, a system can be defined as a group of parts or components working together as a functional unit (Ossimitz, 2000; Salisbury, 1996). A system can be physical, biological, technological, social, symbolic, or it can be composed of more than one of these (Barak & Williams, 2007). Each system consists of closed-loop relations and system thinkers use diagramming languages and methods to visually represent the relations and feedback structures within the systems. They also use simulations to run and test the dynamics to see what will happen (Richmond, 1993). The National Science Education Standards (National Research Council, 1996), like Project 2061 mentioned earlier, identifies systems as an important and unifying concept that can provide students with a ‘‘big picture’’ of scientific ideas which can then serve as a context for learning scientific concepts and principles.

According to Richmond (1993) and Ossimitz (2000), ST includes four main dimensions:

1. *Interrelated thinking*: Understanding that system components have multiple complex linkages, in contrast to linear thinking, where one cause is thought to have only one effect.

2. *Thinking in models*: The ability to construct models and transfer the system knowledge to real situations. To support such transfer, an awareness of a model’s premises is necessary.

3. *Dynamic thinking*: The ability to anticipate future behavior of systems with delays, oscillations, and feedback loops.

4. *Decision making*: Acting successfully in complex situations by choosing the right decision, which has been well considered (i.e., adequately “blinked”).

Systems Thinking and its Role in Education. Traditional teacher-centered approaches to education are much less suitable than learner-centered approaches for teaching and bolstering

ST skills, especially skills related to considering, understanding, and solving complex problems (Arndt, 2006). This is because in the teacher-centered classrooms, students spend most of their time assimilating content that's presented by the teacher (Brown, 2003) where the primary learning activity is memorizing or repeating content. Students are not engaged in ST beyond perhaps parroting back the teacher's thoughts. Although students encounter much content, they do not learn what to do with it. Thus, this type of learning really doesn't help much when confronted with novel, complex problems (Arndt, 2006; Richmond & Peterson, 2005). Furthermore, this approach rarely supports discussion about the relevance of the complex problems, and is poorly suited for the transfer of solutions to similar classes of problems. It comes as no surprise that most facts taught and learned via the traditional approach are quickly forgotten (Arndt, 2006). As a consequence, the expectations and needs for a 21st century educational system are being inadequately met by the teacher-centered approach.

Alternatively, learner-centered approaches are based on the notion that learning is primarily a construction rather than an assimilation process. This means that to learn, the student must construct or reconstruct what is being taken in (Richmond, 1993; Shute, 2007). Students who engage in ST have to actively construct functional relations among relevant components, either mentally or externally.

The competency model of systems thinking

To assess and support ST within a school environment, it's possible to construct indicators for important aspects of systems thinking (Assaraf & Orion, 2005). Having a good competency model should permit educators to collect data about students' knowledge of and performance on a set of tasks requiring the application of ST skills. This information could then be used to make inferences about students' current ST competency levels, at various grain sizes, for diagnostic, predictive, and instructional purposes. Our proposed ST competency model consists of three first-level variables: (1) specifying variables and problems in a system, (2) modeling the system, and (3) reviewing the model results (see Figure 3). Each of these first-level variables has a number of "progeny" and each will now be described in turn.

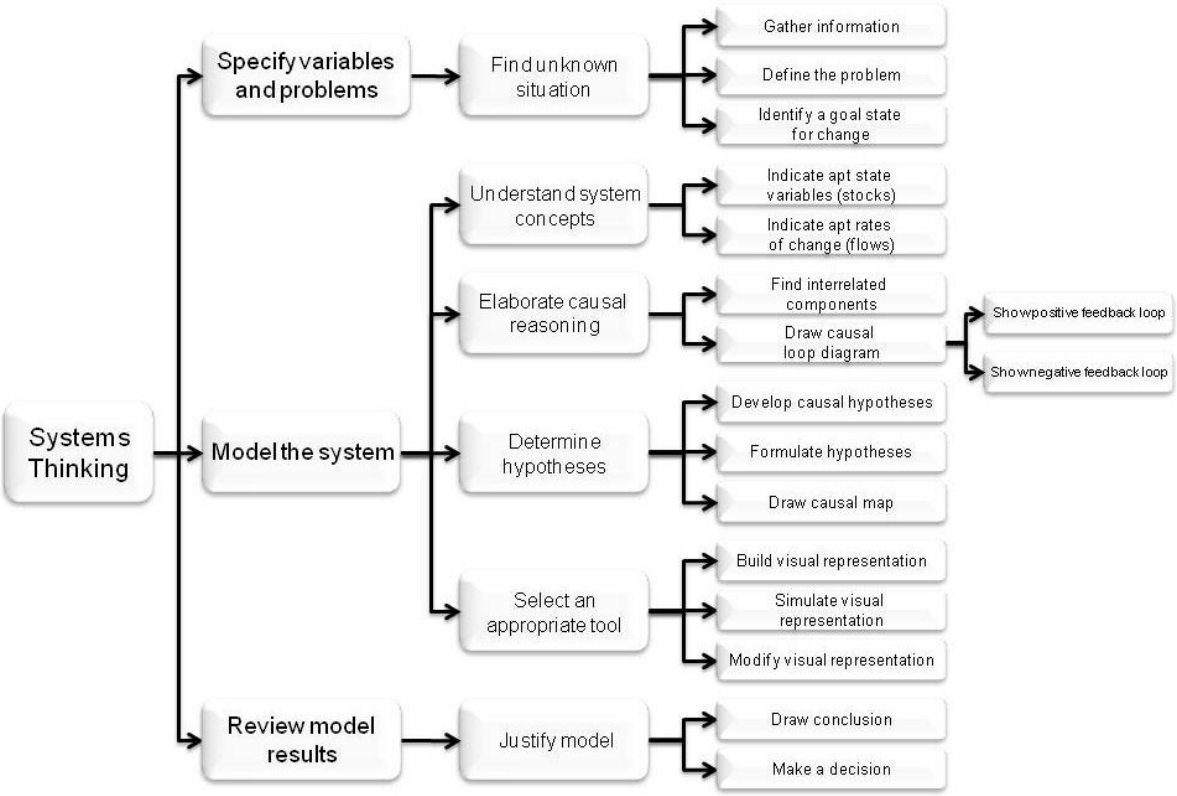

Figure 3. Proposed competency model of systems thinking

Specify variables and problems. We believe that the ST process begins by defining problems, formulating and testing potential solutions, and distinguishing fundamental causes of problems (Walker, Greiner, McDonald, & Lyne, 1998). So what exactly is a problem? Jonassen (2004) defines at least two critical features of a problem. The first relates to an unknown entity within some context (i.e., the difference between a goal state and a current state). The second aspect relates to finding or solving the unknown, which must have social, cultural, or intellectual value. Finding the unknown within a problem is important because if no one perceives an unknown, or even a need to determine an unknown, then there is no perceived problem. After defining the problem(s), system components can be specified in relation to the problem. The best way to determine system components is to answer, "*What causes what?*" questions. For example, "What causes overpopulation?" Some relevant answers may include: poverty, lack of education, inadequate birth control resources, etc.

Richmond and Peterson (2005) listed three fundamental issues that must be addressed at this beginning stage of ST: (1) What elements should be included in the model and what elements should be left out? (2) How should the included elements be represented? (3) How should the relationships between the elements be represented? Representing the particular *relationships* between components is a critical next step following the identification of system components. This is typically referred to as "modeling the system," described next.

Model the System. Modeling is one of the main tools used to show thinking about a system. The intent of a model is to help us share our thoughts with others and simplify complex things, whether it takes the form of a simple picture, a diagram, or a list of elements that portrays the system. Since many elements of a system can't be observed directly, models help us to visualize and externalize those elements (Jonassen, Strobel, & Gottdenker, 2005; Salisbury, 1996). Fortunately, today's computer technologies allow us to simulate almost any complex situation that we might want to study. Computer simulations also highlight and make visible otherwise hidden processes such as planning, decision making, and evaluation processes (Dorner, 1997). One of the most well-known ST tools is called STELLA (Structural Thinking and Experiential Learning Laboratory with Animation; see Mills & Zounar, 2001; Salisbury, 1996). Other software applications that are appropriate for creating system diagrams and models in educational settings include: Powersim, Modus, Dynasis, and CoLab.

One of the most difficult parts of modeling complex systems concerns *interactions*. In such systems, no action is unilateral in its impact. When one element of a system is changed it in turn influences other elements of the system. Thus, ST requires the understanding of the dynamic, complex, changing nature of systems (Salisbury, 1996). To illustrate, consider the *butterfly effect* in Chaos Theory, which describes how very small changes, like the flapping of a butterfly's wings in Miami, can affect extremely large systems, like weather patterns in Paris (for more, see Lorenz, 1995). The focus on interactions within ST contrasts with traditional analysis which typically focuses on separating the whole into constituent parts (Aronson, 1996). Now, to understand the whole system and its dynamic interactions, the concepts of stocks and flows are crucial (Mills & Zounar, 2001; Sterman, 2000). *Stocks* can be defined as state variables (or accumulations) which hold the current, snapshot state of the system. Stocks completely explain the condition of the system at any point in time and do not change instantaneously. Rather, they change gradually over a period of time. Stocks can represent concrete materials, such as the amount of water in a lake, or abstract concepts, such as level of happiness. *Flows* represent changes, or rates of change. Flows increase or decrease stocks not just once, but at every unit of time (Martin, 1997). For example, the total accumulation of water within a lake is decreased by evaporation and river outlets while it is increased by precipitation and river inlets. Consequently all system changes through time can be represented by using only stocks and flows.

In addition to fully understanding relevant system terms (i.e., the aforementioned stocks and flows, as well as the concepts of inputs, processes, and outputs), system thinkers must also be concerned with *feedback loops*. That is, in interrelated systems we have not only direct, but also indirect effects which may lead to feedback loops. Every action, change in nature, etc. is located within an arrangement of feedback loops. Feedback loops are the structures within which all changes occur (Ossimitz, 2000); that is, a closed chain of casual relationships that feeds back on itself (Georgiou, 2007). In other words, feedback represents information about results that supports the system so that the system can modify its work (Salisbury, 1996). The idea of feedback in systems is the most important variable in understanding a problematic situation in a holistic manner, and it also opens the door for quite complex understanding. Feedback loops are represented by causal loop diagrams, and there are two types of feedback: positive (reinforcing) and negative (balancing) (Ossimitz, 2000; Sterman, 2006). Negative feedback intends to achieve some steady state. Positive feedback is self-reinforcing, either in

terms of growth (regenerative dynamics) or deterioration (degenerative dynamics). Both growth and deterioration eventually collapse the system in the absence of negative feedback (Georgiou, 2007). World population and birth rate have a positive feedback relationship. That is, large populations cause large numbers of births, and large numbers of births result in a larger population. Each may view the other as a cause (Richmond, 1993), reminiscent of the old chicken-or-egg conundrum. Adding another factor into the equation (e.g., death rate) would be an example of a negative feedback loop influencing population. As a final point on the feedback issue, a proper understanding of feedback loops requires a *dynamic* perspective, in order to see how things appear and then change over time (Ossimitz, 2000).

Another distinction that's made in systems thinking is between open- vs. closed-loop systems. Most people tend to think in a linear manner and use linear thinking (i.e., one cause, one effect) to achieve their goals. This represents what's called an open-loop system (see Figure 4), where you see a problem, decide on an action, expect a result, and then that's the end of the issue (Forrester, 1996).

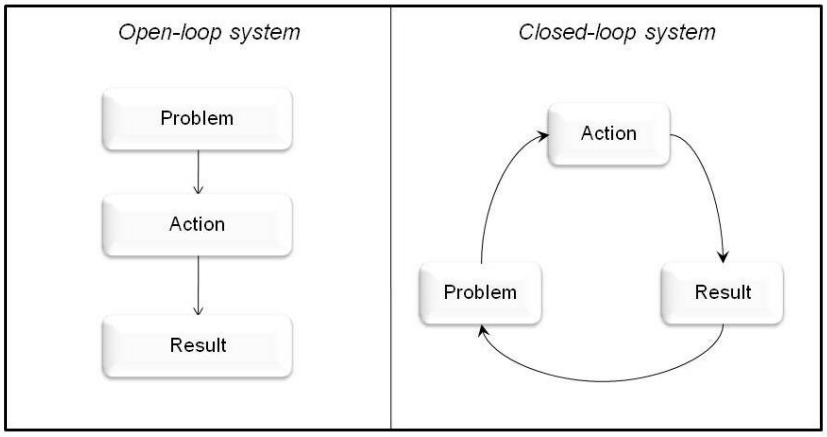

Figure 4. Comparing open-loop and closed-loop systems

However, the real world does not consist of simple linear relations but of complex relations that are highly interconnected and dynamic. Consequently, the behavior of real systems is often difficult to anticipate because it may be counterintuitive, nonlinear, and irreversible. As a result, linear thinking applied to complex systems is likely to fail (Senge, 1994; Sterman, 2000). To illustrate, think about the factors effecting gasoline prices in the U.S. Increasing and decreasing gasoline prices depend on a whole host of factors (e.g., value of the U.S. dollar, supply, demand, OPEC capacity, war effects, Wall Street crises, etc.) and these factors have complex relations with one another. To have a chance at solving complex problems (like predicting gas prices or tracking hurricane trajectories), people need to learn to think in terms of the "big picture" and about how things are related to each other rather than in terms of discrete, detailed facts. ST requires knowing about the individual parts of a system, the role each part plays, and how these parts interact to function as a whole (Assaraf & Orion, 2005). In real life, after gathering information about problem, this usually leads to some action that produces a result. But in actuality, there is no beginning or end. Instead, the process is iterative (i.e., a closed-loop system; see the right side of Figure 4). So, systems are never

totally open. If a system *were* totally open, then it would have no orderly interaction with its environment.

Once causal relationships have been represented and feedback loops established, the process of constructing models requires a person to formulate hypotheses about those relationships (Spector, 2000).

Review the model results. After modeling and simulating the system, drawing conclusions and making decisions are essential to reflect on the obtained results (Richmond & Peterson, 2005). The actual results are compared with the expected results and significant differences must be examined carefully. Differences can be described by computer models. The examination process of unexpected simulation results contains significant opportunities for learning because it requires intensive reflection by the student, as well as adaptation of one's mental model (Sterman, 2000).

Having now reviewed the variables relating to the construct of systems thinking, consider the following illustration of ST in action.

Example of systems thinking

Eric was very excited and couldn't sleep. The reason was that each year, at the end of the summer, his family took a trip to visit Uncle Henry. This was the best time of the whole year for Eric who got to spend time with his favorite uncle down in New Orleans. After a restless night, Eric got up before dawn and packed what he needed. Just when he finished packing, his father called him, "Eric! Could you come to the downstairs?" Eric went downstairs immediately.

"I'm ready Dad! When do we leave?" asked Eric.

"I have some bad news for you. We can't go visit Uncle Henry this year. Our flight was cancelled because of the hurricane that's due to hit New Orleans in the next 24 hours."

Eric was very disappointed as he'd been waiting to see Uncle Henry for a year. Meanwhile, his mother turned on the television and found that all the news channels were talking about Hurricane Katrina. Eric and his family watched the news together, silently. One of the experts on the program explained that one reason for the ferocity of the hurricane had to do with global warming. "Global warning?" asked Eric. "Yes, Eric. People need to figure out this global warming problem really soon!" said his father.

Eric was very disappointed about the cancelled trip, but he was now very curious about the reasons for global warming. If he knew the reasons, he could come up with possible solutions to prevent global warming problems in the future.

After defining the problem, and across the next three months, Eric began gathering information from many sources (books, magazines, the Internet, etc.). He examined all of his information very carefully and took down many notes on his computer. To understand the global warming concepts, he included indicators that changed gradually over time (i.e., the stocks of the system) and affected the stocks not just once, but at every unit of time (i.e., flows). Connecting the various concepts and specifying relationships among the global warming components, he created a concept map on his computer using Cmap (see Figure 5).

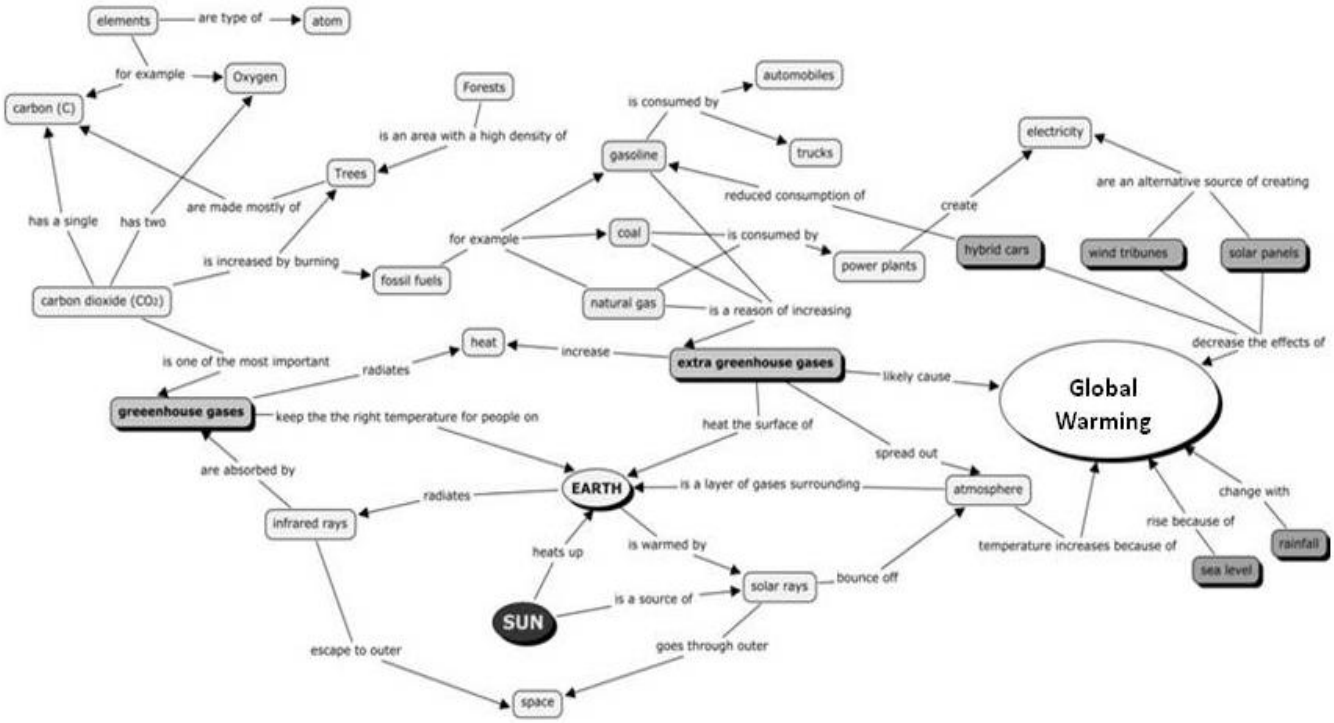

Figure 5. Eric's concept map of global warming

Following a series of careful examinations of his concept map, Eric started to see interrelated components. After identifying those components, he drew a causal loop diagram on a piece of paper to visualize how the interrelated components affected one another. He demonstrated positive and negative loops in that diagram. Figure 6 shows an example of one of his positive feedback loops (for a similar feedback loop, see Medley & DeSpain, 2008).

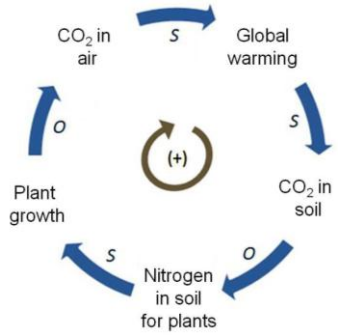

Figure 6. A positive feedback loop from Eric's causal map of global warming

In this causal loop diagram, if global warming increases, then CO_2 stored in soil increases. Eric put an "*S*" on the arrow to denote change in the same direction (i.e., if global warming increases, the CO_2 in soil will be greater than it would have been otherwise; a decrease in the global warming causes the CO_2 to be less than it would have otherwise been). However, more CO_2 in the soil means less nitrogen in soil available for plants to use. This inverse (or opposite) relationship is shown by an "*O*" on the arrow. Next, less nitrogen means less plant growth, and finally, less plant growth means more CO_2 in the air, which leads to increases in global warming.

Finally, he decided to construct a model. He opened his computer and found a good program that allowed him to simulate and build his model. After simulating his model and engaging in revisions, he reviewed the results coming from the model. He could not believe his eyes. There were a lot of things one could do to stop global warming. He knew he personally had to start somewhere, so from that point on, he decided not to use paper needlessly which would help to reduce the number of trees being cut down, which would in turn reduce carbon dioxide output, and hence less global warming!

The next competency we examine is creativity. We posit that it's not enough to be able to engage in logical systems thinking, but it's also very important to be able to come up with *creative* solutions to problems. What is creativity, what are the most important features of creativity, and how can we model and assess this construct?

Creativity

The intuitive mind is a sacred gift and the rational mind is a faithful servant. We have created a society that honors the servant and has forgotten the gift. ~Albert Einstein

Why Creativity Matters for the 21st Century

The APA dictionary of psychology (2006) defines creativity as the ability to produce or develop original work, theories, techniques, or thoughts. Even though many people may believe that creativity is the sole domain of geniuses such as Mozart or Einstein, individuals need a certain degree of creativity to solve the many and assorted problems they encounter in daily life (Mumford et al., 1991; Torrance, 1971).

Simply put, creative thought is a vital part of society and culture (Simonton, 1990; Walberg, & Stariha, 1992), playing a critical role in advancing science, technology, humanities, and the arts (Dudek, 2003). It has also become a key concern of organizations and businesses because of its role in innovation and entrepreneurship. Nearly 50 years ago, Bruner (1962) called for society to embrace and foster children's creativity as a preparation for the future since creativity comprises the foundation of problem solving. But while significant changes of the type Bruner advocated were not realized in this country, recently the European Commission proposed that 2009 will be the "European Year of Creativity and Innovation" to boost creativity for both economic and social reasons.

Despite its importance to a variety of societal functions, creativity has been largely ignored by educational systems and neglected as a research topic in psychology. Sternberg and Lubart (1999) found that approximately 0.5% of the articles indexed in Psychological Abstracts from 1975 to 1994 related to creativity. They described several possible reasons why creativity research has been so under-investigated. First, the origins of the study of creativity were based on a tradition of mysticism and spirituality, which often runs counter to the scientific method. Second, pragmatic approaches to creativity have given some the impression that the study of creativity is driven by a kind of commercialism that, while it may be successful in its own way, lacks a basis in psychological theory and verification through psychological research. Third, early work on creativity was theoretically and methodologically separated from mainstream psychology, resulting in its being viewed as peripheral to the central concerns of psychology. Fourth, problems with the definition of and criteria for identifying and measuring creativity caused research difficulties. And while paper-and-pencil tests of creativity resolved

some of these problems, they led to criticisms that the phenomenon had been trivialized. Fifth, single approaches to studying creativity have tended to view it as an extraordinary result of ordinary structures or processes. Consequently, it has not seemed necessary to have a separate study of creativity and the average person. In effect, other approaches have subsumed creativity under them, as a special case of what is already being studied. Finally, unidisciplinary approaches to studying creativity have tended to view just a small part of the phenomenon.

Due to the reasons noted above, there is no single unified definition of creativity as well as no standardized measurement technique. The most common approach, paper-and-pencil testing, has been amply (and justifiably) criticized as a measurement method since it tends to overly simplify creativity. In addition, such assessments can interrupt the flow of the creative process when an individual is trying to solve a task (Shute et al., in press). Thus, it is important to assess one's creativity in a context, which does not interrupt the natural flow of creative thinking.

Next, we review the literature on creativity and present our competency model of the construct.

Review of the Literature

Definitions of creativity. According to Taylor (1988), there are more than 60 definitions of creativity, and there have been countless arguments over the accepted definition of creativity among psychologists (Amabile, 1983). Despite this lack of agreement, there are some prominent definitions and perspectives relating to creativity.

Guilford's (1950) APA presidential address is often seen as the foundation of ensuing scientific research on creativity (e.g., Brown, 1989; Runco, 2004). He strongly criticized the dominant belief about creativity—that it was a "gift" with special qualities that ordinary people do not have. Instead, he claimed that, "creative acts can therefore be expected, no matter how feeble or how infrequent, of almost all individuals." Guilford conceived of creativity as a set of cognitive processes, and posited eight primary abilities or proclivities underlying creativity: (1) *Sensitivity to problems*: In certain situations a creative person will see a number of problems whereas others will see few or none; (2) *Fluency*: Those people who produce large numbers of ideas are more likely to have significant ideas; (3) *Novel ideas*: Creative people have uncommon but acceptable ideas; (4) *Flexibility*: Creative people can easily switch from old habits of thinking to new ways of thought; (5) *Synthesizing ability*: Creative thinking requires the organizing of ideas into larger, more inclusive patterns; (6) *Analyzing ability*: Symbolic structures must often be broken down before new ones can be built; (7) *Complexity*: A creative person can mentally manipulate a number of interrelated ideas at the same time without becoming confused; and (8) *Evaluation*: Creative people go through some degree of evaluative restraint before settling on an acceptable idea or path.

The structure that is frequently used in creativity research comes from Rhodes (1961) who proposed four factors that interact in creativity: *person* (certain mental abilities and attitudes of creative people), *process* (creative ways of thinking), *product* (some ideas, solutions, and designs are more creative than others), and *press* (some physical and social environments

produce more creativity than others). For example, research focusing on the creative person examines personal traits (e.g., personality types and intrinsic motivation). Process research may be less personal and more behavioral, focusing on cognitive processes such as divergent thinking and problem solving (Runco, 2004), while the product approach examines the outcomes of creative thinking. Rhodes (1961) stated that press refers to the relationship of people and their environment, including social and situational influences such as competition and resources (Mednick, 1962; Murray, 1938).

Torrance (1974) primarily studied creative processes. Per his definition, creative thinking is the process of sensing difficulties, problems, gaps in information, missing elements, something askew; making guesses and formulating hypotheses about these deficiencies; evaluating and testing these guesses and hypotheses; possibly revising and retesting them; and communicating the results. Later, Torrance summarized five subscales of creativity (Torrance & Ball, 1984; Torrance, 1990):

- *Fluency*: The number of relevant ideas; shows an ability to produce a number of figural images.

- *Originality*: The number of statistically infrequent ideas; shows an ability to produce uncommon or unique responses. The scoring procedure counts the most common responses as 0 and all other legitimate responses as 1. Originality lists have been prepared for each item on the basis of normative data, which are readily memorized by scorers.

- *Elaboration*: The number of added ideas; demonstrates the person's ability to develop and elaborate on ideas.

- *Abstractness of titles*: The degree beyond labeling; based on the idea that creativity requires an abstraction of thought. It measures the degree that a title moves beyond concrete labeling of the pictures drawn.

- *Resistance to premature closure*: The degree of psychological openness; based on the belief that creative behavior requires a person to consider a variety of information sources when processing information, and to keep an open mind.

Other research on creativity (e.g., confluence approaches) suggests that there are multiple variables that need to converge for creativity to manifest (Amabile, 1983, 1996; Csikszentmihalyi, 1988; Sternberg, 1985a, 1985b, 1996; Sternberg & Lubart, 1991, 1995). For instance, Amabile (1983) emphasized the importance of social and environmental influences on creativity. She noted that creativity is best conceptualized not as a personality trait or a general ability, but instead as a behavior resulting from particular collections of personal characteristics, cognitive abilities, and social environments. This behavior, which is evidenced in products or responses, can only be completely explained by a model that encompasses all three sets of factors. She defined creativity as the production of responses or works that are reliably assessed as creative by appropriate judges, and also provided a framework consisting of three components: (1) domain-relevant skills, (2) creativity-relevant skills, and (3) task motivation.

Domain-relevant skills can be considered the basis for problem-solving, such as factual knowledge, technical skills, and special talents in the domain. *Creativity-relevant skills* include: (a) cognitive styles that involve coping with complexities, breaking one's mental set during problem solving, and knowing ways to generate novel ideas (e.g., trying a counterintuitive approach), as well as (b) work styles that are characterized by focusing attention and effort, ignoring irrelevant problems, and engaging in self-discipline. *Task motivation* comprises a set of variables that determine one's attitude toward a specific task. A clear contribution of Amabile's (1983) approach is that it explains different levels of specificity for each of the three components. In other words, a person's creativity is *not* the sum of each of the components, but instead the confluence of the various factors. In addition, this definition highlights the importance of intrinsic motivation in relation to creativity.

Similarly (but less parsimoniously), Sternberg and Lubart (1995) suggested that creativity requires a confluence of six interrelated factors: intellectual abilities, knowledge, thinking styles, personality, motivation, and the environment. As they rather cleverly put it, creative people are those who are willing and able to buy low and sell high in the realm of ideas. The first factor, intellectual abilities, consists of three specific abilities: (a) the *synthetic skill* to see problems in new ways and to escape the bounds of conventional thinking, (b) the *analytic skill* to recognize which ideas are worth pursuing and which are not, and (c) the *practical-contextual skill* to persuade others of the value of one's ideas. Second, they defined knowledge as a resource of creativity, claiming that a person needs to know enough about a field to move it forward. "One cannot move beyond where a field is if one does not know where it is." A person can certainly use knowledge from the past, but should be careful that the knowledge does not hinder creative thinking. The third factor of creativity is thinking style—the preferred way of using one's skills and decisions on when and how to deploy the skills. In particular, they claim that a legislative thinking style (i.e., preference to think in new ways) is very important for creative thinking. The fourth factor concerns personality variables, which include: willingness to overcome obstacles, willingness to take sensible risks, willingness to tolerate ambiguity, and self-efficacy. Finally, Sternberg and Lubart, like Amabile, see motivation as an important resource for creativity; particularly intrinsic and task-focused motivation. However, they suggest that intrinsic motivation is not something inherent, but rather, under one's control or volition.

In recent work, Sternberg (2001) expands on this volition idea by emphasizing the importance of decision making in creativity. That is, to be creative a person has to first *decide* to generate new ideas, analyze these ideas, and sell them to others. He proposed a number of different decisions by which one can develop creativity, such as: redefine problems, question and analyze assumptions, recognize that knowledge can both help and hinder creativity, identify and surmount obstacles, take sensible risks, tolerate ambiguity, delay gratification, and try to see things from others' perspectives. This focus on decision making explains creativity in terms of a series of actions as well as cognitive and noncognitive efforts that an individual "chooses" to employ for creative processes and purposes. That is, creativity is as much a decision about and an attitude toward life as it is a matter of ability. According to Sternberg (2006), creative potential has been suppressed by a society that encourages intellectual conformity. "Yet, anyone can decide for creativity." This echoes the sentiments expressed by Guildford over a half century ago.

In summary, there are some common notions of creativity that run through the literature on creativity which we distill as follows: (a) the *output* (e.g., ideas) of creative processes is characterized by both novelty and relevance; (b) there is a specific object (e.g., problem) that serves as the *impetus* or initial point of creativity; and (c) the creative process represents a *confluence* of factors including personality traits, attitudes, cognitive abilities, knowledge, and the environment.

The competency model of creativity

Creativity is a highly dimensional competency, and as such it should be assessed in a manner that fully explores these different dimensions (e.g., personality traits and attitudes). Prior measurement techniques have tended to neglect the dimensionality of creativity (Hocevar, 1981) and thus fail to provide a complete picture of the competency. In addition, many theories of creativity do not provide information at a sufficiently micro level so that one can determine the measurable variables that can be used as evidence of one's creativity. As Brown (1989) pointed out, theorizing about creativity has not been explicitly linked to observable antecedent and consequent conditions. Constructs "hang suspended in the ether," and thus are not tied to reality by either adequate bridge statements or clear operational definitions.

To counter this problem, our competency model for creativity is based on the ECD approach. The suggested model has the following dual features: (1) it embraces multiple dimensions of creativity in the context of problem solving, and (2) it further decomposes those dimensions to levels of specific skills that permit us to make inferences and diagnoses about levels of creativity. Figure 7 shows the first-level variables. More specific variables per first-level variable are then elaborated, followed by some examples of observable variables (i.e., indicators).

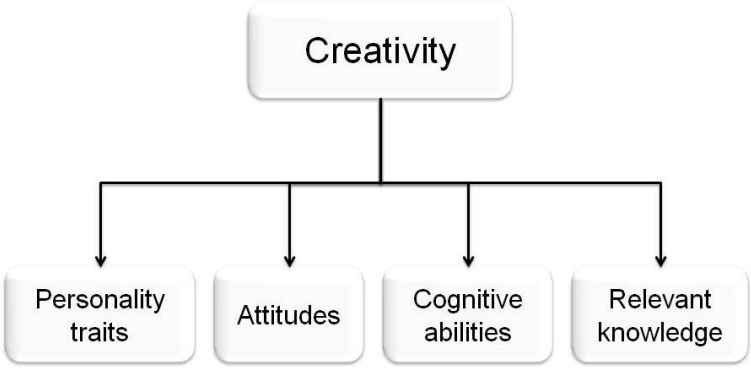

Figure 7. First level of variables of creative problem solving competency model

Personality traits. Traits are not always active but persist even when latent, have low thresholds of arousal, and are not directly observable (Allport, 1937). Eysenck and Eysenck (1985) define *personality* as a more or less stable and enduring organization of a person's character, temperament, and intellect, all of which determine a person's unique adjustment to the environment. Character denotes a person's conative behavior (will or volition);

temperament relates to affective behavior (emotion); and intellect represents cognitive behavior (intelligence).

The five-factor model (FFM) of personality (also known as the Big 5) has often been used as a structure to understand the influence of personality traits on creativity (e.g., McCrae & John, 1992). The FFM hypothesizes that there are five fundamental bipolar dimensions to personality: neuroticism (N), extraversion (E), openness to experience (O), agreeableness (A), and conscientiousness (C). During the 1980s and 1990s, researchers began to examine the *creative personality* (Batey & Furnham, 2006). Studies that directly examined relationships between creativity and FFM found that the personality trait consistently showing the strongest correlation with creativity was openness to experience (Feist, 1999). Openness to experience related to several aspects of creativity, such as originality, sophistication in the arts, and concern for aesthetics (McCrae, 1987; 1993).

So what is the nature of the relationship between openness and creativity? McCrae (1987) focused on the roles that each might play within a creative activity. He suggested that divergent thinking may indicate an *aptitude* for creativity, while openness to experience serves as a *catalyst* leading to creative expression and exploration. This indicates that we might expect creative ability and openness to interact as predictors of creative productivity. That is, creative ability should only be predictive of creative accomplishment to the extent that an individual is open to experience.

Aside from openness to experience, additional research suggests that some of the other FFM factors might also relate to creativity. For example, McCrae, Costa, and Busch (1986) defined the low end of extraversion (i.e., introversion) as overly controlled and "emotionally bland" but the opposite end of this dimension (i.e., extraversion) as active and passionate. Along these same lines, Barron and Harrington (1981) suggested that high energy and self-confidence characterize creative individuals. In addition, Cropley (1990) found willingness to take risks to be related to creativity, an idea supported by Sternberg (1988). Taken together, these descriptions suggest that extraversion, in the form of willingness to grow and take sensible risks, would be positively related to creativity.

In contrast, agreeableness might share a negative relation with creativity. While there is no reason to believe that creative individuals would not be "nice" people, those who are higher on the agreeable dimension are known for cooperation and conflict avoidance (McCrae & Costa, 1990). These descriptors suggest that agreeableness may lead to conformity, whereas creative individuals have been found to be less conforming (Guncer & Oral, 1993) and more autonomous (Nabi, 1979; Perkins, 1993) than others. Figure 8 shows the "personality" fragment of our creativity model.

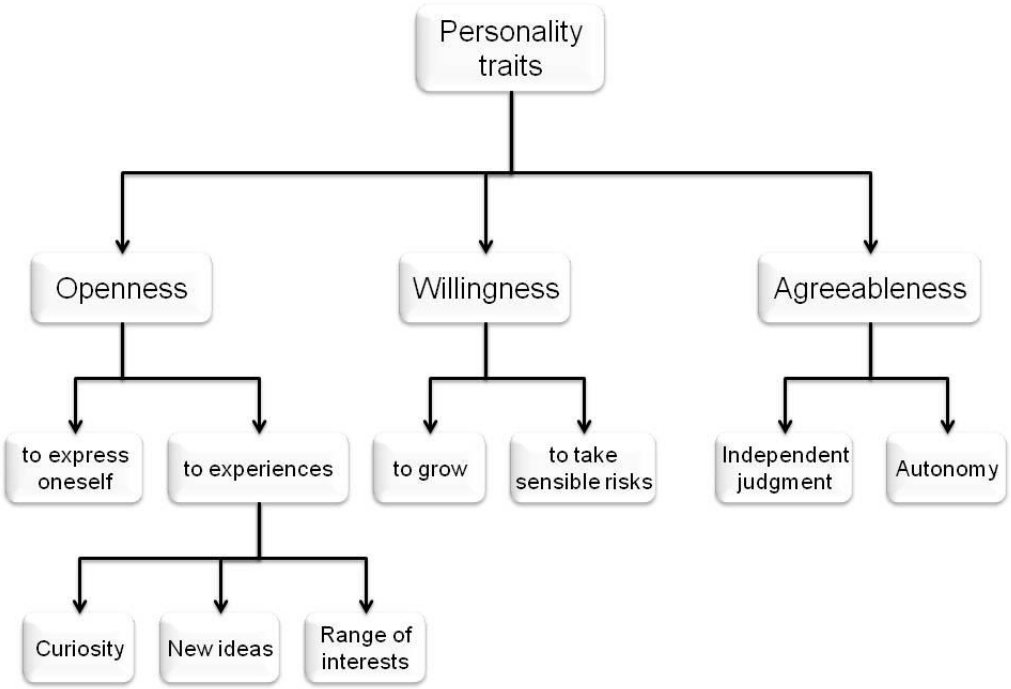

Figure 8. CM of creative problem solving-personality traits

Attitudes. Greenwald and Banaji (1995) define *attitudes* as "traces of past experience that mediate favorable or unfavorable feeling, thought, or action toward social objects." Moreover, attitudes tend to be less stable as compared to traits and abilities (Shute, Lajoie, & Gluck, 2000). One attitude in particular has been examined in relation to creativity; namely intrinsic motivation. For example, Amabile (1982, 1985) found that creative writing that was accomplished under an extrinsic motivation condition was significantly less creative than writing that was produced under an intrinsic motivation condition.

Another attitudinal variable that appears to be related to creativity is self concept. Marsh and Shavelson (1985) describe self-concept (or self-construct) as multifaceted in that people categorize an enormous amount of information about themselves. Felker and Treffinger (1971) found that students with high self-concept tended to score significantly higher than students with low self concept on self reports of creative abilities, verbal fluency, flexibility, and originality. Similarly, Wright, Fox, and Noppe (1975) reported a significant relationship between creativity and creative self-concept. Finally, tolerance for ambiguity is often mentioned as a characteristic of creative individuals (Dacey, 1989; Sternberg 1988).

A problem with this research examining attitudes and creativity is that measures of creativity as well as self concept and other attitudinal variables are primarily derived from self reports. However, there are many problems inherent in self-reported data (e.g., misrepresenting the truth to appear in a more positive light). Countering this problem is one of the reasons we've chosen to use an evidence-centered design approach to develop our assessments. Figure 9 illustrates the variables associated with attitude in our creativity CM.

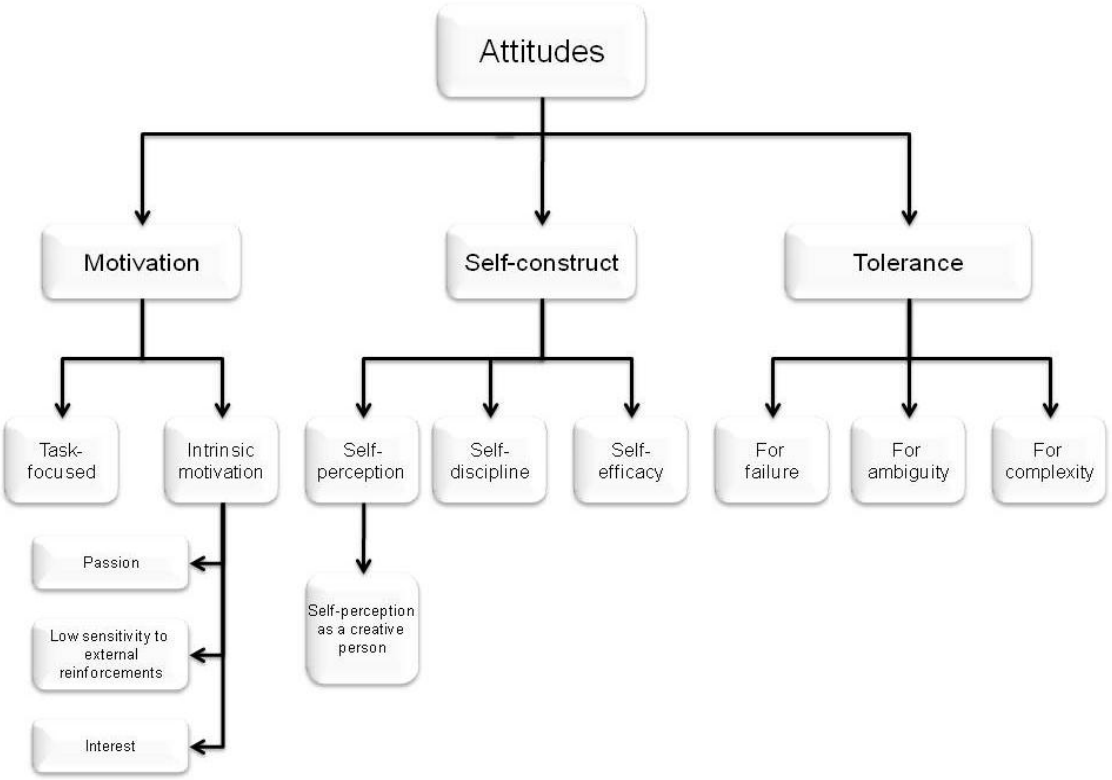

Figure 9. CM of creative problem solving-Attitudes

Cognitive abilities. A problem-finding orientation (which is the first step in systems thinking, as described earlier) refers to an ability that allows a person to recognize critical issues in an area of study and to focus on these issues to the exclusion of others (Perkins, 1981; Sternberg, 1988). The importance of problem finding as an approach to creativity has been documented longitudinally with artists (Getzels & Csikszentmihalyi, 1976).

Another frequently-mentioned cognitive ability that's been associated with creativity is convergent thinking. According to Cropley (2006), convergent thinking is oriented toward deriving the single best (or correct) answer to a clearly defined question. It emphasizes speed, accuracy, and logic, and focuses on recognizing things that are familiar, reapplying a set known procedures or techniques, and accumulating information. Even though the relationship between convergent thinking and creativity has not been investigated as much as divergent thinking (Cropley, 2006), its importance has been emphasized in more "practical" areas of creativity (e.g., technological innovations) (Cropley & Cropley, 2005; Gurteen, 1998).

Creativity is often linked to divergent thinking – more commonly referred to as brainstorming. Guilford (1950) suggested four main characteristics of divergent thinking: fluency (the ability to rapidly produce a large number of ideas or solutions to a problem); flexibility (the capacity to consider a variety of approaches to a problem simultaneously); originality (the tendency to produce ideas different from those of most other people); and elaboration (the ability to think through the details of an idea and carry it out). Based on these characteristics, a variety of tests have been developed to measure divergent thinking. Guilford

(1968) and others (e.g., Torrance, 1974; Wallach & Kogran, 1965) have suggested that creative individuals possess the types of abilities measured by tests of divergent thinking. Other researchers have claimed that divergent thinking is an important component of creativity because the generation of lots of responses to a single prompt (a main aspect of divergent thinking) simply increases the likelihood that at least one will comprise an original idea (Eysenck, 1995; Mednick, 1962).

Runco (1986) examined the relationship between divergent thinking and creative performance in different domains, and concluded that there are particular areas of performance (e.g., writing and the arts) that are more strongly related to divergent thinking than other areas (e.g., music and science). Finally, even though divergent thinking is believed to be an important component of creativity, some have criticized this position because divergent thinking abilities only explain the *potential* for creativity, but not the end result (Runco, 1993; Hocevar & Bachelor, 1989).

Figure 10 shows the sub-model of cognitive abilities that we believe are related to creativity.

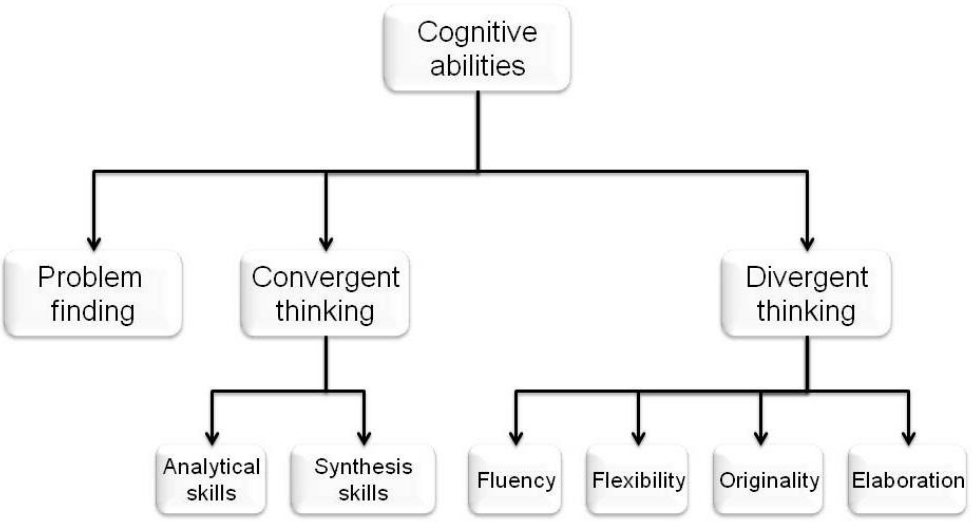

Figure 10. CM of creative problem solving-Cognitive abilities

Creative knowledge. Researchers have long noted the importance of knowledge in creative endeavors (Amabile, 1985; Sternberg & Lubart, 1991, 1995; Wiley, 1998). Specifically, creative *use* of knowledge has been seen as important as knowledge itself. For instance, Weisberg (1999) stated that knowledge may provide the basic building blocks for constructing new ideas, but in order for these building blocks to be available, the mortar holding the old ideas together must not be too strong. So, while it is commonly acknowledged that a person needs to have knowledge of a field to produce something novel within it, it is also widely assumed that too much experience can leave a person in a rut, stuck with a kind of stereotyped responding. The nature of this relationship between knowledge and creativity is believed to be quadratic (i.e., an inverted U shape), whereby most creativity occurs with some middle range of knowledge (Weisberg, 1999).

Polanyi (1966) used the term "tacit knowledge" to describe the fact that expert scientists often know more than they are able to articulate. Polanyi claimed that the essence of the work of creative scientists involved "building up a personal knowledge" that resisted verbalization but nevertheless was the driving force behind the ultimate attempts to come up with creative ideas. Therefore, for Polanyi, tacit knowledge was a crucial part of scientific creativity. A related concept in the psychological literature is "implicit learning" which refers to the acquisition of knowledge that takes place largely independently of conscious attempts to learn and largely in the absence of explicit knowledge about what was acquired (Reber, 1993).

Explicit knowledge is the knowledge that can be articulated, codified, and transmitted easily. See Figure 11 for our sub-model of creative knowledge.

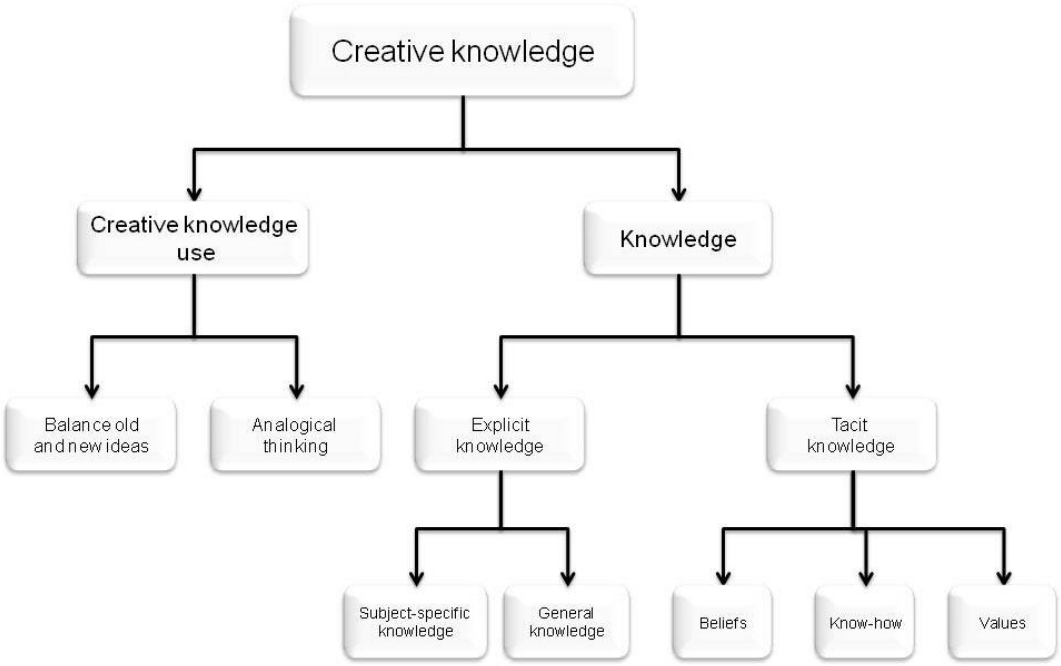

Figure 11. CM of creative problem solving-Creative knowledge

Example of creativity in the context of problem solving

Ashley is a new resident of a virtual world, Second Life. As she explored the Second Life landscape, she wondered if people in Second Life could ride in vehicles. Up to that point, she had only seen them fly or teleport. There were go-karts available for sale, but Ashley decided to build her own scooter.

Ashley sat down in front of her computer thinking about possible designs for her dream scooter. She brainstormed many different options, forcing herself to think outside of the box and not to worry if the ideas were feasible. About an hour into this exercise, she began to elaborate some of the ideas by adding more details. During this process, she thought about her real-world hot-pink *Vespa*, and from that she was inspired to add even more features to her "virtual" scooter design—like a turbo-boost button that she'd always wanted. She was having a blast, and felt quite creative.

Finally, Ashley had a good idea of what her scooter should look like and how it should function. It was time to start building! However, Ashley's enthusiasm and ideas hit a stumbling block: actually building a scooter per her

specifications using Second Life's resident script language, Linden, proved to be much harder than she had anticipated. She simply didn't know where or how to start. She tried to code based on her prior experience with script languages, but failed. However, she did not give up. She believed that the fuzziness she was experiencing was a part of process, so she decided to let herself enjoy the challenge. Because of her high self-efficacy, she knew that she'd accomplish her goal. This insight served to push (or motivate) her through the process.

After several hours of concentrated effort and trial and error experiments, Ashley finally succeeded in building her scooter. Triumph! But then she developed a new concern: Would the other residents of Second Life think her unique, home-grown scooter was cool? Or would they find it lame in comparison to those that were offered for sale in Second Life? Not being one to let others' opinions stand in her way, Ashley next focused on how she needed to sell her idea (and perhaps customized scooters) to others in Second Life.

In addition to systems thinking and creativity, we believe that 21st century *worldizens* should also be able to effectively, efficiently, and respectfully work in different groups. We now present the features and the competency model for collaborative learning.

Collaborative Learning

The wisdom of the masses exceeds that of the wisest individual. ~Anonymous

Why Collaborative Learning Matters for the 21st Century

Many researchers (as well as teachers) agree that learning is enhanced when students work in small groups to express their thoughts, argue ideas, and collaborate on solutions to problems (Johnson, Johnson, & Holubec, 1994; Johnson, Johnson, & Stanne, 2000; Palloff & Pratt, 1999). Small-group learning can also help students develop their critical thinking skills (e.g., ability to analyze, synthesize, and evaluate concepts; Gokhale, 1995) and higher-order thinking skills (e.g., problem solving and inductive reasoning through group communication; Lajoie, 1991). In Johnson and Johnson's study (2002), they showed that students learning within such groups not only demonstrated higher-order thinking skills, but they also retained information longer than students who worked individually. Thus, students develop critical- and higher-order thinking skills in small-group settings likely because they have an opportunity to participate in group discussions, provide personal contributions, think creatively, solve problems, and help to make group decisions to achieve shared goals (Gokhale, 1995; Totten, Sills, Digby, & Russ, 1991).

Collaborative learning has been widely adopted and applied in instructional environments by instructors for the past couple of decades (e.g., Jenkins, in press; Totten, Sills, Digby, & Russ, 1991). Researchers have shown significant effects of collaborative learning on knowledge acquisition, performance, motivation, and skill achievement (e.g., Gokhale, 1995; Johnson & Johnson, 2002; Lajoie, 1991). However, students often do not intuit how to effectively collaborate and thus require guidance or facilitation in order to learn how to best work together. Further, these same skills are very much in demand and valued in the workplace, where collaboration and teamwork have become the norm in many settings. For these reasons, we have chosen collaborative learning skills as important to model and assess for 21st century success.

Next, we review the literature on collaborative learning and provide a preliminary competency model.

Review of the Literature

Definitions of Collaborative Learning. Collaboration may be defined as individuals working together whereby each person is responsible for providing his or her own ideas and other contributions to the group to achieve a common goal. In short, it represents the mutual engagement of participants in a coordinated effort to solve a problem (Ashcraft & Treadwell, 2007; Roschelle & Teasley, 1995).

Collaborative learning involves sharing and combining knowledge, experiences, and perspectives from each member of group, but it also involves a social context that, "nourishes the willingness to engage in the effort to build and maintain mutually shared cognition" (Van den Bossche et al., 2006, p. 493). Collaborative learning has similarly been defined as, "the acquisition and use of information by the group in order to reach a group goal" (Tindale, Stawiski, & Jacobs, 2008, p. 74). According to Mattessich and Monsey (1992), the main features of collaborative groups include: (a) commitment to mutual relationships and goals; (b) jointly-developed structure and shared responsibility; (c) mutual authority and accountability for success; and (d) sharing of resources and rewards.

Based on these definitions of collaboration, we define collaborative learning as the sharing of knowledge, skills, beliefs, and values; working together to negotiate meaning and achieve common goals; and participating in mutually-beneficial roles and relationships.

Collaborative learning offers many advantages to students, including cognitive, social, and motivational benefits (e.g., improved quality of learning, increased efficiency of learning, enhanced motivation, and increased sense of competence) (Johnson & Johnson, 1989; Rysavr & Sales, 1991; Slavin, 1990, 1995). Collaborative learning also supports constructivist learning (i.e., knowledge is a result of the social construction of meaning within a particular social context). In constructivism, the role of the instructor is to facilitate learning instead of directing students how to learn (Driscoll, 2005). The features of constructivism align well to our belief that learning is an active and social process, requiring the dynamic interaction among the instructor, students, and task.

The competency model of collaborative learning

Although many studies have demonstrated significant relationships between collaboration and academic achievement, to date, studies have inadequately examined formative, embedded, and/or transformative aspects of assessment within collaborative learning environments (Lee, Chan, & Aalst, 2005). Furthermore, "learning is nearly always evaluated at the level of *individual* learning outcomes" (Lee et al., 2005, p. 379). What's missing is that collaborative learning involves a group, not just individuals—so measures of group learning should be collected and analyzed. Also, it may be fruitful to examine learning *processes* that occur during collaboration, not simply learning outcomes.

To address some of these issues, we have designed an ECD-based competency model. Figure 12 shows the first-level variables. As we did for the earlier competency models, we elaborate and explain the primary, as well as the lower-level variables needed to support our proposed model. At the conclusion of this section, we provide an illustration of collaborative learning.

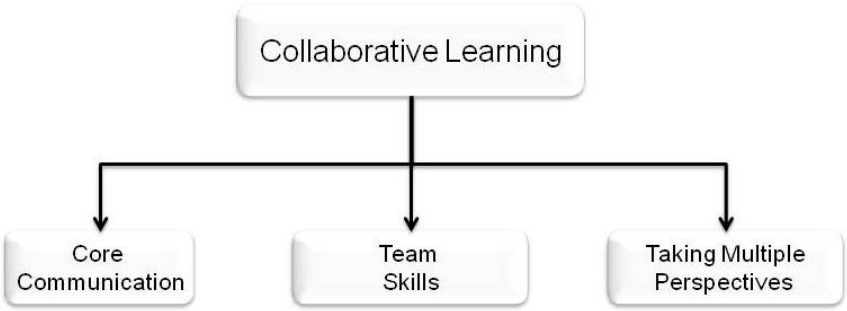

Figure 12. The first-level of variables of our collaborative learning CM

Core communication. Communication is one of most important process variables of group effectiveness in collaborative learning. For example, Larson and LaFasto (1989) noted that in collaborative settings, group members must effectively communicate, which includes communicating with words (e.g., writing, speaking) as well as without words (e.g., eye contact). Communication is absolutely necessary to establish clear and specific goals, as well as to transfer or share information/knowledge to other members so that they may function successfully as a group. Fussell et al. (1998) similarly maintained that participants of a group must communicate, whether using formal or informal communications for completing tasks that are independent, not entirely expressed, or that require negotiation.

What types of communication work best? Yukselturk & Cagiltay (2008) showed that face-to-face meetings are more productive than other types of communication, such as e-mail, online chat, and phone calls. In addition, members also prefer regular face-to-face meetings because of the benefits of synchronous communication coupled with immediate feedback. Virtual environments pose some challenges to successful communication, due particularly to time delays in sending feedback/messages/information, and the possibility for misinterpretations of written text (e.g., Crampton, 2001). Furthermore, Salter and Gann (2002) reported that despite our increasing inventory of innovative information and communication technologies in the 21st century, face-to-face interaction with the immediacy of communication is the most important factor related to learning new ideas and solving problems.

Questioning that goes on during the normal course of collaboration is a very important part of its success. That is, in addition to the importance of interpersonal communication, Leitao (2000) suggested that it is critical for team members to question the credibility of data (information) from someone or somewhere before accepting it.

Many research studies (e.g., Brown and Palincsar, 1989; Doise, Mugny, and Perret-Clermont, 1975; Johnson, Johnson, & Holubec, 2002) have shown that effective collaborative learning in academic environments is a powerful and significant learning strategy. Why is it so potent? Soller (2001) noted that, "Students learning effectively in groups encourage each other to ask questions, explain and justify their opinions, articulate their reasoning, and elaborate and reflect upon their knowledge, thereby motivating and improving [everyone's] learning" (p. 6).

Each member of a collaborative team arrives with his or her own unique perspective on a problem due to differences in background, education, and many other factors. One of the most

important functions of collaboration is to extract the best and most appropriate ideas or solution from all of the team members' perspectives on a problem. Because of this, and as described in more detail in the "team skills" discussion below, researchers tend to favor heterogeneous, rather than homogenous grouping of members.

Negotiating meaning is another important communication skill. This refers to an agreement that is reached by the group based on understanding each contribution. According to Beers, Kirschner, Boshuizen, and Gijselaers (2005), negotiating meaning involves: (1) verifying to what extent one's own understanding of any given contribution is similar to or different from what other people mean or understand; (2) clarifying the perceived information and feedback; and (3) re-verifying meaning, until one fully understands, individually and consensually. On this point, Clark and Schaefer (1989) noted that, "The contributor and the partners mutually believe that the partners have understood what the contributor meant to a criterion sufficient for the current purpose" (p. 262). Figure 13 shows the core communication part of our collaborative learning model.

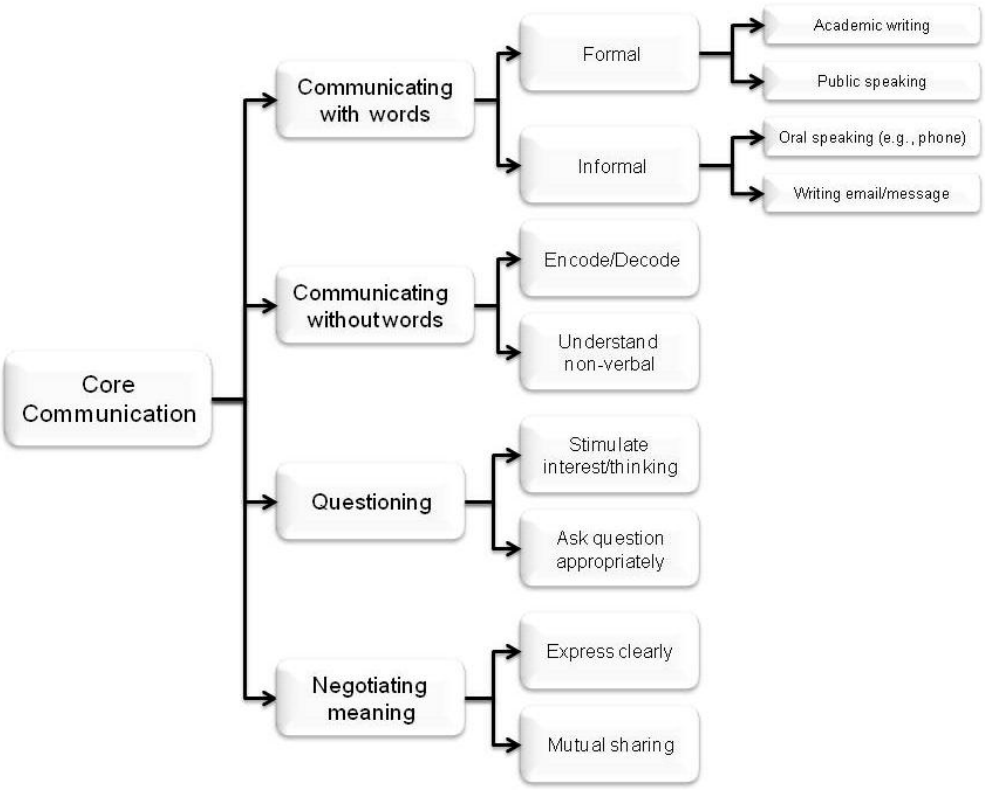

Figure 13. CM of collaborative learning – Core communication

Team skills. In collaborative learning, it is normal to have conflicts and different ideas because individual members are unique in background, opinions, thinking processes, and so on. Thus, in addition to communication, there are other competencies required to succeed within a collaborative (or team) setting. For instance, teams need to negotiate solutions. This involves: (1) checking if other group members' solutions are clear and relevant to the problem at hand, (2) comparing others' solutions to your own, and, as warranted (3) presenting a sound

argument based on others' limitations to the problem until the group can arrive at a common agreement (Beers, Kirschner, Boshuizen, & Gijselaers, 2005).

Vygotsky (1978) stated that individuals in heterogeneous groups contribute more knowledge and experience to the learning process than those in homogeneous groups. Other researchers have supported this position. For instance, Cohen (1994) provided an argument in support of heterogeneous groups; namely, that they provide more opportunities for learning because of the diversity of perspectives that are presented to group members which facilitates the formation of creative solutions. Saleh, Lazonder, and De Jong's (2005) study indicated that low-ability students achieve better performance on the Science Elementary Achievement Test (SEAT) and have higher levels of motivation to learn when they are in heterogeneous groups than homogeneous one because they can receive the assistance they need from more capable group members. The superiority of heterogeneous over homogeneous groups has been further supported by Guzzo and Dickson (1996); Miliken and Martins (1996); and Volkema and Gorman (1998).

Totten et al. (1991) noted that collaborative learning offers students an opportunity to participate in group discussions, take responsibility for their own learning, and ultimately become critical thinkers. Gokhale's study (1995) also demonstrated that students who engage in collaborative learning perform significantly better on critical-thinking tests compared to students who study individually.

Leadership is another important variable in collaborative learning. Grenier and Metes (1995) argued that leadership (i.e., the ability to lead a group of people to reach a goal), has a major impact on the outcome of the initiative, particularly within virtual environments. Leaders provide directions and clear boundaries for the group, and they also tend to work hard, spend more time, and possess more knowledge than other members in relation to achieving a goal (Grenier & Metes, 1995). Leadership can facilitate the collective effectiveness, such as information sharing, and it also can influence cognitive, motivational, affective, and coordination processes in relation to other team members' performances (Zaccaro, Rittman, & Marks, 2001).

Additional research has shown that collaborative learning can not only lead to improved performance, but also to enhanced social skills (Baker & Lund, 1997; Soller, Lesgold, Linton & Goodwin, 1999). For example, when completing tasks in a collaborative setting, equal participation is an important goal as it leads to increased satisfaction for all of the group members (Beebe & Masterson, 1997).

Trust is another significant factor in collaborative learning and a critical issue for healthy group development (Yukselturk & Cagiltay, 2008). Trust has been indicated as a key concept of functional interpersonal behavior (Pruitt, 1998). Furthermore, Handy (1995) and Lewis (1998) have shown that trust is an essential component of successful virtual organizations, and to develop trust in a virtual team, group members may need to meet in person. Figure 14 displays the variables comprising our team skills construct.

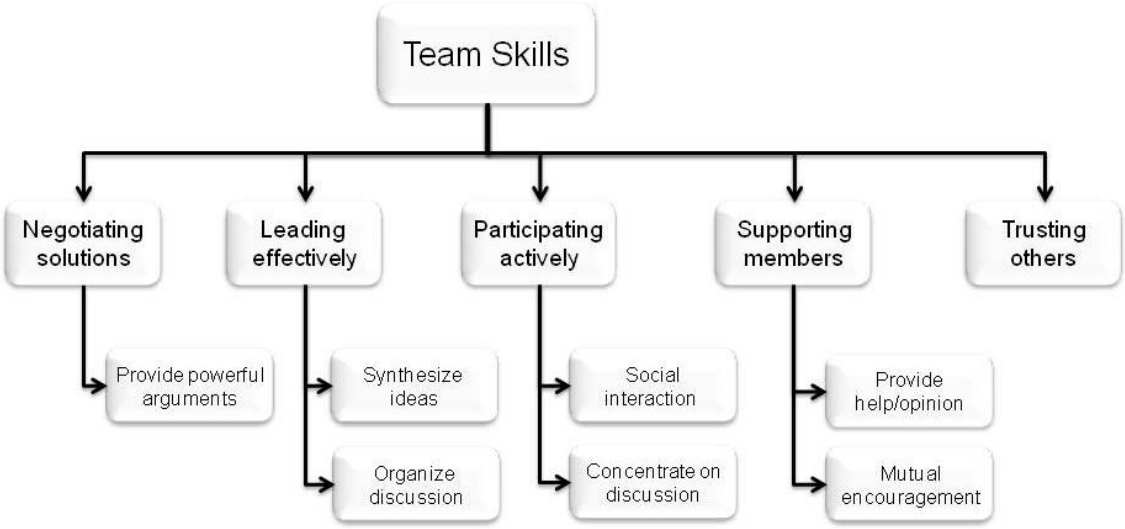

Figure 14. CM of collaborative learning – Team skills

Taking multiple perspectives. Like trust, described above, acceptance and respect are significant components of collaborative learning because they help make collaborative learning function smoothly. In collaborative learning, conflicts occur because members differ along many dimensions. Panitz (1997) pointed out that dealing with people requires respect, acceptance, and figuring out each member's particular set of strengths, weaknesses, and beliefs, writ large. He also noted that, "the underlying premise of collaborative learning is based upon consensus building through cooperation by group members, in contrast to competition in which individuals [try to] best other group members" (p. 4).

Each member of a collaborative group has different levels of knowledge, skills, and experience which cause unique perspectives on life. According to Schwartz et al. (1999), possessing multiple perspectives is beneficial to a group because this permits the connecting of diverse and distributed expertise and ideas among participants (which otherwise would not likely be linked). The degree to which a person can consider alternative perspectives on a topic reflects multidimensional thinking. Members of a collaborative group typically have a variety of arguments/ideas to contribute to the group. This, however, does not mean that all of these perspectives are acceptable. Consequently, participants need to engage in some intrapersonal musings, such as self-evaluation, self-monitoring, and self-determination. Lee et al. (1999) pointed out that, "a student can look at situations from the multiple perspectives raised by fellow students, plan, evaluate new ideas, monitor and assess solutions while keeping an eye out for possible mistakes made by others" (p. 223). Figure 15 presents the construct of taking multiple perspectives.

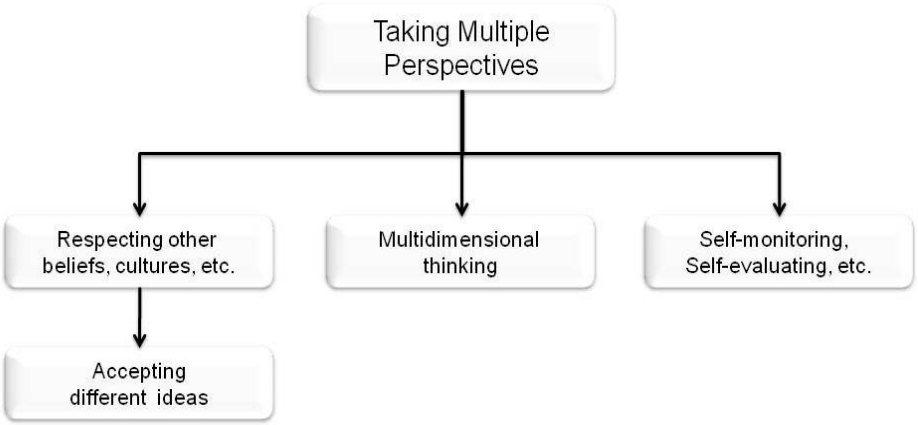

Figure 15. CM of collaborative learning – Taking multiple perspectives

Example of collaborative learning.

Bob is a 5th grade science teacher in Leon County, Florida. He's designing new lesson plans to teach his students about the solar system across 3 class periods. However, Bob has been having a hard time creating the lesson plans because there are a few new transfer students to his class as well as several ESL students. Bob wants to ensure is that *all* students in his class of 25 will learn the relevant knowledge and skills in this instructional unit. In a bold (for him) move, he decides to apply a *collaborative learning approach* for this class. His colleague Marta uses this kind of approach often and successfully in her 5th grade social studies class, and has told him a lot about it. He's hesitant to give up his "power," but Marta convinced him that the end will justify the means.

Therefore, Bob applied the collaborative learning approach when he was teaching the first class, which focused on the Earth and its planets. Before the class began, Bob assigned 4 students to each group, being sure to mix up the groups in terms of gender, language, knowledge, and other characteristics. He did this because he believes that each group member has unique advantages that can be tapped as resources when solving problems.

To stimulate thinking about the earth and its planets, Bob generated some thought-provoking questions (e.g., How many planets are in our solar system? Are the sun and the moon planets? If not, why not? Can people live on other planets? If not, why not?) He planned to present the questions to all of the students before they began working in their groups, and ensure that everyone understood the questions before starting. Bob saw his role as that of a facilitator/consultant—ready to provide support to students when they needed it, but not specific answers. He really wanted the students to acquire the relevant knowledge solely through the group discussion instead of relying on him for the content.

One of the groups consisted of James, Ann, David, and Yan (an ESL student). Bob observed that during the group discussion, James, Ann, and David usually repeated their words and spoke slowly to Yan to make sure that she understood what they meant. Sometimes they drew pictures and used body language during the discussion. Although Yan has communication problems, she is very good at science. Also, she had studied the earth and its planets in her country before she moved to the United States. Rather shyly at first and then with more gusto, she provided much valuable information to the group, such as distance to the sun, size of the planets, and orbiting patterns of planets.

Occasionally, the other group members would question and challenge Yan's information when they thought she might be wrong on a certain fact or phenomenon. When that happened, they all worked together to find the correct (or most reasonable) answer from the textbook, Internet, and magazines that Bob had distributed throughout the classroom. During the course of these 3 class periods, each member presented their individual ideas to the others, trying to gain acceptance. When all members failed to agree, they discussed and negotiated the question again until everyone mutually agreed on an answer. Then they moved to subsequent unanswered questions.

James was chosen to present their group's final answers to the class. He was chosen unanimously because during all group discussions, he went out of his way to make sure they proceeded smoothly. And when other group members appeared to struggle, James had quiet words of encouragement. In the end, all group members agreed (no negotiation needed) that this experience facilitated their learning substantially.

Our fourth competency being showcased in this paper represents another interpersonal skill (like collaborative learning), but this one is primarily related to managing our ever-growing number of virtual relationships and our identities therein.

Social Identity

Why Social Identity Matters for the 21st Century

The more content we contribute voluntarily to the public or semi-public corners of the Web, the more we are not only findable, but also knowable. (Madden, Fox, Smith & Vitak, 2007, p. 2)

Identity has come to matter more than ever in the 21st century because of societal shifts that not only have enabled but also have encouraged increasingly complex constructions and considerations of how we present ourselves to others. Technology plays a major role. Life in the information age means easier access than ever before to details about other people. Technology also facilitates communication with others around the world who might not have otherwise crossed one's path.

The Pew Internet and American Life Project has been collecting data on how people use and are affected by technology. Some key findings from their various reports include:

- 62% of American workers are online at work and 86% of employed Americans make use of the Internet and email at some point in time (Madden & Jones, 2008).
- 55% of all adult Americans have high speed Internet connections in their homes and one third have used a wifi connection somewhere other than work or home (Horrigan, 2008).
- For many, work and personal communications tend to blend, with personal emails being received on work accounts and vice versa (Madden & Jones, 2008).
- It is only after a negative experience related to having personal information online that most American Internet users tend to limit or protect their online presence. That said, overall interest in protecting private information is rising, particularly when it is companies asking for personal information (Fox, 2008).
- Experts predict that by 2020 the Internet will have increased transparency in identity and interactions, but not without drawbacks regarding individual privacy (Anderson & Rainie, 2006).

As can be seen from these findings, online engagement is quite common – and, per all of these reports, growing – which means that there is a parallel need to explore the societal and educational implications of this movement toward online interactions and its impact on our identity. When interacting with others in online environments, individuals need to consider identity in terms of self-presentation and privacy issues. They also may gain insight into the identities of other individuals and groups of individuals (e.g., career or special interest

groups). In these ways technology is shaping both the development and performance of identity.

To start with the most basic notion of identity, we are all born with one legal identity – a name, a family to which we belong, a birth certificate, and other country-specific documentation. There is an expectation that we carry that identity throughout our lives. However, that identity may take on different personas as we engage in different tasks and communicate with different people. One's legal identity still is the expected one in many settings, but name alone does not constitute the full construct of identity. Beyond name, identity also encompasses one's actions, affiliations, and preferences. Noting that each person is an individual and also a member of communities and groups, it follows that with each community comes some hallmarks of membership.

How does this translate into 21st century skills? The ever-growing information landscape and rapid development of online communities and social networking sites has meant that peoples' identities are being represented in more venues and formats than ever before. Given the breadth of access to many electronic records, people are cautioned about using their legal identities or providing too much personal information in online fora. Further, the increasing use of usernames as unique identifiers and requirement that people provide personal information online in the course of conducting everyday tasks has pushed even the most reluctant *worldizen* to begin creating new names and versions of their regular identity.

What does this mean in terms of an individual's life? Consider an average teenager in the United States: She has her own cell phone and regular access to a computer and the Internet. She has an email account, an instant messaging account, and a Facebook account. She uses Google to search for information, and text messages and profiles to keep in touch with people. She's signed up for various online services and accounts, to access material, connect with others, or simply have fun. She leaves electronic traces of her presence everywhere, often without giving it a second thought. She's also used her technology-based tools to learn about other people, including classmates, celebrities, and personal heroes. Her world is broad and interconnected, and she has developed her sense of self in part through her wide-reaching and technology-mediated interactions.

As this teenager grows up, she can expect to continue using technology and leaving an electronic footprint around the world. She will likely get a new email account when entering college, and will have to learn how to communicate effectively with her professors and classmates. As she chooses a field of study and career path, she will need to learn how to be a member of a professional community, full of norms and expectations. She may begin to carry a Blackberry and find herself somewhat tethered to the Internet. Over the span of ten years she may add components to her identity such as college student and later alumna, employee of a particular company, professional in a given field, and member of a civic organization. She may also join virtual groups, where she could become known as a fellow sports fan on a discussion forum or a knowledgeable hobbyist who has her own blog. She may be all of these things at once, but the people who know her from one group may not know of her membership in other groups, and she may wish to keep these parts of her overall identity separate.

The example of this typical American teenager shows just how entrenched people are becoming in a world that is full of information and identity creation and adjustment. We don't typically consider identity something that is taught, but increasingly it should be as the nexus of roles that we all play has become more complex along with the tools we use to navigate and promulgate these roles. Clearly *worldizens* need to know how to efficiently and effectively nurture their own identities in the information landscape, and many do not. Consider as evidence news stories of applicants not being hired because of photos on their social networking site accounts; jobs lost because people used company resources such as time, computers, and email accounts to engage in personal activities and communications; friendships lost over blog entries; and safety compromised because too much information available online. Thus, social identity is a critical area to be mastered in the 21st century.

Review of the Literature

These days, most people initially encounter online environments and establish online identities at an early age as part of their schooling experience and via social and recreational activities at home. Thus, one initially encounters the information age's impact on identity typically well before entering the work force. Teenagers, in particular, tend to have a high level of online activity. For example, electronic game play is fairly ubiquitous among the teen population; about 97% of teens have played these games and about one-quarter have met people via online game play (Lenhart, Kahne, Middaugh et al, 2008). More than half of all teens have a profile on a social networking site and more than one quarter maintain their own web site or blog (Lenhart, Madden, Macgill, & Smith, 2007). One-third of all teens have been contacted by a stranger online, with teens who post online profiles and photos and girls having the highest rate of stranger contact (Smith, 2007). The availability of online information about their identities and the potential for stranger contact can be quite frightening. As a result, about three-quarters of all parents feel it necessary to regulate their teen's online activities in terms of time and content (Macgill, 2007). Further, teens themselves use strategies such as limiting access and providing false information to help secure their own privacy (Lenhart & Madden, 2007).

While teenagers are made aware of the need to protect themselves from online predators, relatively little focus has been placed on teaching them to think about other aspects of the mark they leave online. Similarly, adults do not consider their identity and online presence as much as they probably should. Madden, Fox, Smith, and Vittex (2007) surveyed adults to learn about their actions and attitudes concerning their digital footprints. About one-half of the respondents said that they have searched for themselves and for others online, demonstrating some level of expectation that others will conduct similar searches for them and awareness that they may have a publicly accessible digital footprint. However, less than one-quarter of all users conduct these searches for themselves on a regular or semi-regular basis and few are aware of the true breadth of their own personal information that appears online. Furthermore, about two-thirds are not concerned about how much of their personal information appears online or how they might limit it.

Indeed, limiting one's personal information that appears online is somewhat counter to the social networking movement. With the proliferation of sites such as MySpace and Facebook, people are encouraged to create profiles and share those profiles with either existing friends or

people in their larger social network who might become friends. Profiles play an important part in social networking. Lampe, Ellison, and Steinfield, (2007), in a study of Facebook profiles, found a positive relationship between the number of profile fields that a user has completed and the number of friends a user has. In a chronicle of social networking sites, Boyd and Ellison (2008) point out how not only one's profile but also one's association with others has become a part of identity construction. In other words, your friends and affiliations provide information about who you might be.

Although using false information is a strategy teens use for online protection, there is pressure to be at least somewhat truthful in one's profile in social networking settings with ties to real-world networks. When engaged in this type of social networking there is an increased chance both for verification of user profile information and that users who meet via the online forum will eventually meet in a physical setting (Lampe, Ellison, & Steinfield, 2007). Truth in identity is important to some people because of how it impacts behavior. Millen and Patterson (2003) found that an identity policy requiring online users to use their legal names on a community-based discussion board promoted a sense of trust, user accountability, and civil conduct. Thus, there is encouragement to provide an accurate representation of self on these online sites.

However, not all identity issues center around one's legal or given name. In the online world, we can consider identity possibilities on a continuum, with anonymous at one end and legal identity at the other. Anonymity in online environments allows for free exploration of identity and expression (Turkle, 1995), but it also has its drawbacks. Kilner and Hoadley (2005) examined the role that anonymity plays in an online community of practice. They found that for some participants it provides a buffer of comfort to allow them to share their true thoughts or feelings without worrying about potential repercussions in their everyday lives. However, other community participants felt that anonymity was in conflict with responsible behavior, believing that one should present and stand behind their shared thoughts with their real identities. The points that reside in-between anonymity and legal identity include true pseudonyms and usernames that include elements of one's legal name. However, the pseudonym and username issue is actually a bit more complex than simply consisting of a name variant lying on a point between anonymous and not. The push to create unique usernames for various services and systems has required people to get creative. After all, only one person can have the email username "janebrown" on a given server. Usernames have an impact on one's perceived identity in myriad ways. A username can convey gender, age, interests, and attitude in addition to one's legal identity (Wallace, 1999). It does not require formal study to realize that a potential employer will react better to an email from JohnDoe@mailserver.com than one from BoozeNParty@mailserver.com.

The pseudonym issue is even more complex. People use pseudonyms online for a variety of reasons, including privacy, fun, and following the social norms of a group or community (Dennen, 2006). Pseudonyms and their attached personae can be entirely fictitious creations or versions of one's legal self. Even when they are entirely fictitious, people do become rather attached to these alternate identities through which they have experiences in virtual worlds. One of the most well-known examples of this phenomenon occurred in the early 1990s, when online interactions were just becoming possible for average people (who admittedly were

early adopters) and a virtual community called LambdaMOO was popular. Dibell (1998) chronicles the members of LambdaMOO and their activities and along the way demonstrates how heavily people relate to their virtual identities and how such identities can affect their lives in the non-virtual (i.e., real) world. In one instance, a member whose avatar committed egregious virtual acts such as rape against other members incited great hurt, fear, and anger among members of the LambdaMOO community. So strong was the impact of these actions and the members' identification with their avatars that the case leaked over into the face-to-face world, with victims seeking counsel to deal with the online violence and making offline contact with each other to discuss the event.

Not all incidents in which pseudonyms are used result in such emotionally charged moments. Blogs are an online setting where pseudonyms are rather heavily used and can result in highly developed personae that are partial representations of the blog author. Blogs can serve as a mechanism for maintaining and even further developing one's relationships. Additionally, they are a space in which one may express a particular identity, recognizable by the form and content of what is published there (Stefanone & Jang, 2008). Recuero (2008) noted that many bloggers have a keen awareness of privacy issues related to the information that they place online, and while they do publish blogs as personal journals, they limit the amount of specific online self-disclosure in which they will engage. Dennen and Pashnyak (2008) similarly found that bloggers construct pseudonymous identities for themselves and various people and contextual factors in their lives to allow them to chronicle their life events and get feedback from others with a feeling of being shielded from judgment of people with whom they interact face-to-face. In other words, people may share some highly personal stories online if they feel they have sufficiently obscured their real-life identity.

Identity is not just about the names that one uses, but also and importantly about one's actions, interests, and colleagues. Members identify with online groups to which they belong. Although there are individual differences, there also is an overriding group identity that evolves. Development of community norms for online interactions dates back to early usenet groups (Baym, 1995; McLaughlin, Osborne, & Smith, 1995). Different groups generate their own codes of conduct with which their members identify and follow.

Many people look to online networks to find a community of practice (CoP). The concept of community of practice has become increasingly popular in the last two decades, hailed as a way to promote learning via authentic engagement with other, like-minded individuals. Members of a CoP share language, interests, values, and processes (Lave & Wenger, 1991), all of which can be considered components of their identities. When engaged in a CoP, one is building and sharing their identity as a member and practitioner. Kilner & Hoadley (2005) differentiate learning via an online CoP from other forms of online learning by noting that it lacks a formal teacher and instead relies on community members to apprentice and enculturate others. In many ways, a CoP is a lot like collaborative learning settings, only excluding the instructor from the equation.

The competency model of identity

Up to this point in time, identity has not been considered a competency or well-established as a construct within the literature. However, an examination of how identities are established

and used in everyday life via both observation and the review of literature yields three major categories of identity sub-competencies: Developing Identity, Managing Identity, and Performing Identity (see Figure 16). Each represents a different area of this 21st century competency, and collectively they govern one's ability to juggle successfully the complex relationships and proliferating networks that have become common in modern life.

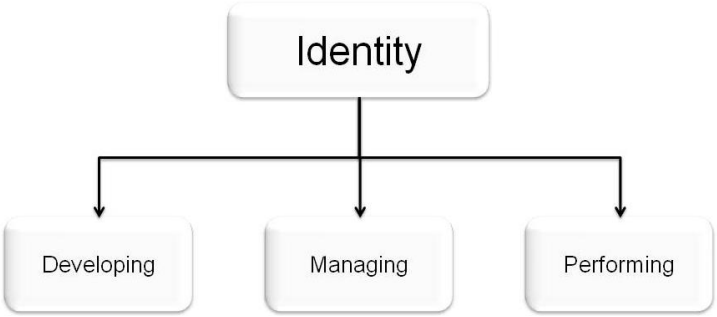

Figure 16. Top level competencies of Identity

Developing identity. What are identities? Can people have more than one identity? Although we may each be limited to one physical body and one legal identity, it is normal for people to have different personas depending on the context of their interactions. For example, a person might identify as an employee and a family member, acting differently as is dictated by the situation. To treat one's boss the same as one's parents most likely would be inappropriate. In each new context or setting, a person must determine if an existing persona fits or a new one may be developed. When taking a new job in a familiar field, a prior work identity could be used and would likely suffice. However, when making a major career shift, a new identity might be necessary. A well-known New Yorker Cartoon features the tag line "On the Internet, nobody knows you're a dog" (Steiner, 1993), implying that online one can take on any chosen persona regardless of whether it is representative of their physical and legal identity.

The act of developing identity potentially occurs each time a person enters a new group or community, whether in the physical or virtual world. The identity need not be drastically different from one's core legal identity, but decisions must be made regarding how one will present in the novel setting. In other words, this sub-competency focuses on answering two key questions: (1) *Who am I?* and (2) *How do I wish to be perceived by others?*

There are four main components of developing identity, each concerned with a different part of an individual's representation: (1) Name, (2) Profile, (3) Social Network, and (4) Image (see Figure 17). In the simplest of cases, a name may be all that is required, although increasingly some basic user information (e.g., a profile) is requested upon joining a group. Profiles may be considered private data, such as when one signs up for a service that collects demographic user data for their own records but pledges to not share that user's information with others, or public data, such as on social networking sites, discussion boards, blogs, and virtual communities, where the information is used to help participants learn about each other. Social networks, namely one's associates and group affiliations, are another source of identifying information that may be shared when developing an identity. Finally, many services and communities allow or require users to share a visual representation of themselves

in the form of a picture or avatar. Across each of these components of developing identity is a shared concern: Selecting a meaningful and appropriate form of self-representation for the given medium, taking into consideration both safety and audience.

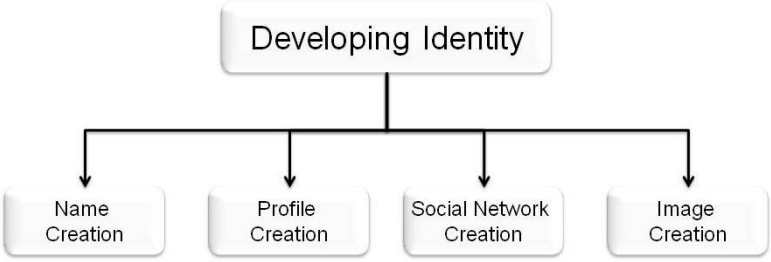

Figure 17. Components of Developing Identity

Managing Identity. Identity management assumes one has already developed an initial identity and is about making determinations about when and how to use a particular identity. In some ways, this is a technical area of identity, focused on using tools and applying rules. In other ways it requires a careful consideration and potential revision of one's self-image and presence in the world.

There are four main components of Managing Identity (see Figure 18). The first, Selecting Identity, represents a common task: matching an existing identity to a particular purpose or group. For example, when joining a professional group and representing one's employer it makes sense to use an identity with a legal name that is tied to a work-related email account. People make these decisions all the time, often with little thought until someone alerts them to an error in judgment. Using an inappropriate identity for a given activity could result in image problems (e.g., less respect than one is due) or actual legal consequences (e.g., losing one's user privileges).

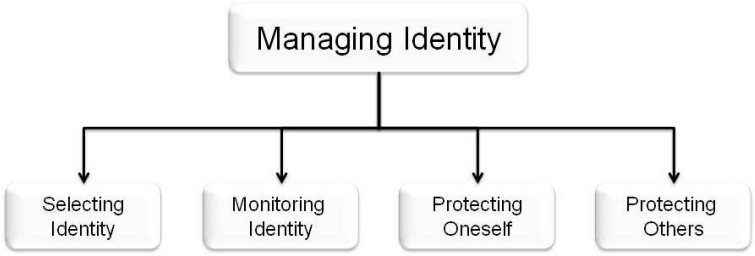

Figure 18. Components of Managing Identity

Monitoring Identity refers to conducting periodic searches to determine what information about oneself is available online and whether or not it is appropriate. Protecting oneself can take various forms, including:

- Selecting and adjusting privacy settings for different online tools
- Identifying safety threats and points of information vulnerability in online interactions
- Communicating with others about preferences regarding online identity

The need to protect oneself may become apparent via one's monitoring activities or may simply become a concern as awareness of the complexity of social networks and the information landscape grows. Finally, Protecting Others involves considering how other people feel about their identities and not sharing information or images of them without their consent.

Performing Identity. Performing Identity is the component of identity that focuses on what it means to belong to a group or network from an interaction standpoint and how those interactions influence one's developing sense of self. There are three main sub-areas, Participating in CoPs, Positioning, and Transitioning Boundaries (see Figure 19). Each involves a slightly different form of performativity and collectively they govern a deeper version of identity than elements such as username and profile. Performing Identity is critical as people become members of a given profession and must learn not only how to fit in at a surface level but also how to think and talk like their more experienced peers. One's ability to perform identity readily impacts their acceptance by and influence in a social network.

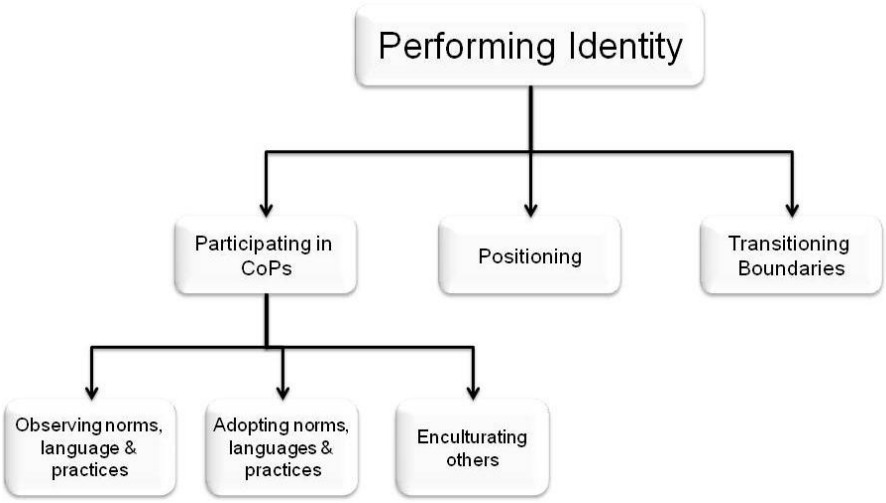

Figure 19. Components of Performing Identity

Participation in a CoP involves performing identity, both from one's initial membership (i.e., when the group's norms, languages and practices are observed and learned) to one's full participation (i.e., when those same things have been adopted and also are used to help enculturate others into the CoP).

Another element of this performativity competency involves positioning. Positioning theory examines the fluid places individuals hold within a discourse and how individuals continuously work together to produce the narratives of everyday life (Harre & van Langenhove, 1999; Davies & Harre, 1990). Positions are different from roles in their sense of negotiated transience. Interlocutors must work together in their interactions to find, accept, and continuously refine their positions. Everyone practices positioning, but not everyone is cognizant of it. Some people have a rather intuitive sense of position and can readily use it to

their advantage in terms of both how they position themselves and how they position others. Positioning can affect one's acceptance, dominance, and impact in a social setting.

Finally, Transitioning Boundaries is an important part of performing identity. As our networks become more complex and overlap, we find ourselves in situations where we must simultaneously interact with people we know from different contexts. Such is the making of an awkwardly funny scene in a movie, but in real life these interactions can be difficult to navigate yet are important to one's portrayal of self. The individual must determine whether the networks and the different identities used in each one can readily be merged or blended or should be kept separate. When they bump up against each other despite one's best efforts to keep them separate, decisions must be made about which identity to adopt for the situation (e.g. Should I be an employee or spouse in this instance?) and how to later recoup from any damages to the other identity. Boundary transitions also occur as one becomes more entrenched in a network. For example, being promoted to management might curtail some of one's prior lunchroom antics. Sometimes these boundary transition experiences lead people to rethink how to manage their identities, either increasing or relaxing their concerns about privacy depending on the nature and outcome of the world-merging experience.

Example of Identity

Emily sits down at her desk to tackle her homework. It's the end of her first week of high school, and already she has much to do. She turns her computer on and starts taking notebooks out of her bookbag.

Barely 10 minutes into her math homework, Emily has a question. Her teacher, Miss Morris, gave out her Instant Messenger and email information and said the class could contact her that way with homework questions. Emily opens up her IM application and gets ready to log in. How fun – and funny! – to IM with a teacher. Usually she just IMs with her friends in the evening.

Emily types in her username: dumb_blonde. It's a joke among her friends, since she is the blondest of the group and does a great airhead imitation.

Just as Emily's IM account connects she has a thought. Perhaps the username "dumb_blonde" isn't the best way to represent herself to a teacher who she hardly knows.

Emily quickly creates a new account. When choosing her new username she has some decisions to make:

How will her new username represent her to her teacher? And to her friends? Will she only use this new account for contacting teachers? Or will it become her main IM identity? Should she use her real name? Or would that be considered unsafe?

Emily settles on emily_smiles as her new username. She will feel comfortable using this account with a number of people.

As she fills out the account set-up form, she has various other choices to make. Will she allow anyone to see when she is online, or just people on her contacts list? Will she make available information such as her age and location? Emily is torn. She likes the ability to freely find and meet other people online, but at the same time she knows safety should be a concern.

Finally Emily gets logged in with her new account, only to find that Miss Morris is not currently online. Thus, she decides to email her teacher instead.

As Emily composes her email she wonders:

How does a conscientious student act via email? Should she introduce herself to Miss Morris with a reminder of which class she's in? Should she be friendly and social? Or should she just get straight to the point and ask her question? Is it necessary to sign the email with her full name?

Done with her email, Emily decides to sign onto Facebook and see what her friends are doing. She finds 2 new friend requests waiting for her. One is from another freshman at her high school who she thinks she remembers meeting during the week. Another is from Mrs. Jaynes, the mother of a child who she babysits. Emily must determine whether to accept these friend requests. On the one hand, the more friends the better. On the other hand, she knows she cannot control what her friends say about her on Facebook and would hate for Mrs. Jaynes to think poorly of her or doubt her performance as a babysitter because of things written on her wall. Emily chooses to wait before friending the fellow student. She makes Mrs. Jaynes a friend with limited access, so Mrs. Jaynes can send her messages but cannot access her wall.

In a matter of 20 minutes, Emily has made several decisions about how she presents herself to others and has taken actions to make sure she is perceived in a desired manner by others with whom she interacts.

Conclusion and Epilogue

We have focused our initial efforts on four main competencies: systems thinking, creativity, collaborative learning, and managing social identities. Why these four and not others? We actually began this project with a much longer list of potential 21st century competencies. Through extensive discussion, research, and negotiation, we then whittled the list down to those showcased in this paper. Valued competencies from the earlier and longer list (e.g., ill-structured problem solving, inquiry skills, and tolerance) could actually be subsumed within our four competencies described herein. For instance, "ill-structured problems" refer to complex issues that don't have clear right or wrong answers, such as poverty, world hunger, global warming, and so on. But when you think about it, combining and applying systems thinking and creativity can go a long way toward solving such ill-structured problems. Similarly, tolerance is an important competency, and it is contained in both our creativity construct (i.e., tolerance for failure, ambiguity, and complexity) as well as our collaborative learning construct (i.e., being able to accept and respect alternative perspectives).

Establishing the four research-based competency models has revealed connections among constituent variables. For example, being able to adopt multiple perspectives is important across all four main competencies; communication is crucial to successful collaboration and also for managing social identities; and identifying problems is a critical part of creativity and systems thinking. In addition, by decomposing our competency models down to the level of indicators (i.e., low-level variables that can be measured) this will permit us to generate assessments around the indicators, collect evidence from the students, feed the data back to the full competency model, and make inferences about students' current standing—either individually or at the group level. This is absolutely key to helping students learn.

Returning to our preamble, how might things have been different for Sarah if she had greater awareness, knowledge, and facility with regard to some of the competencies showcased in this paper? If she possessed skills of an exemplary worldizen, what would her answer be?

Let's first consider the nature of her response had she engaged in a bit of *systems thinking*. Recall that the first step in systems thinking is to identify the problem. The problem is clear –

does her particular tapestry of knowledge, skills, and experiences align with those required to serve as vice president (VP) and potentially president of the United States? And just what does a vice president do, anyway? Very quickly, many other problems come to light. For example, because she's just recently given birth to a special needs baby, will she have enough time to devote to the VP job as well as to her family? Which would be deemed more important if she was forced to prioritize in the case of a national emergency? What would be the consequences if she chose family over country, or vice versa? If she accepts the offer of VP, she'd have to campaign, and if she campaigns, she'd have to be interviewed. Does she know enough knowledge about a wide range of issues—national and international—to enable her to talk intelligently on various topics, or may she possibly embarrass herself? Does she have any skeletons in her closet that could jeopardize the ticket? If so, what would be the range of consequences from, say, that pesky little "firing the commisioner" issue? Obviously, had she thought logically about the issues involved with being a VP she would have noted that her candidacy would not just be a career-forward act, but would likely have a major impact – and not all positive – in almost every arena of her life.

Now, suppose that she chose to discuss the VP decision *collaboratively* with others, especially those with different perspectives from hers. Certainly Sarah was rather flattered and excited to be recognized as a potential running mate, and in that state of excitement it is only natural to want to accept the decision. However, others who are a few steps removed can often see the situation more clearly, able to bracket the excitement with a realistic view of the practical implications of taking such a big move. If Sarah had taken the time to consult with a small group of esteemed and bi-partisan colleagues, she would have received a variety of well-considered opinions about her candidacy based on years of experience and in-depth knowledge of how politics and media work. Her colleagues would likely have pointed out that, for many reasons, the best answer would've probably been something like, "thanks, but no thanks." At least at this particular time. Occasionally, we all are blind to what we really don't want to see. Hence the collaborative group discussion would have raised issues (such as those systemic ones mentioned above) that were not readily apparent to her. Further, the value of talking with these colleagues in a group rather than just as individuals would have been to see how they agreed or disagreed with each other's opinions and advice. Ideally, her colleagues could have led her, collectively, to an in-depth understanding of the complexity of accepting the nomination and allowed her to see the multiple reactions she might be facing once news of her candidacy hit the press.

Creativity could play an important role in the decision-making process as well. Let's suppose Sarah engaged in a collaborative process with her trusted peers, and together they considered systemically what might happen if she accepted the nomination. They need not necessarily accept the projected outcomes of what might happen, but instead could work together to brainstorm alternatives. If she accepted the nomination, did she have to accept some of the challenges listed above, such as being torn between family and serving her country in a time of crisis? What else might happen? How could she influence the outcomes?

Finally, had Sarah contemplated issues of *social identity,* she might have blinked more than once. Upon accepting the nomination, was she really aware of what public information was available about her? Did she know that some of her real-life affiliates, such as her daughter's

boyfriend (and her future son-in-law), had unflattering profiles that were publicly available via MySpace? Had she considered that people might use old photographs posted online to spread rumors and speculate about her family, particularly her last pregnancy? Or that people would blog about her and her family, posting messages, both flattering and unflattering, that would be beyond her control and long archived and searchable on the Internet? Did she consider how her nomination would thrust her whole family into the public eye? Or that she had given out enough information in interviews for someone to hack her email password and access her personal files? Had Sarah been more aware of her social identity, she likely would not have used private email to conduct state business and would have been more conscious of her pre-nomination Internet presence. Additionally, she might have engaged in some proactive management of social identity for both herself and her affiliates immediately upon accepting the nomination rather than waiting to react to what others have done.

So, returning to the issue of Sarah's answer, had she relied more upon these competencies when making her decision, while we cannot say that her answer necessarily would have been different, certainly some of the choices she made about how to present herself and her family might have been rather different. Along the way she certainly would have considered if the timing was appropriate for her to take on such an important public role and how it would impact her family and her privacy. And, had she still said yes, she would have been far better prepared with many ideas for how to manage the myriad tricky challenges to her personal and professional life that would be sure to come in the days ahead.

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