

Developing a Measure of Systems Thinking Competency

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ABSTRACT

Institutions of higher education often promise to graduate individuals capable not only of excelling in their area of expertise but also qualified as exceptional leaders and citizens. Yet, what are the competencies needed from leaders in order to address the most challenging issues facing society? How would higher education cultivate the next generation of leaders for a world of problems we currently cannot solve, and how would it be determined if some graduates were “more prepared” than others to face these challenges?

This dissertation seeks to answer these questions through the work of two distinct manuscripts. The first argues that human processes for meaning-making play critical formative roles in the setting and solving of our most complex problems. In essence, that problem-solving can be considered as embodied acts of meaning-making. This link is made through analysis of Bruner’s concept of narrative and highlights the importance played by naming and framing through one’s unique perspective while attempting to interpret an ill-structured problem.

The second manuscript develops a tool to measure “systems thinking,” a competency that describes the sort of cognitive flexibility that might be beneficial for graduates to be emerging leaders capable of addressing critical societal issues. A framework for considering systems thinking competency is presented and used as the foundation of a scenario-based assessment tool. Results from a qualitative pilot study are shown as part of introducing the tool with primary findings: (a) the tool elicited meaningful data on each of the constructs for which it was designed; (b) emergent within each construct were possible means of characterizing the data that will allow for future study of variation across respondents.

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Attributions

Gary Kirk, Director of VT Engage: The Community Learning Collaborative, and David Knight, Assistant Professor of Engineering Education, were both instrumental in aspects of Manuscript 2. Specifically, Gary authored the scenario and helped develop and refine prompts while David has helped in the discussion of results and refinement of the framework. When eventually submitted for publication both will contribute to improving the quality of the written manuscript and will both be co-authors on the study. Additionally, some of the future research section in the conclusions of the dissertation draws upon the research plan of an NSF grant proposal written with David Knight and those ideas are shared work.

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Introduction to the Dissertation

Background and Purpose

This dissertation began with the seemingly innocuous question of *why?* – *Why does higher education exist? Why do students pursue higher education? Why does the world need higher education?* There are no clear or simple answers to these questions. In “College at Risk” from the *Chronicle of Higher Education*, author Andrew Delbanco (2012) claims a newer economically driven instrumental view of higher education has become more dominant in recent press than the more historical views of education as a liberating force to free the heart and mind. While not necessarily mutually exclusive in practice, common rhetoric seems to pit the two as polar opposites – a choice of efficiency, competitiveness and marketability versus a broad liberal arts education pursuing knowledge for its own sake and developing good citizens. As quoted in “College at Risk,” former President Bush said “Education is how to make sure we've got a work force that's productive and competitive” and President Obama had a similar claim in 2009, “Countries that outreach us today, will outcompete us tomorrow” (as quoted in Delbanco, 2012). Contrary to that, advocates for more traditional framings of education as designed to produce good humans, good citizens, need simply point to the lack of critical discussion among the general populous to demonstrate a need for the civic aims of education and the development of well-rounded individuals (e.g., Thomas, 2010). And yet, these two framings so often pit against one another, are both over-simplified and even seem to treat those involved in education as merely objects to be acted upon – tools to be sharpened or citizens to be trained. In contrast to this dichotomous view, the American Association of Colleges and Universities (AAC&U) argues both a civic and an economic case in support of their modern definition of liberal education in the 21st century:

Liberal Education is an approach to learning that empowers individuals and prepares them to deal with complexity, diversity, and change... A liberal education helps students develop a sense of social responsibility, as well as strong and transferable intellectual and practical skills such as communication, analytical and problem-solving skills, and a demonstrated ability to apply knowledge and skills in real-world settings (2015).

Embracing this view of the purpose of higher education is inspiring but yet difficult to operationalize. It is easy for institutions and individuals alike to rally around the notion of empowering students to draw upon integrated knowledge from an array of courses, experiential learning opportunities, and daily life in order to address the most pressing challenges facing society – but, *what would we in higher education have to rethink to better align with this view?* and *what would be the signs of positive progress?*

This dissertation begins to explore those two motivating questions by first claiming *we must prioritize the agency of the learner and cultivate skills in metacognition and self-regulation*. John Dewey posits a similar view when he claims “the criterion of the value of school education is the extent in which it creates a desire for continued growth and supplies the means for making this desire effective in fact” (1916, p. 53). This view contains none of the rhetoric around employability, disciplinary competency, or specific “content coverage” that seems to dominate current conversations about the value of courses and degrees. However, as discussed earlier, the two worlds are not mutually exclusive. That is, by emphasizing processes that help individuals to be more proactive regulators of their own learning and growth, they will better achieve that which they set out to do (e.g., develop skills, master content areas, obtain employment). To be more specific, this construct is referred to as self-regulation which Paul Pintrich (2000) defines as “an active, constructive process whereby learners set goals for their learning and then attempt

to monitor, regulate, and control their cognition, motivation, and behavior, guided and constrained by their goals and the contextual features in the environment” (p. 453). Yet, honing skills in metacognition and self-regulation are not alone sufficient to achieve the sort of aims articulated by AAC&U (2015). It is not just about knowing how to work within a system or set of constraints, but also being willing and able to think outside of them. In his book *Pedagogy of Freedom*, educator and activist Paulo Freire (1998) argues that we often forget human free will and choice within the institution:

My role in the world is not simply that of someone who registers what occurs but of someone who has an input into what happens. I am equally subject and object in the historical process. In the context of history, culture, and politics, I register events not so as to adapt myself to them but so as to change them, in the physical world itself. I am not impotent (p.73).

In addition to prioritizing learner agency (e.g., Freire) and cultivating skills in metacognition and self-regulation (e.g., Pintrich), the AAC&U (2015) aims also require that *we must rethink the goals and contexts of education itself*. In our learning environments, everything that happens is experiential. A test is an experience. A cooperative learning activity is an experience. Completing an online module is an experience. Feedback from an instructor is an experience. This seemingly simple observation actually carries heavy implications because it means that learning itself is not an objective process. This is not to take a specific stand on the debate of objective truth, but rather an admission that regardless of how objective the content (e.g., $2+2=4$), the learner’s individual interpretation and application of that matters more than the content itself. Admittedly, even in dodging an objectivity-subjectivity debate, the word “matters” implies some set of values - matters to whom?, for what?, how do we know? Though

the answers to these questions might differ from person to person, the implicit value above is that learning itself matters if it is of future use in some way. This is essentially a simple understanding of transfer, which Halpern and Hakel (2003) describe as “the purpose of formal education” (p. 38). In a review on transfer literature, authors Bransford and Schwartz (1999) portray two different views of the concept. The first is considered more traditional, is rooted in experiments traced back to Thorndike and Woodworth in 1901, and is focused on a paradigm that “asks whether people can apply something they have learned to a new problem or situation” (p. 67). The alternate view proposed is termed preparation for future learning (PFL) and is discussed as an approach where “the focus shifts to assessments of people’s abilities to learn in knowledge-rich environments” (1999, p. 68). Thus, regardless of one’s epistemological belief on knowledge itself, if transfer, broadly defined, is valued as an aspirational goal – if learning is to be applied in any way in the future – then subjective meaning-making of experience is critically important. Yet, questions remain, such as: how does self-regulation relate to one’s active meaning-making process? and how does meaning-making impact the application of knowledge through constructive action? The first manuscript of this dissertation, addresses those questions by framing problem-solving as embodied acts of meaning-making and exploring the qualities embodied by an exceptional problem-setter and solver.

The second question discussed in response to the AAC&U (2015) definition of liberal education was “*what would be the signs of positive progress?*” Reframed in the context of the discussion of self-regulation, learner agency, and transfer as a goal of learning, it seems that current institutional assessment measures are inadequate. The increased modularization of curriculum and requirements for accreditation necessarily prioritize disciplinary competence but at the cost of any overarching picture of transdisciplinary competence of graduate students.

Even as many universities have general education or liberal education requirements, a diploma ultimately represents successful completion of a specific set of courses with no sense of the degree to which an individual might be able to integrate knowledge across that array of courses. Yet, a diploma and an education are distinct. An education, particularly a liberal education, seems to imply more, though it is hard to systematically quantify or qualify just what *more* might mean in this context. The second manuscript of this dissertation explores this through the introduction of a tool to measure systems thinking competency, a metacognitive strategy characterized by an ability to flexibly frame, reason, and act in consideration of multiple dimensions in response to pressing issues in society.

Organization of the Dissertation

As discussed briefly above, this dissertation is primarily framed around the contributions of two distinct manuscripts. The first is a theoretical piece that uses Bruner's (1990) construct of *narrative* (what he claims as the dominant structure through which we organize, interpret, and communicate our experiences) to highlight *naming and framing* through uniquely individual *perspective* as a governing function of the *meaning-making* process. These emergent core elements (i.e., *naming and framing* and *perspective*) bridge *meaning-making* and *problem-solving* processes and open up broader exploration of how one might cultivate a capacity for *flexible* and *critical meaning-making* in order to address society's most complex challenges. The manuscript closes with a framework for visually mapping primary dimensions of the *meaning-making* process in order to inform future research and practice.

The second manuscript introduces a scenario-based tool designed to serve as a measure of systems thinking competency applicable across disciplines in a higher education setting. The manuscript establishes the conceptual framework and offers initial steps towards the validation

of the systems thinking assessment tool through a pilot study with undergraduate and graduate students. Specifically, qualitative analysis of open-ended responses gathered from students representing different class years and disciplines are used to discuss the degree to which the scenario elicits data on a subset of specific competencies from the framework.

The final chapter of this dissertation discusses key conclusions, implications for practice, and future research stemming from the work of the two manuscripts.

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Manuscript 1:
Problem-solving as Embodied Acts of Meaning-making:
A Conceptual Framework

Leadership scholar Margaret Wheatley writes in *Finding Our Way: Leadership for an Uncertain Time* that “chaos can’t be controlled; the unpredictable can’t be predicted. Instead we are being called to encounter life as it is: uncontrollable, unpredictable, messy, surprising, erratic” (2007, p. 114,125). The most challenging problems that face professionals today, characterized by their unpredictability and messiness, are often classified in the literature as *wicked problems* (Head, 2008). Some particularly tricky aspects of wicked problems include: (a) each problem is fundamentally different from even the most similar of problems, (b) attempted solutions significantly affect current problem formulation, and (c) the direct effects of an attempted solution are delayed in time, and causality is muddled (Rittel & Webber, 1973). These wicked problems beg the question, how can institutions of higher education prepare graduates to be leaders capable of addressing society’s most pressing problems?

Rooted in that question, the aim of this paper is optimistically ambitious. The central argument to be developed is that human processes for meaning-making play critical formative roles in the setting and solving of our most complex problems. In essence, that *problem-solving* can be considered as embodied acts of *meaning-making*.

The angle into this conversation will begin with a discussion of Bruner’s (1990) construct of *narrative* (what he claims as the dominant structure through which we organize, interpret, and communicate our experiences). With *narrative* as the foundation, the argument will build to highlight *naming and framing* through uniquely individual *perspective* as a governing function of the *meaning-making* process. These emergent core elements (i.e., *naming and framing* and *perspective*) enable the analogy between *meaning-making* and *problem-solving* processes and

open up broader exploration of how one might cultivate a capacity for *flexible* and *critical meaning-making* in order to address society's most complex challenges. Finally, a framework for visually mapping primary dimensions of the *meaning-making* process will be presented as a tool for guiding research and practice.

As an orienting reminder, this paper is an attempt to weave together ideas from across fields. In that attempt, concepts will be introduced (e.g., narrative) that ultimately represent volumes of specific scholarship. Because of physical and conceptual space limitations in building the argument, each concept must travel without the robust development and critique from the body of literature it represents.

Considering Narrative

In *Acts of Meaning*, Jerome Bruner (1990) challenges the quest for certainty in modern psychology with a question ever as relevant today as when it was written, “Are not plausible interpretations preferable to causal explanations, particularly when the achievement of a causal explanation forces us to artificialize what we are studying to a point almost beyond recognition as representative of human life? (p. xiii). From a paradigm rooted in that challenge, Bruner believes that in order to better understand human psychology, one must prioritize studying how humans, individually and collectively, interpret experience and make meaning. To explore this, Bruner provides a thorough conceptual development of *narrative*, what he considers to be the dominant means for organizing, interpreting, and communicating experiences. By extension, narratives fundamentally affect how one learns, knows, and acts. In the following sections, each constitutive element of Bruner’s construct of narrative will be discussed. Before thorough development, these elements are summarized below to provide context:

It [narrative] requires, first, a means for emphasizing human action or “agentivity” – action directed toward goals controlled by agents. It requires, secondly, that a sequential order be established and maintained – that events and states be “linearized” in a standard way. Narrative, thirdly, also requires a sensitivity to what is canonical and what violates canonicity in human interaction. Finally, narrative requires something approximating a narrator’s perspective: it cannot, in the jargon of narratology, be “voiceless.” (Bruner, 1990, p.77)

Agentivity

For Bruner (1990), narrative is fundamentally linked to intentional mental states and purposeful interactions within and between individual agents. That is, humans are proactive beings with the ability to shift focus, set goals, and interact with both the external physical world and one’s internal mental world. Individual perceptions of others are similarly governed—that they too are capable of and actively practicing intentional thought and action towards goals. Thus, in considering narrative as a means for organizing, interpreting, and communicating experience, objects and interaction cannot be devoid of meaning. Examine the image from the Library of Congress archives shown in Figure 2.1 (Fisher, 1935).



Figure 2.1. Library of Congress image used to explore Bruner's four elements of *narrative*. This image can be found at <http://www.loc.gov/pictures/item/2001696793/> and is listed by the Library of Congress as having "No known copyright restrictions"

Viewing Figure 2.1 and considering Bruner's concept of *agentivity*, one notes how readily objects are given meaning and agents direction. A sandwich and a hat are more than their constituent parts as they serve some purpose designed by those interacting in the photo. Similarly, the viewer ascribes intent (e.g., thankfulness, helpfulness) to each actor.

Sequentiality

Bruner (1990) offers *sequentiality* as a significant defining characteristic of narrative, in his words, "a narrative is composed of a unique sequence of events, mental states, happenings

involving human beings as characters or actors” (p. 43). At first glance, this seems to be a simple tautology that time flows in one direction and is just an extension of the interpreted goal-directed action of agentivity. Considering Figure 2.1 again, even though only one moment in time is shown, the viewer intuitively leaps to fill in scenes both before and after the snapshot (e.g., the streaks on one individual's face were the result of a hard day's work, the sandwich will be eaten and hunger sated). Thus, sequence is created even when none is given.

However, sequentiality is not just about a constructed timeline. Bruner notes that one of the complexities of sequentiality is that a finite series of events/states/happenings must be considered as both separate from the broader context and inseparable at the same time. In essence, boundaries must be drawn to make distinctions and to process within perceptual limits while also understanding that the drawn boundaries are artificial and incomplete. Because of this boundary drawing (what to include, what to exclude) the organizational process is inherently an interpretive act. By placing events next to one another, connections are made and meaning assigned. Even though time exists linearly and continuously, as narrative is actively constructed, the individual decides starting and ending points and significant marks in between.

Canonicality

Bruner (1990) offers a third critical dimension of narrative by exploring its ability to mediate experiences and interactions that seem to be exceptional. One of the seeming paradoxes of human nature involves an ability to be incredibly adaptable and resilient while simultaneously needing structure, organization, and stability to survive and thrive. For Bruner, it is culture that codifies what is “normal” in daily life and establishes general stability. Those in the United States “know” that morning is the most appropriate time to drink coffee, cars drive on the right-hand side of the road, and that “How are you?” is usually just a greeting and not an invitation for

intimate conversation. Narrative thus becomes the tool through which one maneuvers a dissonant experience so that it still somehow fits within cultural norms. Considering Figure 2.1 once again, the exchange of a sandwich through a doorway is not an everyday occurrence. Yet, as the viewer makes meaning through narrative, culturally acceptable rationale emerges (e.g., neighbors or charities might offer a hungry individual food). Through ascribing goal-directed action to agents (*agentivity*) across time (*sequentiality*), a series of organizational steps makes the image fit, even in its abnormality, with the general order that comprises one's world.

Complicating canonicity. Having established that narrative is a means through which dissonant experiences can be interpreted and explained into alignment with existing norms, the origins of norms becomes an increasingly relevant issue.

One frame through which to explore the roots of cultural norms comes from the concept of institutionalization from Berger and Luckmann's (1966), *The Social Construction of Reality*. Foundational to their premise is that humans, as social creatures, develop habits out of their regular interactions that cause one to typify one's self and others into particular roles. It is as if a rhythm is developed with one another so that actions might be more automatic and interactions more predictable. Institutionalization occurs when these habits and typified roles become both historical and objective. In describing these features, Berger and Luckmann (1966) claim, "this means that the institutions that have now been crystallized (for instance, the institution of paternity as it is encountered by children) are experienced as existing over and beyond the individuals who 'happen to' embody them at the moment" (p. 58). Additionally, this means that institutions themselves are understood as both subject and object. For a father, the institution of fatherhood directs and shapes an individual by defining the cultural norms through which that

role is viewed. However, the individual actor also has an influence on how others come to understand the institution of fatherhood through unique enactment of that typified role.

Yet, institutions alone do not define what is and what is not normal for a particular individual in a given culture. If it were, interpretation of a norm across different individuals would be much more similar than they actually are. To consider this, Berger and Luckmann (1966) forward primary socialization, a concept that describes the process through which children come to know the worlds they exist in, and their associated norms, through the filters of the significant others in charge of socialization. To continue the paternity example from earlier, one's understanding of the norms of fatherhood were shaped both by the broader institution of fatherhood and by that individual's significant others. Because this process occurs during childhood, one of the unique features of primary socialization is that these mediated versions of cultural norms are perceived as both laden with emotion (institution of fatherhood viewed through one's emotional feelings from/towards one's father) and also taken as the singular reality. In Berger and Luckmann's (1966) words, "since the child has no choice in the selection of his significant others, his identification with them is quasi-automatic" and later, "the child does not internalize the world of his significant others as one of many possible worlds. He internalizes it as *the* world, the only existent and only conceivable world, the world *tout court*." (p.134-135). It is for this reason that what is defined as normal during this period persists so strongly even as one later comes to learn that individual understandings are not *the* understanding.

Narrative Voice

The remaining dimension of narrative is concerned with narrator *voice* and story's ignorance of its own truth or falsity. That is, narrative is inherently interpretive and therefore

perspectival. In Bruner's (1990) words, "despite past literary efforts to stylize the narrator into an 'omniscient I,' stories inevitably have a narratorial voice: events are seen through a particular set of personal prisms" (p. 54). Returning to the story constructed out of Figure 2.1, examples throughout have portrayed the image as one where a hungry hard-working individual, unable to make ends meet, thankfully accepts aid in the form of a sandwich from a more financially able neighbor or charitable organization. This construction exists ignorant of any actual intention of the agents (agentivity) and the real progression of the preceding/proceeding scenes (sequentiality). For example, the constructed story presumed helpfulness as a motivation of the giver when the sandwich could actually be payment for services rendered. Or, the assumed exchange could be reversed, where the fully visible character is giving rather than receiving the sandwich. One could imagine several possible interpretations though each is ultimately subjective relative to what possibilities constitute normal or plausible for the viewer (canonicity).

Historian Keith Jenkins (1990) also explores this notion of interpretive reality, or subjective epistemology, as he argues that there is one past and multiple histories. That is, there is a specific reality made of physical interactions that occur in time and space, but what is thought of as history relies on individuals interpreting that reality through their own experiences along with individual and cultural tools. Bruner (1990) touts this, what he calls "shadowy epistemology of the story" as an exceptional quality of *narrative*, a part of his belief that "the existence of story is a perpetual guarantee that humankind will 'go meta' on received versions of reality (p. 55). In essence, that individuals will always strive to make meaning, intuitively and deliberately. In the case of Figure 2.1, that simply by presenting it, the viewer immediately sets about the work of interpreting it.

In considering *voice*, it is important to remember Bruner's (1990) mention of interpretation through "personal prisms" and the broader discussion of canonicality: the lenses used in interpretation are largely shaped by an individual's held identities and roles, and by what according to one's world, is normal, true, or right. Further, fact and fiction are muddled and what many might consider to be "objectively true" is actually the construction of "objectivity" as created by several individuals through coordination of their subjective values and interpreted experiences (one conception of Berger and Luckmann's (1966) *institutions*). Following this line of thought, it becomes clear that any educational endeavor contains an implicit, if not explicit, epistemological value. For example, teaching in mathematics necessarily communicates a story about the nature of certainty in the field – does calculus "work" because it is "how the world works" or because it seems to be a predictive tool that has generally stood the test of time and varied use? Though some might consider such discussion of *voice* and related epistemological positions as an attempt to plunge all into a relativistic abyss where nothing can ever be "known" at all, that is not the intent. Rather, consider that the most pressing educational implications of *voice* are in the asking of such questions as (a) *how do we know what we know?*; (b) *who decides?*; (c) *through what lenses?*

Meaning-Making as Process

The discussion thus far has focused on narrative as the primary structure through which experiences are organized, interpreted, and communicated with particular attention to the four essential elements of narrative (i.e., agentivity, sequentiality, canonicality, narrative voice). While Bruner's (1990) discussion of narrative is thorough, and he proposes a broad array of connections (e.g., drama, childhood development, cognitive psychology) in their development, a direct and concise way to conceive of the process of narrative construction is elusive. If

narrative is the structure and *meaning-making* the process, then we have so far painted a complex portrait of that *meaning-making* process: one in which the individual is an agent with voice, one who thinks, feels, acts, and then interprets experiences in the context of what is socially and culturally normal yet still through a set of lenses that is unique to that individual.

In considering this meaning-making process via its constitutive narrative structure, an emergent procedural element is the conscious or subconscious decision of what warrants inclusion/exclusion in the first place. In an exploration of the social construction of silence, Robyn Fivush (2010) highlights this same underlying element, “Narrating our experiences by very definition implies a process of editing and selecting, voicing some aspects of what occurred and therefore silencing other aspects” (p.1). In an attempt to condense the *meaning-making* process into more conceptually tangible functions, consider as paramount the boundary drawing process that defines what is included or excluded (voiced or silenced) as *naming and framing*. After defining *naming and framing*, *perspective* will be explored as the unique governing angle through which *naming and framing* occurs.

Naming and Framing

In this argument, naming and framing serve as interrelated but distinct concepts defining the organizational and attributional processes associated with the agentivity and sequentiality dimensions of narrative described earlier. To *name* is to identify and define a particular feeling, thought, individual, goal, problem, or experience; to make it object and concrete, even if incomplete. From the paternity example earlier, one might connect the set of mixed emotions (e.g., love, pride, worry) felt towards one’s son and call them *fatherhood*. In that attempt, a set of emotions and experiences are being bundled together and named in an effort to make them something that can be examined or discussed as a whole. Or, to return to Figure 2.1, upon seeing

an individual receiving a sandwich from another, the interaction itself might be labeled as *charity* or the intentions as *helpfulness* (to the owner of the hand) *and thankfulness* (to the man tipping his hat).

Framing, in this case, establishes the context by setting the boundaries of what is and is not to be considered for analysis. If naming is pointing at an object, the frame establishes the broader scene. On one hand, naming and framing can be thought of as related via a telescoping feature with naming focusing on a zoomed-in feature and framing involving the immediate context. Yet, there is a recursive element as well, where the named object can be broken into parts and thus serve as framing for a more specific element of the previous whole. Consider again the example of Figure 2.1. The interpretive frame accompanying the constructed story of Figure 2.1 named as *charity* is dominated by ascribed primary roles of giver/receiver and a time window that only considers this specific interaction and very little else (hunger in this interpretation is a temporary state, and the sandwich is a momentary solution irrespective of yesterday or tomorrow's need). If one were to zoom in on some element (e.g., the grime on the man's face), suddenly the framing for that takes on its own contextual features (e.g., the result of yet another tireless day in a coal mine). For Bruner (1990),

Framing provides a means of “constructing” a world, of characterizing its flow, of segmenting events within that world, and so on. If we were not able to do such framing, we would be lost in a murk of chaotic experience and probably would not have survived long as a species in any case. (p. 56)

So, in essence, framing sets the rules for what is and what is not to be considered in an analysis or an act of meaning-making. It seems that inherent in naming and framing are conscious or subconscious decisions with respect to particular dimensions – drawing from analysis of

agentivity and sequentiality elements of narrative, let them be *detail* and *time* dimensions. The *detail* dimension is fundamentally concerned with the recognition, identification, and definition of salient elements, objects, and interactions. The *time* dimension takes into account that anything existing in the *detail* dimension also has past, present, and future considerations and also that the sequential ordering of any particular elements of the *detail* dimension is of prime importance. For example, consider that the subject taxonomy for the Library of Congress classifies Figure 2.1 as fitting under two categories: *tramps* and *charity*. Note that the inclusion of either tramps or charity in association with the image would shape analysis relative to detail and time dimensions. For example, the word "tramps" portrays this sandwich as one of many, part of a continuous state of hunger. Similarly, the smudge of dirt might be interpreted not as the result of hard work (as suggested in an earlier example), but rather as the grime resulting from vagrancy. Alternately, the word charity does not necessarily imply hunger over such an extended window of time. Note also that the word tramps places primary focus on the individual seen receiving the sandwich while the word charity focuses attention on the interaction itself. In each case, the differential naming and framing results in different boundary drawing on the specifics of the *detail* dimension (e.g., sandwich, smudge of dirt) and the associated *time* windows (e.g., momentary hunger vs. state of poverty, result of hard work vs. vagrancy).

From the previous example, one can quickly see that attention to *detail* and *time* dimensions are not entirely sufficient. In the examples surrounding Figure 2.1, why has the analysis fixated on the exchange of the sandwich? Why not, instead, the man's clothes or the dirt on the doorway? It is clear that there are factors that shape the naming and framing process that are both individual and cultural. Let us then consider that naming and framing occurs from a specific subjective *perspective* that is informed by both canonicality and voice elements of

narrative discussed previously. *Perspective* is more complex in construction than *detail* and *time* dimensions; specifically, *perspective* is a fluid, tangled mix of past experience, individual internalization of social and cultural roles and values, all with affective tags.

Perspective

Studying the tangled mix just described requires recall of the earlier discussion of Berger and Luckmann's (1966) institutions and primary socialization. One of the critical features of institutions discussed was that they exist "over and beyond the individuals who 'happen to' embody them at the moment" (p. 58). Thus, the question of how cultural narratives shape individual narratives, and how cultural tools inform individual tools for meaning-making becomes particularly important. Bruner (1990) paints the analogy:

When we enter human life, it is as if we walk on stage into a play whose enactment is already in progress – a play whose somewhat open plot determines what parts we may play and toward what denouements we may be heading. Others on stage already have a sense of what the play is about, enough of a sense to make negotiation with a newcomer possible. (p. 34)

Before discussing how *perspective* specifically shapes the naming and framing process, the process through which one develops *perspective* will be explored by examining the works of Lev Vygotsky related to socio-cultural learning and development.

Vygotsky's insights on higher mental functions. One of Vygotsky's key contributions focused on the study of the development of higher mental functions (e.g., Vygotsky 1931/1997). These functions generally refer to the set of capacities that seem to separate humans from much of the rest of the animal world (e.g. language, symbolic manipulation). Vygotsky (1931/1997) discusses a process of internalization stemming from the basic tenet that "every higher mental

function was external because it was social before it became an internal, strictly mental function; it was formerly a social relation of two people” (p. 105-106). That is, anything that might be considered as “knowledge” was somehow first introduced or observed as a social interaction. A crude analogy might be to consider how one learns a new educational buzz word: A colleague uses a word in a committee meeting and others nod their heads in a mix of awe and agreement. Not knowing this word but wishing one’s colleagues would nod in that same way, an individual might look it up in a dictionary (a cultural artifact with socially-mediated definitions) and/or might begin trying it out to see how or if it functions. Over some period of time, as the word is used repeatedly, if desired results are achieved (e.g., nods of amazement from colleagues, effective communication), it begins to be fully integrated with the rest of one’s language – it is no longer a new or tentative word, but rather one that can be both readily used in thought and action, fully internalized. A critical yet subtle element here is that individual agency still remains salient in Vygotsky’s social constructivism. Just as an individual might routinely misuse an “internalized” buzz word, it is as if any nugget of potential knowledge from a social interaction is necessarily edited and adapted to fit the individual.

Further, Vygotsky (1999) describes his notion of genetic history that affects both how higher mental functions are developed and practiced. He claims that they are developed from behavior and thus have a unique social history based on the interactions that prompted development. Said another way, capacities to reason or problem-solve, for example, were developed through behavior and practice, through the individual internalization of social relations described previously, and cannot be divorced from that history of experiences. Thus, the most complex processes are individual representations of culturally-laden capacities with personal and social histories – they are limited (and perhaps, at times, enhanced), by the

environments through which they are learned. Consider an abstract concept from the Figure 2.1 example such as charity. Each individual has uniquely different histories that shape the understanding of that concept (e.g., interactions as giver or receiver, observations of one's significant others as giver or receiver). Yet, even with these individual differences, there are cultural histories that also shape the concept of charity (e.g., *noblesse oblige*, from a religious tradition: the Parable of the Good Samaritan). Considering a different function as a final example, in an attempt to solve a complex math problem today, one is bringing to bear a capacity that is shaped by each other related problem ever attempted and tomorrow's capacity will be forever different (even ever so subtly) from today's.

Considering the constitution of individual perspective. Thus far, it has been claimed that perspective is shaped by individual representations of culturally-laden capacities with personal and social histories and that both one's unique past experience and shared cultural histories play critical roles in shaping the perspective through which naming and framing occurs. To make the tangled mix a step more complex, each of these individual and cultural lenses also has an associated affective tag that affects the application of a particular lens. Bruner (1990) discusses this briefly in summarizing classical studies of Bartlett (1923):

In the actual effort to remember something, he [Bartlett] notes, what most often comes first to mind is an affect of a charged “attitude” – that “it” was something unpleasant, something that led to embarrassment, something that was exciting. The affect is rather like a general thumbprint of the schema to be reconstructed (p.58).

In the previous example of the concept of charity, while one's significant others in charge of primary socialization may have demonstrated models of what charity is and is not, one's own

adoption or rejection of those models may have been based in part by one's affective response to those very individuals. Berger and Luckmann (1966) posit a similar claim,

The social world is ‘filtered’ to the individual through this double selectivity [referring to both social structure and individual idiosyncracies]. Thus the lower-class child not only absorbs a lower-class perspective on the social world, he absorbs it in the idiosyncratic coloration given it by his parents (p. 132).

Building from this discussion, it is as if up to a certain point in life, perspective is generally fixed relative to the culture and perspectives of those in charge of one's socialization. Bruner (1990) claimed that each individual has a set of “personal prisms” (more colloquially, *lenses*) through which events are interpreted (p. 54). Thus the argument developed herein would imply that through growth and socialization one develops uniquely individual versions of social and cultural *lenses*. Further, those whose socialization is similar equips them largely with a similar, though in no way exact, set of *lenses*. This analysis begs the question about what specific *lenses* constitute perspective.

Because so many human phenomenon cannot be disentangled, it seems impossible to claim that a biological typology of different *lenses* exist. For the purposes of this argument, and rooted in the work of Bruner, Vygotsky, and Berger and Luckmann, *past experiences* and their interpretations are the fundamental building blocks for lenses. Bruner’s notion of how meaning-making seeks to create order from life indicates that humans, by nature, attempt to organize their experiences through the application of cultural tools. Ernst von Glaserfeld (1984) captures a similar idea while summarizing his epistemological position that “knowledge can now be seen as something that the organism builds up in the attempt to order the as such amorphous flow of experience by establishing repeatable experiences and relatively reliable relations between them”

(p. 39). Thus, as *past experiences* are organized and reliable relations emerge, they become the backdrop through which each new experience is compared. In essence, this is a reiteration of Berger and Luckmann's discussion earlier of institutions and primary socialization. Inhabited *identities/roles* and associated *beliefs/values* emerge as bundles of similarly interpreted *past experiences* and provide means for organizing and comparing new experiences.

Thus far, it has been posited that perspective is fundamentally shaped by a series of specific lenses and that those lenses might be broadly considered as the result of all past experiences with specific identities/roles and beliefs/values representing particular bundles of past experiences. Note that identities/roles and beliefs/values are intimately related and do not represent distinct categories. For example, *fatherhood* might be an identity but there are countless values about what “good” fathers should do that in turn make up fatherhood as an identity. In terms of conceptual rigor, highlighting the role of past experiences, identities/roles, and beliefs/values does not create robustly distinct categories of lenses that comprise perspective. However, there is practical utility in highlighting perspective as a product of these types of lenses.

In practice, considering past experiences, identities/roles, and beliefs/values can activate different pathways that help consider perspective from multiple angles. Consider then that (a) *past experiences* in the context of a given experience represent constitutively similar experiences, often due to similarities in evoked emotions, actors, and/or goals; (b) *identities/roles* elicit responses relative to the ways in which those concepts are culturally conceived (e.g., profession; family status; racial, ethnic, or gender identity); and (c) *beliefs/values* are more domain general and focused on judgmental relations (e.g. good/bad, right/wrong) or overarching concepts (e.g., responsibility, courage).

To demonstrate, consider once more the example from Figure 2.1. Explore potential *lenses* shaping the *perspective* of the owner of the hand (giver) in analyzing the interaction with and situation of the individual receiving the sandwich. For the giver, previous acts of charity, interactions with other hungry individuals, and experiences as a third party to other charitable acts all represent aspects of *past experiences* that may influence interpretation of the current situation. Additionally, several cultural messages influencing this interaction (often conflicting and with little regard to “truth”) might exist: (a) when one gives aid, the receiver exhibits thankfulness (identities/roles); (b) those dependent on charity are always dependent (identities/roles); (c) *noblesse oblige*, those with more power and resources must provide for others (beliefs/values); (d) through hard work, anything can be achieved (beliefs/values). Recall once more that both the cognitive and affective relation to similar past experiences and the cultural messages regarding identities/roles and beliefs/values affect one’s specific *perspective* on a given situation.

Meaning-making: Naming and Framing Through Perspective and Altering Lenses

The concerted effort to condense the meaning-making process into more conceptually tangible functions has highlighted that naming and framing (the boundary drawing process that defines what is included or excluded in analysis) occurs through the unique governing angle that is perspective (a set of individual lenses comprised of past experiences, identities/roles, and beliefs/values). This process is depicted in Figure 2.2.

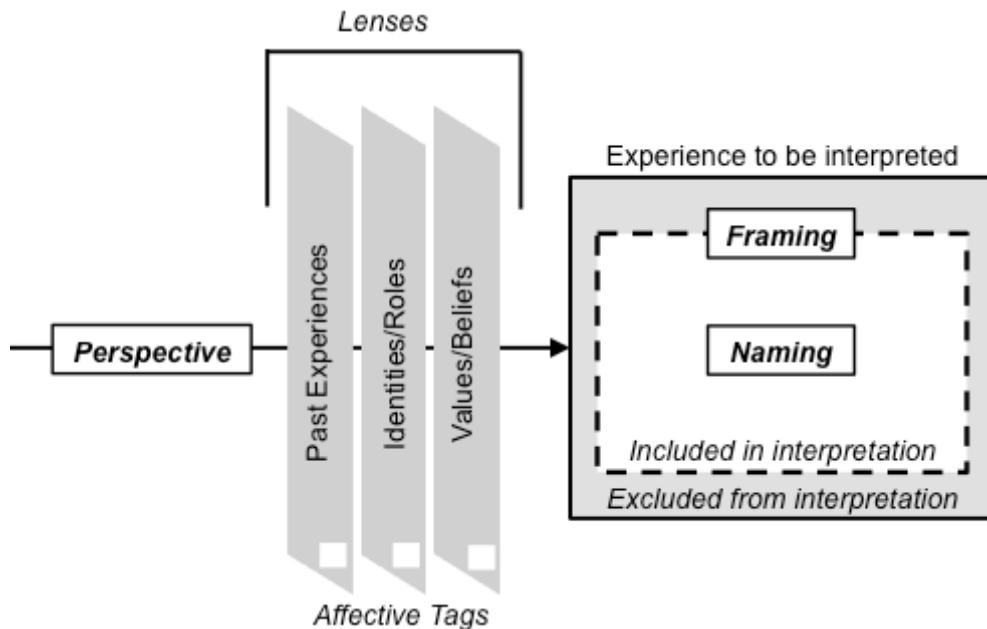


Figure 2.2. The process of naming and framing through a set of lenses that comprise perspective.

Having explored the role of naming and framing through perspective in meaning-making, the possible pathways of processing the experience at hand emerges as the critical next step. It was claimed earlier that narrative becomes the tool through which one maneuvers a dissonant experience so that it still somehow fits within cultural norms. This would seem to indicate that whatever the experience or interaction, that one somehow seeks to trim the experience through an explain-to-fit process with the order and stability one have constructed. Author Christina Baldwin (2007) eloquently captures the essence of this process in *Storycatcher: Making Sense of Our Lives through the Power and Practice of Story*, where she posits “we constantly weave life events into narrative and interpret everything that happens through the veil of story... we make the world fit into the story we are already carrying” (p. xi). Yet, this portrayal seems incomplete, as if one is always at the mercy of how one’s primary socialization shaped any consideration of normal. The work of Jean Piaget (1951) considering adaptation in the development of

intelligence offers significant insight into pathways of processing dissonant experience that prioritize the agency of the individual making meaning.

One of Piaget's (1951) principal assumptions focuses on the individual striving for equilibrium between self and the environment. Given some experience that creates an imbalance, Piaget claims that adaptation is the process through which equilibrium is reestablished and that adaptation is characterized by a blend of *assimilation* and *accommodation*. In the specific case of intelligence, Piaget posits:

Intellectual adaptation always involves assimilation whether it is on the level of [conceptual] thinking which introduces the new into the known by means of judgment, thereby reducing the universe to its own terms, or on the level of sensory-motor intelligence which structures the things perceived by bringing them into its schema

(p.183)

Though Piaget focuses more on the individual organization than the role of social interaction and culture, *assimilation* is conceptually analogous to Bruner's (1990) explain-to-fit process described earlier. While *assimilation* involves the organism reshaping a dissonant experience, *accommodation* involves reshaping of the conceptual framework through which the experience is perceived and processed. Discussing accommodation, Piaget (1951) claims, "Intelligence is also accommodation to the environment, inasmuch as no pure assimilation ever occurs, since the existing schemata of intelligence are constantly modified in order to adjust them to the incorporated new elements" (p. 183).

To incorporate Piaget's (1951) concepts, first recall Figure 2.2 which highlighted that naming and framing (the boundary drawing process that defines what is included or excluded in

analysis) occurs through a unique governing perspective (a set of individual lenses comprised of past experiences, identities/roles, and beliefs/values). Combining the ideas of Piaget and Bruner, Figure 2.2 can be extended to include possible pathways for making meaning of an experience whereby the experience is processed through a balance of intellectual *assimilation* and *accommodation*. Note that this process, depicted in Figure 2.3, is cyclical. That is, the same lenses that affect perspective in naming and framing are the same lenses that are strengthened, switched, or altered in the process of assimilation and accommodation. Moreover, as this process of assimilation and accommodation takes place, the now meaningful experience becomes yet another part of the past experiences lens for future acts of meaning-making.

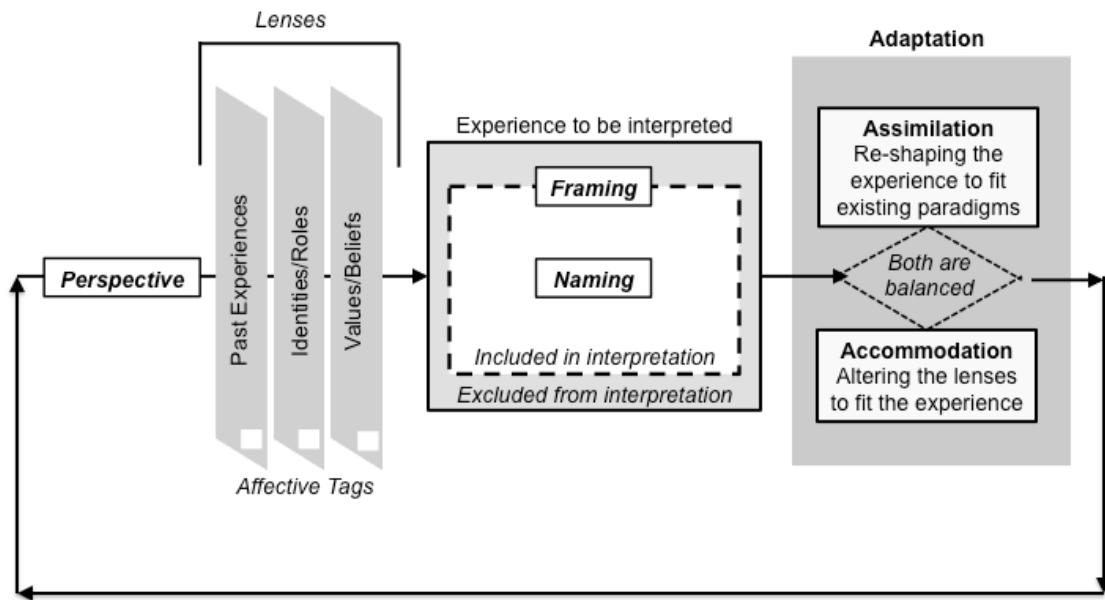


Figure 2.3. A map of the meaning-making process from the naming and framing of an experience through perspective to the balance of assimilation and accommodation in interpreting the experience.

Problem-solving as Embodied Act of Meaning-making

At the outset, it was claimed that the fundamental premise for the importance of this paper is that processes for meaning-making play critical formative roles in the setting and solving of our most complex problems—*problem-solving* as embodied (referring to the inseparable influence of cognition, affect, and behavior on one another) acts of *meaning-making*. Recall that the development of meaning-making was rooted in a discussion of broadly framed narrative structure, a structure dealing with actions and interactions, and with negotiation and interpretation between expectation and experience. Meaning-making then is not simply to be viewed as limited to reflective activities in experiential learning (just one of the places where people might confine meaning-making within education). Rather, the process of naming and framing through perspective is critical in any interpretation of dissonance—goal-setting, encounters with difference, change management, and, for the focus of this paper, problem-solving.

To more robustly argue for problem-solving as embodied acts of meaning-making, first consider the definition of a problem itself. For problem-solving scholar David Jonassen (2000), a problem is understood as “the difference between a goal state and the current state” (dissonance) where achieving the goal state is deemed to have some inherent value (e.g. to one’s self, the world) (p. 65). Problem-solving then is the overarching activity describing the intentional journey from current state to goal state. Jonassen (2000) claims that the individual problem-solver is tasked with mentally constructing a problem space and then intentionally, physically or mentally, manipulating that problem space towards the goal state. Said another way, “the learner must identify not only the nature of the problem, but also an acceptable solution, and a process for arriving at it” (Jonassen, 1997, p.67). Thus it is clear that robust problem identification and definition is paramount.

In *Logic, The Theory of Inquiry*, John Dewey (1938) claims that “the way in which the problem is conceived decides what specific suggestions are entertained and which are dismissed; what data are selected and which rejected; it is the criterion for relevancy and irrelevancy of hypotheses and conceptual structures” (p. 108). Note the conceptual similarities between Dewey’s claims and earlier development of naming and framing as the boundary drawing process that defines what is included or excluded in interpreting some experience. In the language of the problem-solving literature, naming and framing is related to qualities of the problem that make it either well-structured or ill-structured. Well-structured problems are characterized by clear problem elements and defined goals leading to convergent absolute solutions through repeatable known algorithmic methods (Jonassen, 1997; Shin, Jonassen, & McGee, 2003). In contrast, ill-structured problems are characterized by obscured or emergent problem elements, multiple or nonexistent solutions, no clear repeatable patterns for addressing the problem, and/or require interpretational judgments often based on personal subjective factors (Meacham & Emont, 1989; Shin, Jonassen, & McGee, 2003). While the solving of well-structured problems relies on appropriate use of algorithms, research indicates that required competencies for solving ill-structured problems are different. Solving ill-structured problems requires an iterative process of reflective design and argumentation in constructing the problem space (Jonassen, 1997; Schön, 1990), and problem-solver success has been shown to be related to epistemological beliefs (Angeli & Valanides, 2012; Schraw, Dunkle, & Bendixen, 1995; Voss, Wolfe, Lawrence, & Engle, 1991;) and advanced use of metacognitive strategies (Jonassen, 1997; Shin, Jonassen, & McGee, 2003). For example, in discussing metacognitive strategies, Jonassen claims (1997):

Learners must answer questions, such as: How much do I know about this problem and its domain? What do I believe to be true about it; what are my biases? Have I heard stories or accounts about this situation? Have I read anything about it? Do I know where I might find information about it? If not, then who might? (p.80).

These questions are clearly related to the set of lenses that comprise perspective (past experiences, identities/roles, beliefs/values).

From this discussion, the solving of ill-structured problems requires subjective interpretation based on boundary drawing about what is to be included or excluded in the problem-space. Further, these decisions are shaped by the past experiences and epistemological beliefs of the individual solver. In essence, this reiterates the meaning-making process described earlier as one of naming and framing through perspective. Thus, if the conceptual structures through which meaning is made and through which problems are interpreted are the same (problem-solving as embodied acts of meaning-making), then a proactive means of controlling the meaning-making process becomes increasingly important. In short, how can the individual consciously and intentionally leverage individual perspective in the naming and framing of problems while also recognizing the incompleteness of a singular perspective?

Proactive Control of Meaning-making Process

The meaning-making process depicted thus far is one in which naming and framing ultimately occurs through a perspective that is largely shaped in early formative years. While Berger and Luckmann's (1966) concept of primary socialization does provide for the development of initial lenses, individuals are not forever at the mercy of the institutions and individuals from youth. Several arguments exist around if, when, and how a shift from passive object to active agency occurs—in a metaphor from teaching and learning, individuals are not

simply vessels to be filled. In order to explore what proactive meaning-making might be required for the complex problem-solving endeavors described earlier, theories of *self-regulation* and *self-authorship* will be presented to establish context for considering meta-level control of processes.

Self-regulation

Psychologist Albert Bandura (1989) rejected the binary of human as fully autonomous being or programmable robot and forwarded a model of both agent and object simultaneously. His model of *triadic reciprocal causation* focuses on ways in which individual cognition, affect, and behavior shape and are shaped by one's environment.

In the model of reciprocal causation, people partly determine the nature of their environment and are influenced by it. Self-regulatory functions are personally constructed from varied experiences not simply environmentally implanted. Although people's standards and conceptions have some basis in reality, they are not just ingrafts of it. Through their capacity to manipulate symbols and to engage in reflective thought, people can generate novel ideas and innovative actions that transcend their past experiences. (Bandura, 1989, p.1182)

Models such as Bandura's (1989) have been critical in the development of self-regulation as a meta-level construct, described by educational psychologist Paul Pintrich (2000) as "an active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate, and control their cognition, motivation, and behavior, guided and constrained by their goals and the contextual features in the environment" (p. 453). Though scholars disagree on exact specifics, using Pintrich's definition of self-regulation positions and Baird's (1990) definition of metacognition (referring to "the knowledge, awareness, and control of one's

own learning”) indicates that metacognition is embedded within the more comprehensive capacity of self-regulation (p. 184). Similarly, the active meaning-making process described in this argument is interwoven throughout the process of self-regulation. Specifically, naming and framing plays an essential role in the setting of goals, monitoring of progress, and identifying real and perceived constraints. Additionally, the adaptation process whereby the individual both assimilates and accommodates to process an experience represents an aspect of self-regulatory control of conceptual structures.

It is clear from the definition above that self-regulation is a meta-level capacity, inclusive of the meaning-making process, that positions the individual as proactive agent.

Self-authorship

Based on extensive longitudinal interviews of students, Marcia Baxter Magolda forwards the theory of self-authorship to describe stages through which individual knowers become more proactive meaning-makers. Simply defined, *self-authorship* refers to the “development of an internal voice to coordinate external influence in constructing one’s beliefs, values, identity, and social relations” (Baxter Magolda & Crosby, 2011, p. 2). This theory first emerged from studying the epistemological beliefs of students and resulted in four distinct ways of knowing that exist on a developmental arc: *absolute*, *transitional*, *independent*, and *contextual*. For the purpose of this argument, consider the two poles of absolute and contextual knowing. *Absolute knowing* is characterized by the definitive nature of knowledge, that a given assertion is either true or false. Experts in a domain are believed to have the answers and individual uncertainty is mitigated via expert consultation. In *contextual knowing*, individuals embrace that uncertainty exists in knowledge and value both their own opinions and that of experts. Baxter Magolda (1999) describes this stage:

Contextual knowers felt their rationality in terms of consulting experts and processing evidence was necessary but simultaneously valued working through their perspectives by accessing their own experience and others' perspectives. Contextual knowing involved constructing one's perspective in the context of one's experience, available information, and the experiences of others (p.51).

The emergence of these ways of knowing led Baxter Magolda (1999) to extend the work of other human development scholars to more robustly construct a theory of self-authorship. Specifically, one foundation for self-authorship stems from Kegan (1994) and his assertion that modern life demands a higher order level of consciousness (self-authorship) characterized by: "the ability thus to subordinate, regulate, and indeed create (rather than be created by) our values and ideals—the ability to take values and ideals as the object rather than the subject of our knowing" (p. 91). This ability is critical to earlier discussion of canonicality, primary socialization, and Piagetian adaptation. Specifically, self-authorship offers insight into the ways in which the lenses that shape perspective become alterable. For example, the lenses shaping an individual's perception of charity might begin somewhat fixed (e.g., direct application of *noblesse oblige* cultural message) but become more multi-faceted as the individual has relevant experiences causing transitions along the arc from absolute knowing to contextual knowing.

Through brief exploration of self-regulation and self-authorship, it is clear that meta-level constructs exist to describe *how* and *in what ways* the individual might proactively control the meaning-making process. Under the assumption that this proactive control is possible, and in consideration of the relationship between meaning-making and problem-solving, the subsequent question becomes *what kind of naming and framing is needed to address complex ill-structured problems?*

What Kind of Naming and Framing is Needed?

Naming and framing is intuitive and biological. In a book chapter entitled “The Role of Attention in Cognition,” Herbert Simon (1986) describes the attentional bottleneck whereby individuals must make sense of overwhelming amounts of sensory data in order to direct behavior. He determines:

The organism needs a mechanism to guarantee that only a very small part of the potentially available stimulus information, and only a very small part of the information potentially available from long-term memory, is brought to bear on behavior during any short interval of time (p. 106).

Humans seem wired for rapidly and often subconsciously drawing conclusions about what is salient, making inferential judgments, and acting. In fact, as Simon (1986) points out, “...when experts look at a problem situation in their domain of expertness, they immediately recognize familiar features in the situation, and these turn out to be the principal relevant features for correct handling of the situation” (p. 111). It is easy to see how the survival-of-the-fittest trait that helps humans quickly notice and flee predators has shaped the ability to intuit nuances of social interaction and quickly troubleshoot a variety of complex technical systems (e.g., cars, computers).

Yet, this same feature that is so natural and helpful can also be deeply limiting in a wide variety of situations and problems that arise today. The period of primary socialization often leads to incomplete and discriminatory views because of the relatively narrow perspectives one is exposed to during childhood (Berger & Luckmann, 1966). The same capacity that helped humans survive (e.g., “run from animals with large sharp teeth”) in modern society can become (e.g., “all people with <insert characteristic here> are dangerous, stupid, evil, less than me”). Further, in some cases, existing mindsets and expertise can be a hindrance in problems requiring

creative thinking as seen in functional and design fixedness studies (Adamson, 1952; Chryska & Weisberg 2005; Duncker, 1945; Jansson and Smith 1991). While noticing salient features in technical problems is advantageous, many problems are not technically challenging in nature alone. In an extension of ill-structured problem-solving literature, scholars write about several classes of complex problems such as *dilemmas*, *social messes*, and *wicked problems*. In these situations, characterized by uncertainty, uniqueness, and volatility, more than technical expertise is needed. It is not a matter of an expert recognizing a specific pattern and prescribing a solution via appropriate algorithm, but rather one in which multiple perspectives must be considered to name and frame a new problem and where even that novel naming and framing may need to change over time.

Thus, some meta-level awareness and control around naming and framing is needed to adequately face the challenges of today and tomorrow. Specifically, these situations demand a capacity for *flexible*, *critical* naming and framing along with an ability for *constructive synthesis leading to action*.

Flexible. *Flexibility* in naming and framing refers to an ability to consider multiple and distinct perspectives for a given situation and the fundamentally different boundaries of inclusion or exclusion that those perspectives imply. Returning to the example from the image of the man in Figure 2.1 used to discuss elements of narrative, flexible naming and framing would involve considering that the individual's hunger could be a result of temporary misfortune, lack of economic opportunity, or consistent poor resource management. A compelling case for the need for this sort of frame flexibility emerges from Schön and Rein (1994) as they set out to explore gridlocked policy controversies in their book *Frame Reflection*. The authors are motivated by a desire to understand what makes these controversies so intractable, and a hope that a better

understanding will lead to healing strategies that foster positive change. In their framework, policy controversies are stuck because different parties have different frames, often “exempt from conscious attention or reasoning,” that are in conflict and irreconcilable through facts or argument (p. 23). These frames script the problem-setting process for each party by telling different stories through unique lenses. Today’s political gridlock falls quite naturally within this framework. For example, a common debate considering abortion is divided as pro-life or pro-choice. Even at first inspection, the mismatch is obvious: life and choice are two fundamentally different worlds (names and associated frames) through which to examine the issue. Schön and Rein (1994) argue that it is this very disagreement in the “naming and framing” of any controversy that causes its intractable nature because the struggle represents “symbolic contest over the social meaning of an issue domain, where meaning implies not only what is at issue but what is to be done” (p. 29). Said another way, it isn’t merely a disagreement about what to do, but rather what the problem *is* in the first place.

It is clear from this argument that one’s ability to flexibly frame is critical to meaning-making—to intentionally include and exclude different elements in order to view a given situation or problem in multiple ways and, in so much as it is possible, to view from varied projections of perspectives. This requires a proactive flexibility, as our initial gut reactions, while useful, are generally incomplete for complex situations. For example, the story (and therefore the problem) dramatically shifts depending on whether the individual from Figure 2.1 is hungry because of a temporary misfortune or lack of economic opportunity. In one case, the solution may be a sandwich while the other might require governmental policy reform (depending on specific causes of lack of economic opportunity).

Critical. In this case, *critical* refers to an intense analysis of the factors and assumptions that undergird any lens, particularly with an attentiveness to historical power dynamics and their biased influence on perception. Critical meaning-making is characterized by reflexivity in analysis and an implicit admission that any perspective is limited. In considering the example from Figure 2.1, critical meaning-making would understand that charity is a term laden with a specific history of privilege and oppression and that the color of the hand likely played a role in making the interpretative decision to assign roles of giver and receiver. Criticality is not to be conflated with pessimism. Rather, it assumes that naming and framing is not sufficient when done only by the loudest, most popular, or easiest to access voices and seeks to proactively hear and consider voices that seem marginalized.

Criticality also requires deconstruction (and thereby contextualization) of canonicality. Many scholars have posited eloquent arguments dealing with the blurred lines between constraints of “normal” and oppression. Fivush (2010) argues:

Culturally canonical, or dominant, narratives provide a culturally shared understanding of the shape of a life and how a life is to be understood, and in this way cultural narratives provide authority to define a culturally appropriate narrative of a life, and the power to validate certain narratives over others (p. 90).

In this way, it becomes clear to all that there are standards for living life *rightly* or *wrongly*. Marilyn Frye (1983), in her essay on “Oppression” in *The Politics of Reality*, discusses oppression:

The experience of oppressed people is that the living of one’s life is confined and shaped by forces and barriers which are not accidental or occasional and hence avoidable, but are

systematically related to each other in such a way as to catch one between and among them and restrict or penalize motion in any direction (p. 4)

Taken together, it is not that “normal” itself is inherently oppressive, but rather that it can be so when part of persistent and comprehensive structures that ultimately limit, ignore, marginalize, and abuse those that don’t “fit.” While many modern societies tout inclusivity, it is important to consider so many oft overlooked messages embedded in the language used daily. For example, consider the gender binary or the conflation of race and ethnicity that exists on institutional surveys, or even the seemingly innocuous question before a dinner party “does anyone have any dietary restrictions?” Time and time again, the message is, those that do not fit the norm, must identify and explain themselves or else be ignored. And, as Frye (1983) notes, oppression is ultimately made of the sum total of many structures that, when taken individually may seem dismissible. A detailed discussion of these structures, with particular attention to the significant difference between suffering and oppression as well as detailed analyses of oppression based on gender and sexual orientation, can be found in detail in her works.

Constructive synthesis leading to informed action. While naming and framing should be both flexible and critical, it is easy to imagine how deliberative and intentional meaning-making might lend itself to becoming trapped by inaction. One’s capacity for this sort of analysis is constrained by biology—each individual has perceptual limits on just how much can be considered all at once. Thus, another imperative capacity involves constructively synthesizing the different names and frames of a given situation and ultimately acting. In this case, acting might often be considered as physical action, but it could also be thought of as reorganizing one’s lenses (accommodation) or other cognitive processes.

Think of an investigating officer charged with reconstructing the scene of an automobile accident and assigning blame based on conversations with those directly involved, witnesses, and physical data. While each component is helpful and paints part of the picture, there is a balance between having enough diverse information to be confident and fair in one's judgment but yet not so much data to waste valuable time and money.

By analogy, to be flexible, critical meaning-makers capable of informed action, one must walk a balance whereby one considers just enough varied namings and framings, actively undermining single-fixedness on first intuitive leaps, to have a more complete, incomplete picture.

Towards a More Concise Framework

This discussion has been rooted in a portrayal of humans as active constructors of meaning from experience. Further, a need to be more proactively become aware of and control (meta-level capacity) that process has been demonstrated—to be capable of *flexible* and *critical naming and framing* (decisions about what should be included or excluded in *detail* and *time* dimensions) with particular attention to one's unique *perspective*, the angle through which one views a given interaction, experience, problem, or goal. Yet, the question remains of how one could meaningfully try to better research, practice, or teach this process. In conceptualizing a framework to do that, consider the series of building blocks below, starting with considering both experience and goals in the *detail* dimension. The figures that follow are loosely based on extensions of Doolittle's discussion of Vygotsky's zone of proximal development (ZPD) as a framework for cooperative learning (1997, p. 86).

The *detail* dimension is fundamentally concerned with the recognition, identification, and definition of salient elements, objects, and interactions and Figure 2.4 demonstrates how we

might conceptualize a particular goal or experience. The top half of Figure 2.4 can be considered an excerpt from Doolittle's ZPD figure (1997, p. 86) and is intuitive from how we define problems or goals as a discrepancy between present and desired states. The bottom half of Figure 2.4 is a conceptual analog but focused on a particular experience or interaction. In this case, instead of the distance representing problem complexity, it represents perceptual acuity, one's ability to recognize salient elements of that experience or interaction. In both cases, naming and framing is represented by what is included and excluded. Recalling discussion on Figure 2.1, naming and framing of the example included specific salient elements (e.g., sandwich, hat) and ignored other possibilities (e.g., clothes worn by the individual, dirt on the doorway).

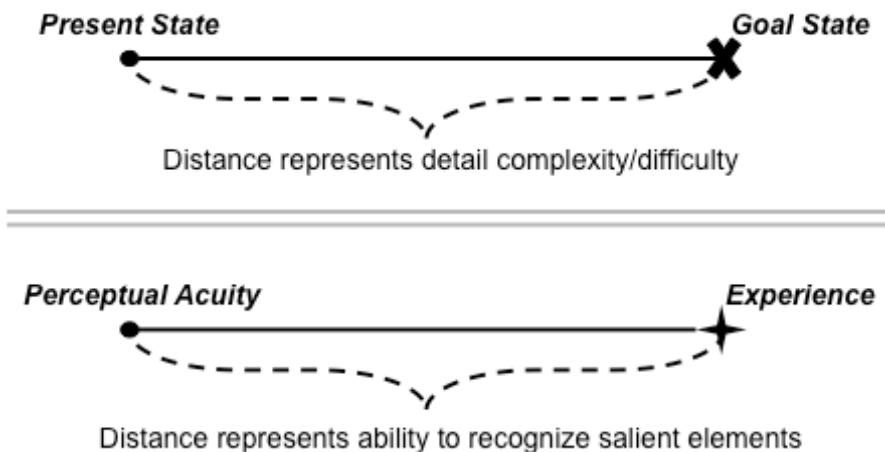


Figure 2.4. Considering goals and experiences within the detail dimension

In Figure 2.5, the *time* dimension is added. The top half is now nearly a reproduction of the Doolittle figure without specifically denoting ZPD and instead focusing on discrete steps from past to future in the eventual achievement of a given goal. While considering the progression itself as *learning*, it is also important to recall some critical elements of Bruner's (1990) *agentivity* here. In this paradigm, individual actors are ultimately in charge of their own learning. Thus, for a specific goal over a given time window, *naming and framing* refers to the

definition of the goal itself and associated steps to achieving it, *self-regulation* as the meta-level capacity guiding the journey, *learning* as the progression in the journey, and *achievement* as attainment of the goal. Time is incorporated into the experience/interaction visualization differently. One's present perceptual acuity (ability to recognize salient elements) is already a function of all relevant past experiences. Drawing upon the same example, analysis of Figure 2.1 has fixated on the sandwich and the hat because past experience has indicated those items are more salient than others in that context. Naming here is still the interpretive identification of what an experience was and was not - what actors were involved, why, for what duration of time. Framing then could be considered those past experiences that shape one's present perception. Recalling earlier discussion about expertise, this process is often done subconsciously. In the same vein, the similarity of a past experience to present does not necessarily indicate strength of impact on present perception.

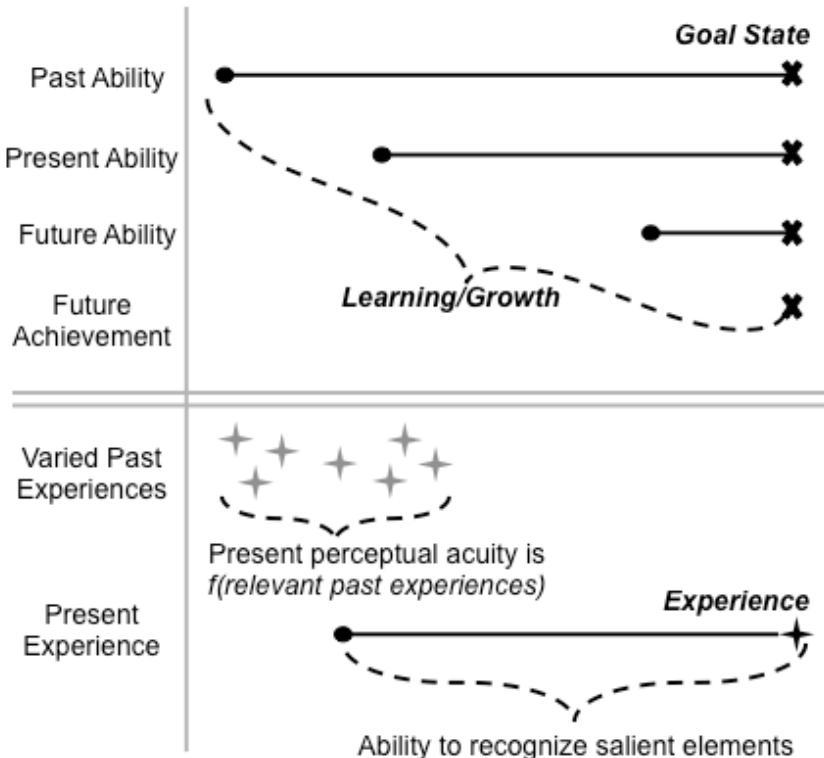
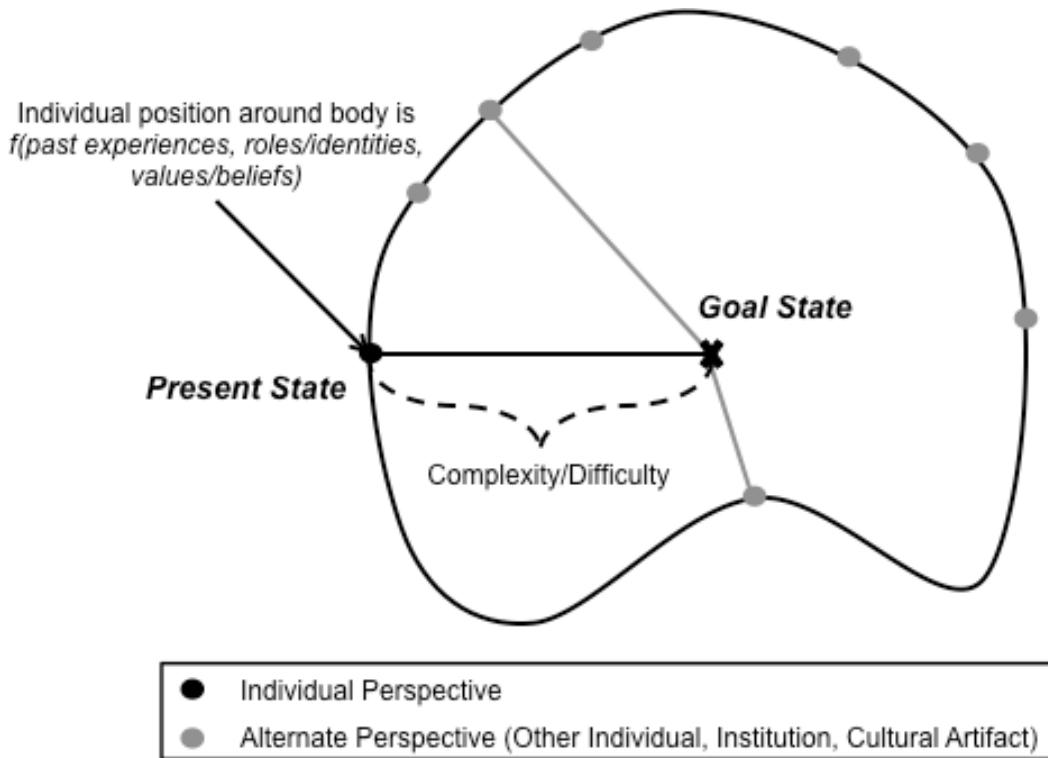


Figure 2.5. Considering goals and experiences within *detail and time* dimensions

Up to this point, there has been a distinction between goals (problems) and experiences. Yet, depending on one's beliefs about learning, these can actually be intermeshed. Many consider experience—interaction within the actor's mind and/or with other agents in the outside world—as the foundation for learning. Thus, viewed from a particular angle, making meaning (organizing experience, assigning it value, deriving meaningful knowledge from it) and learning are one and the same. This aligns with Dewey's (1916) framing in *Democracy and Education*, where he suggests "Since growth is the characteristic of life, education is all one with growing: it has no end beyond itself" (p. 53). From this, Figure 2.5 becomes a cycle where each step in ability over time relies on the meaning-made from a specific experience. That is, experiences lead us through time and serve to prompt learning.

Because of the limitations of three-dimensional figures on paper, Figure 2.6 keeps the *detail* dimension and replaces the *time* dimension with the *perspective* dimension. Conceptually, the figure is a freeform body with the distance from a point on the body to the center representing the detail complexity of a goal state. One's position on the body is a function of the domain of the goal or experience and the individual roles/identities and values/beliefs that were derived from the discussion of Berger and Luckmann's (1966) institutions and primary socialization. As one might intuit, the freeform figure eloquently demonstrates that, depending on the complexity of a given goal, difference in perspective could result in fundamentally different naming and framing. Just as one would be blind to the content on the backside of a piece of paper while looking at the front, so too might perception of a given goal be fundamentally flawed because of a limited vantage point from the body.



*Figure 2.6. Considering goals and experiences within *detail and perspective* dimensions*

Earlier, flexible and critical naming and framing were discussed along with abstract examples of what that could look like. One purpose for the figures presented above is to make those abstractions more tangible. Using the three-dimensional framework presented above, flexibility can be conceived of multiple ways:

- In the goal sections of Figures 2.4 and 2.5, flexibility involves thinking through multiple pathways to achieve a given goal. In some cases, there may be multiple pathways to multiple solutions to a given goal (e.g., satisfy the hunger of the individual from Figure 2.1)
- In the experience sections of Figures 2.4 and 2.5, flexibility involves shifting frames for what defines “saliency” and re-weighting the role of particular past experiences to actively undermine potential fixedness. For example, flexible framing in describing the

situation of the hungry individual may require considering a longer-term time scale than is implied by the sandwich.

- In Figure 2.6, flexibility involves considering how individual perspective changes depending on which roles/identities and/or values/beliefs are allowed to be most dominant. For example, the giver might need to see the myth inherent in the message “through hard work, anything can be achieved” in order to more flexibly perceive the cause of the individual’s hunger.

To pictorially represent criticality would require significant mapping of several individual perspectives on Figure 2.6 for a given domain (problem). Note that there would not be an even distribution around the body. Majority identities would cluster together based on how they were socialized and because of the silencing elements presented in the brief discussion of criticality related to oppression. Also, recall that the distance from any point on the body to the center represents complexity/difficulty and is ultimately different for each person. While this difference across individuals could be partly because of different ability levels, it is also caused by issues related to historical privilege and oppression (e.g., systematic marginalization, lack of access to appropriate resources). With this in mind, critical naming and framing is characterized by a rooted awareness of one’s position on the circle, humble admission that one’s perspective is limited and thus all naming and framing is somewhat incomplete, and a desire to understand a more full picture through open-minded interaction with diverse perspectives. Criticality is also represented by one’s ability and willingness to expand lenses (accommodate) when encountering dissonant experiences.

Extensions of the Framework

One of the primary goals of this paper has been to highlight the importance of meaning-making and its relation to all educational endeavors, particularly the key processes related to solving ill-structured problems. In terms of the three-dimensional framework of *detail, time, and perspective* offered, problem-solving can be visualized as the process of naming and framing from present to goal state with attention to particular pathways and progress across time towards those goals (Figure 2.5). Additionally, the diagrams used can offer particularly meaningful extensions into modeling of the problem-space itself with respect to the size and nature of the goal state itself. For example, some problems are complex because (a) difficulty changes over time (an individual's distance from the center in the detail dimension could vary with time in because of the problems dynamic nature and not just as a result of learning as shown in Figure 2.5) and (b) the problem looks different from different vantage points (the goal state in the center could be the double-sided piece of paper described earlier where modeling a problem based on only the perspective of the front-side would never lead to an appropriate solution). Considering a three dimension figure with axes of *detail, time, and perspective* one can envision a collaborative problem-solving endeavor as the collective naming, framing, and action of different people from around the freeform body and at different points of time in past, present, and future. One's ability to model the problem more complexly would be a function of the numbers of actors and diversity of perspective (conceptually, the team can “see” the problem for what it is based on an ability to effectively view it from multiple points around the body and through time and the collective picture they paint of what is “in the center.”)

Conclusions

The central argument herein has been that human processes for meaning-making play critical formative roles in the setting and solving of our most complex problems. In particular, *naming and framing* through uniquely individual *perspective* was highlighted as a governing function of the *meaning-making* process. Because of the analogy between meaning-making and problem-solving, the competencies needed to address ill-structured problems led to broader exploration of how one might cultivate a capacity for flexible and critical meaning-making. Finally, a framework for visually mapping primary dimensions of the meaning-making process was presented as a tool for guiding research and practice.

Though the dimensions proposed (*detail, time, and perspective*) are supported by selected human learning scholars and problem-solving theorists used in the development of the framework, research and conversation should be directed towards exploring if the way in which this framework was conceptually presented is related to how individuals consciously proceed through naming and framing of problems and making meaning of experiences. Because assessing complex problem-solving ability is so difficult, perhaps this framework could be useful in developing ways to assess the rigor of one's reasoning through novel and presently unsolvable situations. While this is one of the most exciting research implications of the framework, it should not be construed as these are the *only* dimensions, the *true* dimensions, or that one need be able to think in these specifically defined ways in order to be a complex problem solver and flexible, critical meaning maker.

Ideally there would be several practical teaching implications left to the reader depending on how this entire paper sits in the context of one's own field. However, one broadly applicable implication involves ways in which instructors or departments frame experiential learning activities. Often these activities require some kind of "reflection" that might include written

assignments, oral discussions, or ePortfolio creation. While the framework presented doesn't suggest any particular activity might be better or worse than another, it does offer insight in the nature of any prompting. There is often debate over how to prompt these activities with passionate advocates ranging from highly structured to intentionally unstructured. Whatever the degree of structure, this framework suggests that prompting should involve attention to *detail*, *time*, and *perspective* dimensions. One should encourage students to flexibly consider what is included or excluded from "the experience"; what identities/roles and values/beliefs are shaping their interpretations, and hypothesize why they are playing such a large role; what past experiences are similar or different, and in what ways; and how others around the freeform body of perspective might interpret the experience. Attention to these dimensions does not necessarily create a structure that prescribes student meaning-making, rather it calls attention to all the critical elements that Bruner (1990) argued shape the way in which we organize narrative.

A related implication is that the figures presented might help orient constructs of *reflection* and *reflexivity* that are sometimes conflated. Because scholars disagree about specific definitions, the intent is not so much to attach additional formal definitions, but rather to offer a way one might conceive of them relative to the framework presented above. *Reflection* generally evokes ideas of looking back on the past, analyzing ways in which one changed or grew and how that might affect future decision making (e.g., Dewey, 1910). With relation to the figures, *reflection* seems to primarily exist in the domain of Figure 2.3, by developing an awareness of the shaping effect of a particular experience, seeing it for the step in ability and time that it offered, and using it to guide continued naming and framing. *Reflexivity*, on the other hand, seems to be more concerned with the lenses through which one sees the world (e.g., Bruner, 1986). Thus, reflexivity involves questions like *why am I on the freeform body where I am?*,

who is and is not nearby, why might that be so?, what do I see others may not?, and what do I struggle to see that others see easily? (Figure 3.6).

Limitations

At least two limitations seem particularly important. First, the framework is based on interpretations of the work of many others in an attempt to synthesize across bodies of literature. As with any attempt to synthesize, nuanced meaning from the original work was lost. Significant excerpts were used where appropriate to leave as much context intact as possible though the reader is strongly encouraged to examine both original sources and any scholarly critiques of those sources. Second, reaching for simplified and broadly applicable conception of the meaning-making process is inherently incomplete and approximate work. As such, this serves as *a* framework: *a* potential conceptual framework that, while based on the writings and research of prominent scholars, remains yet to be empirically tested and refined.

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Manuscript 2:
Developing a Measure of Systems Thinking Competency

This manuscript includes intellectual contributions from Gary Kirk & David Knight (see Attributions). After collaboratively editing for submission to a journal, they will be co-authors.

Critical thinking scholar Richard Paul (1993) believed “Governmental, economic, social, and environmental problems will become increasingly complex and interdependent... The forces to be understood and controlled will be corporate, national, trans-national, cultural, religious, economic, and environmental, all intricately intertwined” (p. 13). A look across the global landscape suggests that society is indeed faced with seemingly intractable challenges (e.g., United Nations Millennium Development Goals such as Eradicate Extreme Poverty and Hunger). Because of these challenges, institutions of higher education are compelled to cultivate graduates capable of addressing complex problems from varied perspectives by collaborating across disciplinary silos and utilizing integrative and critical thinking skills. Increasingly, government agencies and the private sector are demanding such competencies and have identified interdisciplinary issues as among the most pressing for society (e.g., National Science Board 2010; U.S. Department of Education, 2006; National Academy of Engineering, 2004; National Institutes of Health, 2006; and National Research Council, 2012).

Yet, most colleges and universities are not designed to assess interdisciplinary and transdisciplinary competencies of their graduates. Although some institutions may be traditionally associated with cultural (mis)perceptions (e.g., public versus private, large research institution versus small teaching college), at the very core, each conferred degree represents a particular disciplinary competence through successful completion of an accredited curriculum. Universal competencies across disciplines (e.g., teamwork, effective communication skills) are

laudable and necessary but are not enough on their own to prepare graduates to tackle the most pressing societal challenges. The driving question then becomes, how do we cultivate the next generation of leaders for a world of problems we currently cannot solve, and how would we even begin to know if some graduates were “more prepared” than others to face these challenges? It is this two-part question that motivates us to identify and measure “systems thinking,” a competency of potential benefit to all graduates as emerging leaders in their fields.

The purpose of this study is to introduce a scenario-based tool designed to serve as a measure of systems thinking competency to be used across disciplines in a higher education setting. This paper establishes the conceptual framework and offers initial steps towards the validation of the systems thinking assessment tool through a pilot study with undergraduate and graduate students. Specifically, qualitative analysis of open-ended responses gathered from students representing different class years and disciplines are used to better understand the content of student responses and the degree to which the scenario elicits data on a subset of specific competencies from the systems thinking framework.

Literature Review and Conceptual Framework

“Systems thinking” has many definitions. Senge et al. (1994), for example, defined it as “a way of thinking about, and a language for describing and understanding, the forces and interrelationships that shape the behavior of systems” (p. 6). It may be applied to the physical sciences and engineering to reach a finite solution and to social or cultural problems to enhance understanding of sub-system interdependence (Checkland, 1981). As problems continue to grow in complexity, however, the lines between the physical and social sciences have blurred, and social, economic, political, environmental, and community contexts must be taken into consideration when developing solutions.

The most challenging problems that face professionals today contain combinations of the intertwined complexities described above and are classified in the literature as *dilemmas* or *wicked problems*. Jonassen (2000) asserts “dilemmas are the most ill-structured and unpredictable type [of problem] because often there is no solution that is satisfying or acceptable to most people, and there are compromises implicit in every solution” (p.80). *Wicked problems* are often characterized by (1) the unique nature of each problem, even from others that seem very similar, (2) that any attempt to address the problem in turn affects the how the problem is fundamentally framed, and (3) that causality is obscured, particularly by the temporal distance between an intervention and any direct effects of the intervention (Rittel & Webber, 1973). We believe these situations call for a metacognitive strategy—a flexible way of framing, reasoning, and acting within multiple dimensions, which we conceptualize as “systems thinking.” In this paradigm, distinguishing between an expert’s systems thinking and a novice’s systems thinking cannot adequately be assessed by solely focusing on right or wrong solutions. Instead, that assessment might better be determined through analysis of a student’s fluency in reasoning through a posed *dilemma* or *wicked problem*.

We conceptualize this fluency by criteria emerging from our review of the systems-thinking literature, including the critical elements of *problem*, *time*, *social* dimensions as well as the associated interrelationships between those dimensions (see Figure 3.1). This framework was developed from intersections in select problem-solving literature from engineering education, critical thinking from a philosophical perspective, leadership and community development theory, organizational theory, and public policy theory. In doing so, we assume that each field fundamentally wrestles with problems that are laden with similar complexities, and common elements from each field might provide valuable insight into a more

interdisciplinary framing of systems-thinking competency. To justify this theoretical framework, we include the following excerpts from the literature: *systems-thinking* from the systems-thinking and program evaluation communities, an established framework for *critical thinking*, and the notion of *frame reflection* as a process for navigating policy conflict.

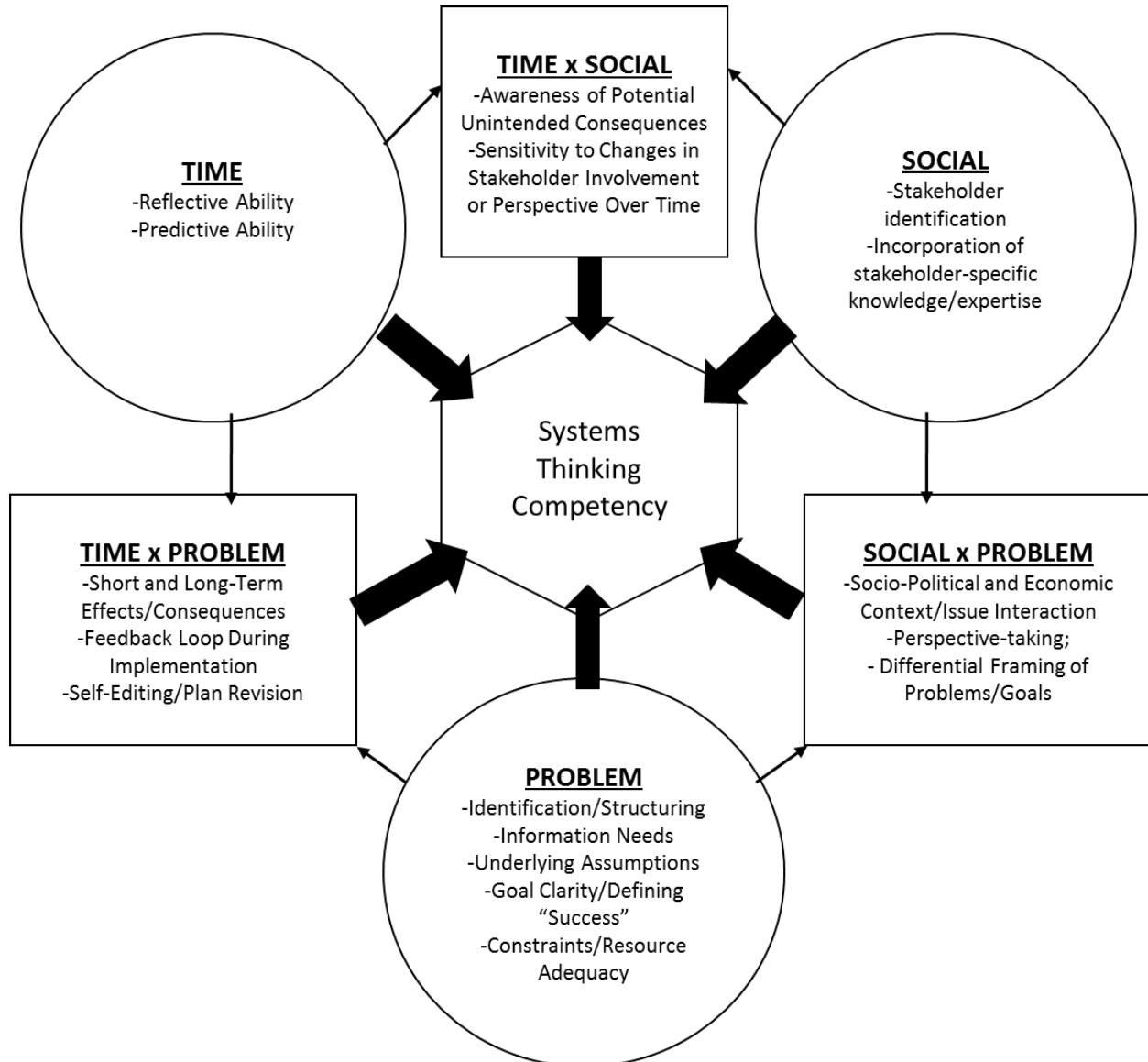


Figure 3.1. Conceptual framework based on the systems-thinking literature from multiple disciplines.

In considering systems-thinking as a metacognitive strategy, Hung (2008) suggests that it is necessary to train for this skill explicitly because individuals do not automatically consider interrelationships and connectedness. Systems-thinking scholars Midgely and Richardson (2007) forward the notion of *boundaries*, which are intentional or unintentional frames through which we try to view a system of connections that are within our conceptual limits. This boundary-forming process serves as a foundation for systems-thinking—individuals work reflexively and adaptively within their limits rather than modeling every complexity with precision. Such a concept undergirds *systemic intervention*: “purposeful action by an agent to create change in relation to reflection upon boundaries” (2007, p. 172). In Midgley and Richardson’s framework, this process entails critically reflecting on boundaries, selecting or merging potential methods, and then acting intentionally. Thus, flexibly defining systems, taking perspectives, recognizing distinctions, and reflecting throughout the process describe the intentional, conscious awareness, and control of a metacognitive strategy. In the sections that follow we discuss each dimension of the framework and describe the complexities that arise when these dimensions intersect. When specific constructs to be discussed later are summarized, a few example references are given for further study.

Problem

The problem dimension has been studied extensively by scholars in the problem-solving and critical-thinking communities and is largely concerned with a process of naming and framing. A problem is commonly understood as a difference between the current reality and a desired goal (Jonassen, 2000). Thus, critical problem solving activities include defining the current and goal states, assessing one’s resources (e.g., cognitive, physical), identifying

additional resource needs (e.g., information, financial), identifying constraints, and exploring underlying assumptions that underpin one's thoughts and actions. Problem solving involves cyclical interplay between cognition (the mental modeling steps above) and action (trying a potential solution and evaluating its efficacy). Critical thinking scholar and philosopher Richard Paul's (1993) framework serves as a basic structure through which to reason systematically and critically. His framework is not a recipe to problem solving, but rather a fundamental structure that underlies, implicitly or explicitly, any critical thinking or problem solving endeavor.

According to Paul (1993), reasoning should derive from a well-understood, long-term purpose that also provides the foundation for a clear question or problem. Frame of reference remains important throughout the process because the thinker ultimately decides which empirical and conceptual elements to consider. Additionally, Paul points to assumptions as the "starting points of reasoning: all reasoning must begin somewhere, must take some things for granted" (p. 209).

Building on this and other works, in our framework we include the following elements within the *problem* dimension: identification/structuring (e.g., Bransford, Sherwood, Vye, & Rieser, 1986; Simon, 1973), information needs (e.g., Voss, 1988; Wood, 1983), underlying assumptions (e.g., Paul, 1993), goal clarity/defining success (e.g., Wood, 1983), and constraints/resource adequacy (e.g., Jonassen, 1997; Newell & Simon 1972).

Social

The social dimension is fundamentally concerned with the involvement of stakeholder and societal perceptions – those (e.g., individuals, organizations, cultural institutions) who have influence over or are affected by a problem and any attempted solution. Simple instances of a social aspect of problem solving include when a given problem requires the involvement of multiple parties with different expertise (e.g., architects and engineers in building design).

Schön and Rein (1994) investigated intractable policy disputes to identify strategies that might foster positive change. Central to their exploration is the notion of *frames*, defined as “underlying structures of belief, perception, and appreciation” that undergird political positions. In their framework, policy becomes stuck because different parties have different frames, often “exempt from conscious attention or reasoning,” that are in conflict and irreconcilable through facts or argument (1994, p. 23). These frames script the problem-setting process for each party by telling different stories through unique lenses; thus, disagreement tends to be about defining the problem as opposed to generating solutions. Key elements of their framework include an iterative process, recognition of limitations and constraints, interdependent variables, and trust to sustain cooperative inquiry. A final element from Schön and Rein’s work is the notion of reflection-in-action. Building on this and other works, in our framework we include the following elements within the *social* dimension: stakeholder identification (e.g., Jonassen, 1997), and incorporation of stakeholder-specific needs, knowledge, or expertise (e.g., Kahane, 2010). Problems become significantly more complex when the *problem* and *social* dimensions are intertwined and different stakeholders have distinct and often conflicting framings of the problem itself (e.g., local citizens of a neighborhood near a proposed building site and the site’s development team).

Time

The time dimension refers to the past, present, and future of given problems, stakeholders, and attempted solutions. In a simple framing, reflective and predictive abilities are the consideration of past and potential futures in one’s current problem solving activities. As Paul’s (1993) framework suggests, critical thinkers must make *inferences*, with the researcher becoming the instrument of analysis who makes connections and logical jumps based on

empirical and conceptual material at hand. Moreover, the critical thinker must consider *Implications and Consequences*, which may not be concluded from the reasoning process and often may be in the blind spot of the thinker. It is predicated on the notion that “all reasoning comes to an end, yet could have been taken further” (p. 210). Thus, in our framework we include the following elements within the *time* dimension: reflective ability (e.g., Schon, 1994) and predictive ability (e.g. Simon 1986; Schon & Rein 1994).

Time is also intertwined with the other two dimensions. For example, complexity in *time* and *problem* spaces refers to short and long-term impacts of any potential solution (e.g., early attempts to repair the Deepwater Horizon oil spill resulted in additional problems that had to be addressed later) and when the definition of the problem itself might vary with time (e.g., flooding could be an infrastructure problem today but could be a public health, disease issue tomorrow). Or, consider the interrelation of *time* and *social* dimensions, as stakeholder involvement or perspective varies over time (e.g., changes in elected leadership influences higher education funding priorities) and when unintended consequences arise in the future because of current blind spots of the problem solver (e.g., using propane to dry out an abundant harvest in the northeast in 2013 resulted in a propane shortage during the abnormally cold winter season).

These dimensions offer lenses and angles through which one might consider various complexities of *dilemmas* and *wicked problems*. While the lines between each dimension are somewhat blurred, our framework fundamentally positions systems thinking as a metacognitive strategy through which one might flexibly and iteratively consider a problem through these different lenses. Some problems may simplify (e.g., some problems may not be framed differently across a social dimension), but ultimately, the expert systems thinker can reason through these various dimensions with both rigor and ease.

Methodology

Preliminary Work on Measure Development

We used this theoretical framework (Figure 3.1) to craft a problem scenario designed to draw out reasoning processes of college student respondents around a subset of constructs from the framework that seemed measurable via single administration (e.g., reflective ability in problem solving is difficult to measure in a scenario administered at a single instance of time and thus is not included). The problem scenario is framed in a community setting, a fictitious town of Abeesee, that seeks to be accessible to diverse populations of undergraduate and graduate students and to reduce any advantages of domain-specific knowledge in the reasoning process. Though this particular tool and setting is novel, it follows similar strategies as from other ill-structured problem solving assessment tools such as in Shin, Jonassen, and McGee (2003). For context, the initial vignette describing the situation in Abeesee is given below.

The Village of Abeesee has about 50,000 people. Its harsh winters and remote location make heating a living space very expensive. The rising price of fossil fuels has been reflected in the heating expenses of Abeesee residents. In fact, many residents are unable to afford heat for the entire winter (5 months). A University of Abeesee study shows that 38% of village residents have gone without heat for at least 30 winter days in the last 24 months. Last year, 27 Abeesee deaths were attributed to unheated homes. Most died from hypothermia/exposure (21), and the remainder died in fires or from carbon monoxide poisoning that resulted from improper use of alternative heat sources (e.g., burning trash in an unventilated space).

The measure is structured in three distinct phases: *processing, response, and critique*. The *processing* phase collects individual responses about the way in which respondents frame the

problem in response to the vignette, what sources of additional information they would require before designing a solution, potential measures for success, and groups they would involve in any decision making. The *response* phase specifically asks for an outlined draft plan for addressing the situation as well as perceived challenges in implementing that plan. In the *critique* phase, respondents are asked to analyze and critique a sample plan (i.e., an “attempted solution”) via prompts that would lend insight into one’s ability to perceive the goals of others and to brainstorm potential unintended consequences and adequacy of resources. The scenario and associated phases and prompting questions can be found in Appendix A.

The intent of this study was to pilot this scenario with undergraduate and graduate students representing diverse disciplines and expertise in order to better understand the nature of student responses and potential alignment with the intended constructs and competencies within the framework. As part of an overarching goal of developing and validating a scenario-based tool to measure systems thinking competency, this initial study is framed around the following research questions, to be explored through qualitative analysis of written responses to scenario prompts:

1. How do respondents frame and identify salient features of the ill-structured *problem* in the Abeesee scenario?
2. How do respondents attend to *social* aspects of complexity as they reason through the ill-structured problem in the Abeesee scenario?
3. How do respondents attend to *time*-related aspects of complexity as they reason through the ill-structured problem in the Abeesee scenario?

During data analysis to investigate these research questions primarily, a prefigured coding approach was used to assess the degree to which specific constructs from the systems thinking

framework of Figure 3.1 are elicited by the scenario. To clarify the relationship between the systems thinking competency framework, the scenario tool, and this qualitative study, Table 1 below describes the alignment of (a) the specific expected constructs that could be assessed by the scenario, (b) the phase(s) of participant response during which the constructs might be addressed, and (c) the associated research questions.

Table 3.1

Alignment between Systems Thinking Competency Constructs, the Scenario Tool, and the Research Questions

<u>Construct</u>	<u>Scenario Phase</u>	<u>Research Question</u>
Problem Identification	Processing	RQ 1: Problem
Information Needs	Processing	RQ 1: Problem
Stakeholder Awareness	Processing	RQ 2: Social
Goals and Measures of Success	Response, Critique	RQ 1: Problem, RQ 2: Social, RQ 3: Time
Unintended Consequences	Critique	RQ 1: Problem, RQ 2: Social, RQ 3: Time
Implementation Challenges	Response, Critique	RQ 1: Problem, RQ 2: Social, RQ 3: Time

Data Collection

To provide adequate time for robust, descriptive responses, administration of the scenario tool required approximately 30-45 minutes. As part of a stratified purposeful sampling, this pilot study embedded the scenario as an in-class activity for select undergraduate and graduate courses in the field of Leadership Studies (i.e., specific sections of a 1000, 3000, and 5000 level course). This sample was chosen because enrollment in these courses involves a diversity of disciplines and the stratified academic levels provide data across levels that could be targeted for future use of the scenario within higher education. Individual responses were collected via online electronic version of the scenario with 27 total respondents that were included in this study (10 from 1000 level, 10 from 3000 level, and 7 from 5000 level). The activity took place

at the end of the semester and individual instructors used the activity as a way to discuss themes of the course throughout the semester. As a form of member checking, respondents can edit any response they deem necessary before final submission in each phase.

Analysis

The full text from all prompts in processing, response, and critique phases was used as narrative data for both inductive and deductive analysis within and across respondents. Analysis began with prefigured coding strategies based on the specific constructs described in Table 3.1 (i.e., problem identification, information needs, stakeholder awareness, goals and measures of success, unintended consequences, and implementation challenges). Analysis continued with a subsequent secondary level of coding based on an open-ended search for emergent sub-codes within a specific prefigured code (Creswell, 2013; Rossman & Rallis, 2013). Internal validity of the measure was explored based on the degree to which the tool elicited the data within the expected constructs and the degree to which variation could be seen in responses. Though coding was done by the lead author of the study, peer debriefing through periodic conversations with other authors and structured researcher memos with each response were used to mitigate effects of researcher biases while vetting the themes emerging from the data.

Results

In an effort to better understand this tool and strive towards a measure of systems thinking competency, results are discussed primarily through the prefigured codes (constructs from Table 3.1) with specific attention to the related subcodes that emerged within each construct and allowed for consideration of how specific responses varied across respondents.

Problem Identification

The intentionally vague Abeesee scenario leaves the task of identification and structuring of the problem to the respondent. An assortment of data exists to prompt possible dimensions of the problem with no explicit intent that one piece of given information is more important than another (e.g., 38% of village residents have gone without heat for at least 30 winter days in the last 24 months). In considering the diversity of responses received, subcodes emerged related to the *scope* of the problem identification and the overall *alignment* with other key constructs.

Scope. As respondents described perceptions of the problems and/or issues facing Abeesee, answers were expectedly diverse (e.g., economic with the affordability of heat or average income, environmental with a need to develop a portfolio of alternative energy sources). Yet, even across these different answers, responses clustered between those that focused solely on a specific dimension (e.g., economic or environment) in contrast to those including the intersection of multiple dimensions (e.g., economic and environmental).

Alignment. Another emergent subcode involved the degree to which the problem(s) as identified by the respondent in the first prompt are featured throughout later responses. The degree of alignment was subjective, ranging from minimal, involving a link between the identified problem and the subsequent plan, to more significantly aligned with several other constructs (e.g., information needs). Although, generally, alignment might be considered better than misalignment, in this situation judging that difference is not always as clear and could be attributable to instrument issues rather than individual quality of response. For example, if a response identifies heating costs as the main problem but develops a plan focused on creating additional jobs in Abeesee, misalignment between the two could be an indicator of poor strategies for the problem solver or it could be that the respondent implicitly identifies both aspects as connected as an overarching economic issue but does not explicitly state this link. In

Table 3.2 below, excerpts from responses are featured to demonstrate both *scope* and *alignment* features of problem identification.

Table 3.2		
<i>Excerpts Demonstrating Scope and Alignment of Problem Identification</i>		
<u>ID</u>	<u>Characterization</u>	<u>Excerpts</u>
#12	singular in scope; misaligned	“cost for heating is expensive and not affordable” yet the primary focus of the plan is not on cost, “1) educate the people on proper techniques on what to burn and what not to;... 4) offer a shelter for the later parts of the winter...;”
#21	multiple in scope; misaligned	“the problem lies in the struggle between lack of economic resources of the Abeesee and the rising cost of the fossil fuels” yet the first steps of the proposed plan are “1) buy insulation; 2) put insulation in the homes of Abeesee;”
#20	singular in scope; well-aligned	“with the high price of fossil fuels, they may need to find an alternative resource or method to provide proper, safe heating” and then seeks to “develop an improved house design to optimize heating... incorporate alternative fuel/energy”
#4	multiple in scope; well-aligned	“...appears to be a health-related problem due to conditions in the region, particularly with access to physical resources associated with producing heat the problem... (and) residents’ ability to purchase fossil fuels” and then asks questions about alternate heat sources, education for residents about safety, dispersion of economic wealth, and identifies appropriate stakeholders
<p><i>Note.</i> Text above within quotation marks indicates specific quotes from a written response. Text not in quotation marks are transitions from the author to clarify rationale for a given characterization or to transition between quotes.</p>		

Information Needs

The information needs construct is primarily understood through a specific prompt where respondents brainstorm what additional context would be required to begin addressing the issues in Abeesee. *Alignment* emerged again and was the most meaningful subcode allowing for distinguishing between responses with respect to information needs. Similar to what was discussed in problem identification, alignment ranged from misaligned to well-aligned depending on how thoroughly the information needs response was informed by and carried

through into other constructs (e.g., problem identification). Table 3.3 below shows excerpts demonstrating alignment related to information needs.

Table 3.3		
<i>Excerpts Demonstrating Alignment of Information Needs</i>		
<u>ID</u>	<u>Characterization</u>	<u>Excerpts</u>
#7	misaligned	<u>Problem ID:</u> “the intensity of the cold; they have few natural resources; do not have workers enough to fill their need for heating;” <u>Information Needs:</u> “number of schools, health centers, the nearest airport, the nearest big city or capital”
#1	well-aligned	<u>Problem ID:</u> “...relates to their access to natural resources which are used to heat homes” <u>Information Needs:</u> “Where the nearest biggest city is,... cost for Abeesee to invest in geothermal, solar, or other forms of natural resources? Have they looked at tapping into other resources?”

Stakeholder Awareness

Stakeholder awareness as a construct is concerned with the ability to identify and include relevant stakeholders and in this scenario was primarily explored through a specific prompt to identify stakeholders while also searching for other places throughout a response where stakeholders may be explicitly or implicitly included. Though there was some interpretation difference with the stakeholder prompt leading a small number of respondents to describe qualities of stakeholders rather than entities or individuals, the lists themselves were surprisingly similar. Major institutions (e.g., government, schools, charities, university of Abeesee) showed up frequently, as did specific professional roles (e.g., scientists, entrepreneurs, engineers, politicians), and the catchall of “the people” or “the community.” The emergent subcode allowing for separating responses involved the manner and degree of *integration* of stakeholders throughout different prompts in the response phase. Several responses showed no integration at all while those that did directly incorporate stakeholders into their overall response did so either

as part of targeted consulting or as part of a coalition building effort. Examples of these two categories can be found in Table 4 below.

Table 3.4		
<i>Excerpts Demonstrating Degree of Integration of Stakeholder Awareness</i>		
<u>ID</u>	<u>Characterization</u>	<u>Excerpts</u>
#20 Consulting		<u>Stakeholders</u> : “... people knowledgeable about proper insulation, heating, and alternative resources...” <u>Process</u> : “With the input of professionals of different areas... discuss different possibilities and options. With help of the architect, I would hope to develop an improved house design to optimize heating.”
#4 Coalition-building		<u>Stakeholders</u> : “opinion leaders, groups that have established educational programs in the area, and those that control distributions of the fossil fuels...” <u>Process</u> : “... conduct interviews with key representative of each stakeholder group... bring the groups together... work to empower each group to individually do what they could to address the issue.”

Goals and Measures of Success

Exploring the goals and measures of success construct relied heavily on the plan-related prompts in the response phase and the evaluation-related prompts of the critique phase. Data from these prompts provided a portrait for each respondent that varied greatly in terms of the *scope* and *measurability* of the identified goals as well as the overall *alignment* with key elements of problem identification and the proposed plan.

Scope. One of the primary emergent subcodes involved the identification of short-term and/or long-term goals. In responses that addressed this time-related dimension, some focused only on either short-term or long-term while other plans attempted to incorporate elements that focused on both.

Measurability. Another separation was noted in the feasibility of measuring or tracking progress towards the stated goals. No real degrees were noted here, responses either identified potential metrics or did not.

Alignment. Goals and measures of success represented a final critical piece in the overall alignment of a particular response. As with problem identification and information needs, there are varying degrees of alignment. Table 3.5 below provides excerpts as examples of scope, measurability, and alignment features of goals and measures of success.

<i>Excerpts Demonstrating Scope, Measurability, and Alignment of Goals and Measures of Success</i>		
<u>ID</u>	<u>Characterization</u>	<u>Excerpts</u>
#5	Scope not clear Not measurable Misaligned	<u>Problem ID:</u> “it is extremely cold and quite expensive to heat” <u>Plan:</u> “harvest the power an (sic) knowledge within Abeesee” <u>Goals:</u> “it would accomplish creating an open forum to express concerns and discuss possible solutions. The plan would allow Abeesee to decide what is needed...”
#3	Scope not clear Measurable Well-aligned	<u>Problem ID:</u> Primarily issue of lack of education causing deaths <u>Goals:</u> “Educating constituents on how they can safely heat their home and decreased number of winter related deaths” Specific target numbers of educational sessions given in plan.
#10	Short and long-term Measurable Well-aligned	<u>Problem ID:</u> “main issue is price of heating... harsh climate” <u>Plan:</u> “lobby energy company to lower prices... use money to build emergency heated shelter... consult on housing and how to make houses safe to use alternate heat sources, and create alternate ways to supply heat to residents for lower cost” <u>Goals:</u> “less heat/cold related deaths; less days without heat in winter conditions; more people with some heat through winter”

Unintended Consequences

This construct was primarily analyzed in the section where respondents were asked to critique both their own plan (prompt: “What challenges do you see to implementing your plan? What are the limitations of your approach?”) as well as the sample plan provided (prompt: “Please describe any unintended consequences that you think might result from this plan”). The

primary emergent subcodes in interpreting responses involve both the *reflexivity* and the *complexity* of the unintended consequences described.

Reflexivity. The prompt involving critique of the sample plan required every response to directly address unintended consequences. However, because the prompt in critiquing one's own plan contained two related questions but only one response block, not every response with respect to one's own plan included identification of unintended consequences. Thus, a clear distinction within the construct was seen in responses that also demonstrated flexibility in being self-critical and identified what could otherwise be major blind spots of an attempted solution.

Complexity. Another distinguishing feature noted was the degree to which a response explored possible limitations and unintended consequences. In some cases, answers remained relatively simple and focused on important but surface analysis while other responses displayed a flexible examination of interrelated complexities within problem, social, and time dimensions. Excerpts demonstrating both *reflexivity* and *complexity* of the unintended consequences construct are shown in Table 3.6 below.

Table 3.6 <i>Excerpts Demonstrating Reflexivity and Complexity of Unintended Consequences</i>		
<u>ID</u>	<u>Characterization</u>	<u>Excerpts</u>
#5	Not reflexive Simple	<u>Own plan</u> : “you need people to show up and play a role in the process” <u>Sample Plan</u> : “division among the community between the haves and the have nots”
#11	Not Reflexive Complex	<u>Own plan</u> : “the people of Abeesee would still have to go through several winters with no heating until new products were developed an everyone gained access to it” <u>Sample Plan</u> : “people might not be sure on how to ‘make improvements’ to their home and end up investing on the wrong thing or changing something else generating an entirely new issue”
#13	Reflexive Complex	<u>Own plan</u> : “... the plan really only benefits the people who need heat... so people who already have heat may feel left out or not important to the community since it is not helping them.” Another challenge could be that people will accept the help at the beginning but will not be able to keep themselves going when the help runs out.” <u>Sample Plan</u> : “people who do not get the money will feel they are not important, or people who do not need the money will fake that they need the money and the review committee will give it to them.”

Implementation Challenges

As a construct, implementation challenges refers to a respondent's ability to identify expected barriers to their crafted response to the Abeesee scenario. The primary distinguishing feature between individual responses was the described *complexity* inherent in the response. As with the unintended consequences construct, some answers remained focused on important but surface analysis while other responses displayed a flexible examination of interrelated complexities within problem, social, and time dimensions. Excerpts demonstrating different complexity of responses can be seen in Table 3.7 below.

Table 3.7 <i>Excerpts Demonstrating Complexity of Implementation Challenges</i>		
<u>ID</u>	<u>Characterization</u>	<u>Excerpts</u>
#10	Simple	Relevant yet surface level considerations: “\$50,000 might not be enough money. Convincing heating companies to lower prices probably will get shot down. People may abuse the emergency shelter”
#1	Complex	Demonstrates an ability to reason through ways social and time dimensions affect problem formulation and attempted solutions: “Stakeholders may not be willing to come to an agreement with each other. Their personal problems with one another could inhibit their goal of the overall well-being of the situation. Business may not negotiate with Abeesee stakeholders and force them to pay full price. This plan does not have a back-up solution in case any of the procedures were to fail.”

Note. Text above within quotation marks indicates specific quotes from a written response. Text not in quotation marks are transitions from the author to clarify rationale for a given characterization or to transition between quotes.

Instrument Feedback

The final question asked respondents to share any feedback on the tool itself with particular attention to times when prompts were unclear or confusing. Most respondents either chose not to provide feedback on this question or indicated no significant issues. Four responses identified different aspects of the vagueness of the whole scenario. Of those comments, one individual focused on specific contextual information they felt was needed for Abeesee (aligned with Information Needs questions), another individual felt there was no indication of the expected level of depth to each response throughout, a third was initially unclear whether problem definition prompts were requesting restatement or interpretation, and the fourth individual affirmed that scenarios and tools like this inherently have some degree of ambiguity and confusion.

Discussion

The primary purpose of this study was to establish a conceptual framework for systems thinking competency and to introduce a scenario-based tool designed to measure specific

constructs from within the broader framework. The results stem from a qualitative analysis of 27 student responses and lead to two key findings: (a) the tool elicited meaningful data on each of the constructs for which it was designed; (b) emergent within each construct were possible means of characterizing the data that allow for study of variation across respondents. Together, these findings offer a significant first step in a multi-step process of developing and validating this tool as a measure of systems thinking competency.

In considering the first claim, it is important to recall that the scenario was written for a specific subset of the constructs associated with systems thinking competency that seemed measurable via single administration (e.g., reflective ability in problem solving is difficult to measure in a scenario administered at a single instance of time and thus is not included). The full conceptual framework shown in Figure 3.1 contained dimensions (i.e., primary domains associated with systems thinking competency) as well as constructs (i.e., specific potentially measurable qualities or characteristics of thinking associated with a relevant dimension). Analysis was designed paralleling this framework, namely that the overarching lens was that of the three research questions (i.e., related to problem, social, time) to be explored using the constructs intentionally embedded within the scenario as prefigured codes for the first level of analysis. For reference, these specific constructs that were embedded in design and observed in results are represented in bold text within Figure 3.2, a figure that is otherwise a reproduction of Figure 3.1. While the tool does not provide information on every potential construct from the systems thinking framework, the scenario and prompts elicited enough information to allow for meaningful exploration of responses within each construct that was intentionally embedded within the scenario. That is, the results indicated that the tool is an effective means of generating data relevant to specific constructs of the systems thinking competency.

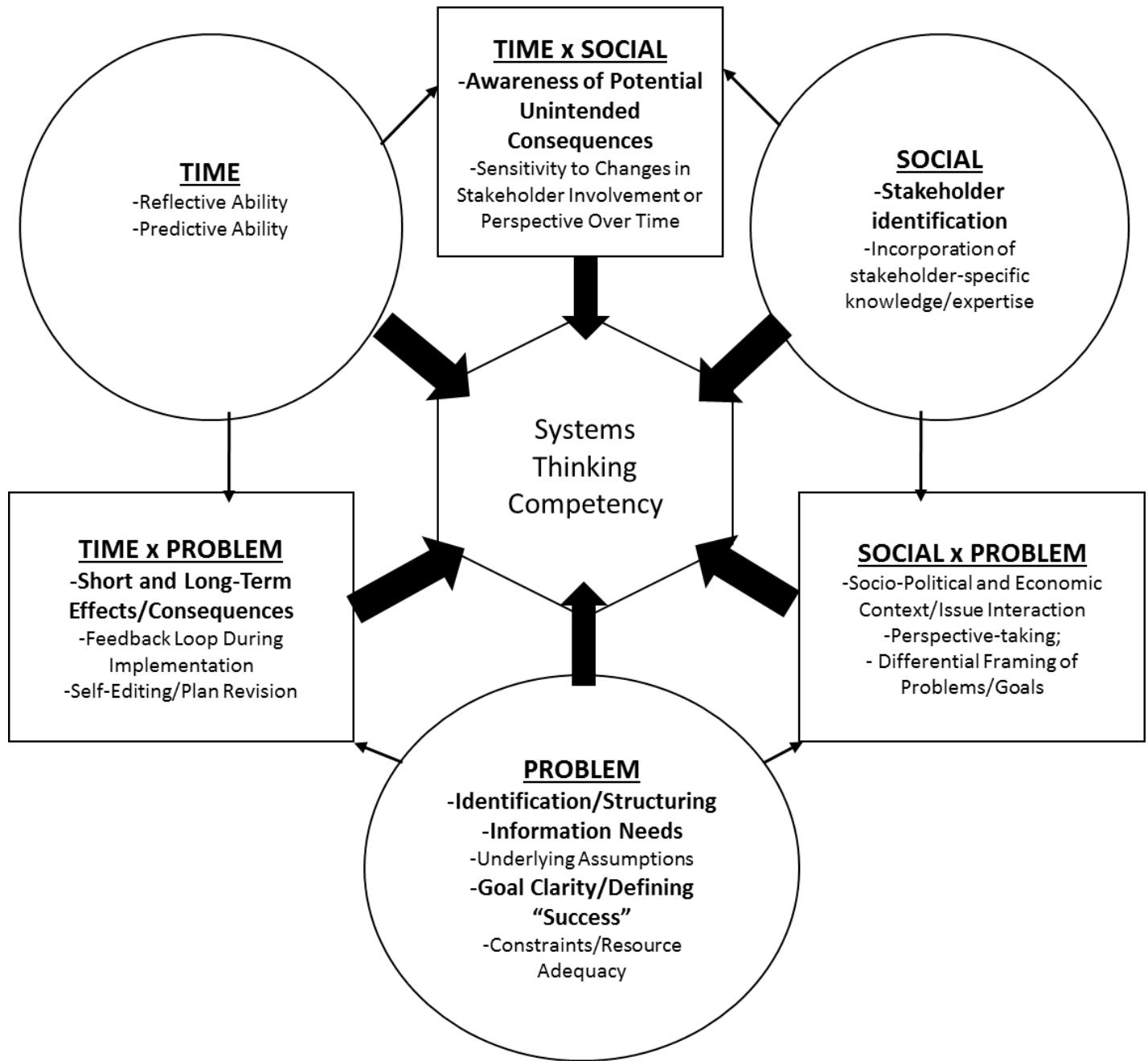


Figure 3.2. Conceptual framework of systems thinking competency with specific constructs

embedded in design and observed in results represented in larger and bolded text.

While the previous conclusion is encouraging, it is primarily a confirmatory step that claims *the tool elicited meaningful data on each of the constructs for which it was designed*. What is most significant from these results stems from the identification of subcodes within each

construct (prefigured code). That is, *emergent within each construct were possible means of characterizing the data that allow for study of variation across respondents*. This could be particularly useful in the construction of a scoring rubric to systematically explore the overall quality of responses. Developing a scoring rubric is particularly critical since there is no correct answer based on the content of the responses and thus means of distinguishing between responses with respect to quality within a construct is desirable (e.g., it is not about whether a respondent names specific “correct” economic or education related goals, but rather whether the goals incorporate short and long term aims and the degree to which the goals are measurable and aligned with other constructs). Each emergent sub-codes within each prefigured code and the means of characterizing different responses with respect to each sub-code will serve as a foundational framework for a scoring rubric to be fully developed in future steps of validating this tool. Table 3.8 below summarizes the appropriate research question considered, the prefigured code (construct) associated with the research question(s), all of the identified sub-codes within each prefigured code (construct), and the specific means of characterizing different responses within a given sub-code.

Table 3.8

Summary of Research Questions, Prefigured Codes (Constructs), Associated Sub-codes that Emerged within Prefigured Codes, and the Associated Characterization of Sub-codes

<u>Research Question:</u>	<u>Prefigured code (Construct)</u>	<u>Sub-codes</u>	<u>Characterization</u>
RQ 1: Problem	Problem Identification	Scope Alignment	singular, multiple misaligned, well-aligned
RQ 1: Problem	Information Needs	Alignment	misaligned, well-aligned
RQ 2: Social	Stakeholder Awareness	Integration	consulting, coalition-building
RQ 1: Problem RQ 2: Social RQ 3: Time	Goals and Measures of Success	Scope Measurability Alignment	unclear, short and long-term not measurable, measurable misaligned, well-aligned
RQ 1: Problem RQ 2: Social RQ 3: Time	Unintended Consequences	Reflexivity Complexity	not reflexive, reflexive simple, complex
RQ 1: Problem RQ 2: Social RQ 3: Time	Implementation Challenges	Complexity	simple, complex

Additionally, feedback on the instrument itself was informative and prompted some suggested improvements, but no response identified items that are a major cause of concern for ongoing efforts to refine and validate this tool. Although these results are meaningful and indicate progress, the method for collecting feedback about the tool itself did not yield the depth of data intended and future studies should devise alternative means of soliciting instrument feedback (e.g., focus groups with participants specifically targeting instrument interpretation).

Overall, the two key findings—that the tool generated the data it was intended to generate and that responses varied across emergent subcodes within each construct—together represent a significant and meaningful first step of many that are needed to fully develop a valid measure of systems thinking competency. To further contextualize these findings, relevant limitations and a future work plan that seeks to address these limitations are discussed in the section that follows and serve as a roadmap for instrument validation.

Limitations

Throughout the development of the instrument and the interpretation of the results, several critical assumptions were made that warrant robust discussion. The first concerns the very notion of *measuring thinking* and is one that psychologists and philosophers have long debated. The second is that of significant potential for *instrument bias* stemming from written responses to lengthy prompts as well as a scenario that may privilege some knowledge more than others. The third to be discussed is that of the overall *limited scope* of the study and how it affects interpretations and future work.

Measuring thinking. From a rigorously positivist perspective, the notion of measuring thinking, much like the measurement of learning, is limited at best if not impossible. A common means is to evaluate performance on a given task and use that performance as a proxy for the construct (e.g., the classic “candle problem” exploring functional fixedness and problem solving ability from Duncker, 1945). Alternately, the “think-aloud” approach offers another method where individuals verbalize their thought process during and/or in reflection upon some specific cognitive task (e.g., Ericsson & Simon, 1980; Kuusela & Paul, 2000). In effect, the approach of the present study is a hybrid of these two approaches where a respondent’s reasoning process is captured through written responses to prompts. However, the current tool as implemented in this study lacks the objective scoring that typically accompanies many cognitive tasks, and the written responses do not gather the depth of data one could get from an interview during and after the task. Yet, despite these shortcomings, the purpose of this study is to lay groundwork for a validated tool that would include the scoring rubric and a future step in validation could include think-aloud studies to pair with the written responses.

Instrument bias. Despite attempts to make the Abeesee scenario as accessible as possible to different populations, it is impossible to completely eliminate instrument bias.

Because the tool involves a fictitious scenario with relevant statistics, it assumes that respondents will have sufficient context to interpret key elements of the vignette. Issues of heating were chosen because they are common enough to be deemed accessible by most undergraduates at institutions of higher education in the United States. However, some respondents might be more familiar with heating related issues and thus respond differently than others in ways that are not necessarily related to systems thinking competency. Although content knowledge might seemingly privilege some disciplines or specific prior experiences over others, because the tool evaluates systems thinking with respect to particular dimensions instead of seeking a particular “correct answer,” this effect is minimized.

A final critical contributor to instrument bias involves written responses to the intentionally vague or seemingly missing prompts throughout the tool. Usually, clarity, conciseness, and limiting effects of unrelated skills (e.g., writing ability) are all hallmarks of a stellar assessment tool (Miller, Linn, & Gronlund, 2009). However, because a key aspect of systems thinking competency involves how the respondent frames and addresses a given ill-structured problem, there must be a balance between framing enough for instrument clarity and fairness without over-structuring such that respondents are led to complexity in their responses that would otherwise not be present (Singleton & Stratis, 2010). Considering this, it is critical to continually question the degree to which the response given to any particular prompt is an accurate reflection of the respondent’s systems thinking ability and in what ways instrument bias might be obscuring that result.

Limited scope. This study was designed primarily as a first step towards validating the tool as a measure of systems thinking competency. Respondents were chosen from among populations of specific LDRS 1000, 3000, and 5000 level courses in order to explore a range of

grade levels all under the assumption that it would provide enough variation in the data to robustly explore how individual responses map onto the systems thinking framework. Beyond knowing the course a respondent was enrolled in, no further demographics were collected. After the tool has been validated and a scoring rubric developed, future studies should collect data on student backgrounds and educational experiences to better understand where variations in systems thinking ability occur.

Future Work

Based on the results described above, this current work suggests that the scenario-based tool does collect the information it was designed to collect in addition to offering potential means of discriminating between students responses and thus the project to validate the tool should proceed. Based on the findings from this pilot study, and in consideration of the noted limitations, future efforts should proceed in four specific ways:

- (1) Vet the instrument with faculty and administrators with expertise in systems thinking through qualitative interviews exploring strengths and shortcomings of the tool as it relates to how each individual scholar conceptualizes and assesses systems thinking competency.
- (2) Develop a scoring rubric based on data from this study and pilot the rubric using scholars from step (1) in a future study that also collects demographic and discipline information from respondents to explore variations based on different populations. Initial drafting of the rubric should begin with the major constructs of this study as critical categories of evaluation with distinctions between beginner and advanced responses deriving from the subcodes that emerged from analysis of each construct (e.g., competency within the construct of *problem*

identification should be derived from both the *scope* and *alignment* of the relevant responses)

- (3) In the study from step (2), include a small sampling of think-aloud interviews to supplement written responses and conduct several focus groups to gather more feedback about the instrument than afforded by the free response section in this current study.
- (4) In parallel with the study described in steps (2) and (3), embed survey-based scales that might be expected to correlate with systems thinking competency as part of the effort to establish concurrent validity (e.g., success in solving ill-structured problems has been shown to be related to epistemological beliefs in Angeli & Valanides, 2012).

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Conclusion to the Dissertation

This dissertation was motivated by the idea that the purpose of higher education is to empower students to draw upon integrated knowledge from an array of courses, experiential learning opportunities, and daily life in order to address the most pressing challenges facing society. Specifically, the two motivating questions were: *what would we in higher education have to rethink to better align with this view?* and *what would be the signs of positive progress?* Manuscript 1 explored the intersection of self-regulation, learner agency, and transfer as a learning outcome as a response to rethinking an aspect of higher education. Specifically, the manuscript explored how meaning-making processes critically affect the setting and solving of our ill-structured problems. In particular, naming and framing through uniquely individual perspective was highlighted as a governing function of the meaning-making process. Further, exploration of the competencies needed to address ill-structured problems gave rise to broader discussion of how ways to develop a capacity for flexible and critical meaning-making. Finally, a guiding framework for guiding research and practice was given by presenting a visual mapping of primary dimensions of the meaning-making process.

Manuscript 2 focused on the question about what signs of positive progress might look like by introducing a conceptual framework for systems thinking competency along with an associated scenario-based measurement tool. Results of a pilot study involving qualitative analysis of responses from undergraduate and graduate students to the scenario suggested the tool could prove useful and should be the focus of ongoing work. The primary conclusions were (a) the tool elicited meaningful data on each of the constructs for which it was designed; (b) emergent within each construct were possible means of characterizing the data that allow for study of variation across respondents. The second conclusion is particularly important in future

refinement of the scenario and development of a scoring rubric since an assessment tool's ability to accurately discriminate between responses is a key component of instrument validation.

Further, respondent feedback on the instrument itself was both minimal and supportive. It is important to note that the pilot study was a first step in a much broader plan of work in order to fully develop the tool as a valid measure of systems thinking competency.

Implications for Practice

A primary implication for practice from the work in Manuscript 1 involves those curricular or co-curricular structures that heavily involve experiential learning opportunities. With these activities, designing and facilitating reflective learning opportunities is often considered of paramount importance. In designing those learning opportunities, prompts can be developed in consideration of the key dimensions (*detail, time, and perspective*) from the framework of Manuscript 1. For example, students could be encouraged to flexibly consider what is included or excluded from “the experience”; what identities/roles and values/beliefs are shaping their interpretations, and hypothesize why they are playing such a large role; what past experiences are similar or different, and in what ways; and how others around the freeform body of perspective might interpret the experience. The goal in this case would not be to script the meaning-making process but rather highlight all the critical elements that Bruner argued shape the way in which we organize narrative with the expectation that it might better facilitate learning.

Because Manuscript 2 focuses on the introduction of a measure for systems thinking competency it is premature to suggest any practical implications from that initial work.

Future Research

One of the most pressing areas for future research stemming from this dissertation is the continued effort to introduce and validate the measure of systems thinking competency. The first phase of the research should primarily focus on establishing the measure's construct validity (i.e., whether the operational measure represents its intended purpose or construct (e.g., Creswell, 2009; Shadish et al., 2002). To achieve this aim, the preliminary measure should be vetted with select faculty members and practitioners who have some scholarly expertise in teaching or researching systems thinking. A primary goal will be to see if the interpretation of "systems-thinking" that led to the development of the tool in this dissertation matches the interpretation of relevant faculty and practitioners, and if those individuals might find the tool useful for measuring systems-thinking in their classes or programs. Their perceptions of the range in students' systems-thinking abilities can be used in conjunction with the data from the qualitative study of manuscript two to development a scoring rubric with the long-term intent of a means to compare scores on the measure across large populations. Sample interview questions are shown in Table 4.1.

Table 4.1
Sample interview questions for relevant faculty and administrators

- | |
|---|
| <ol style="list-style-type: none">1. What does it mean to have systems-thinking abilities?2. How do you assess your students' system thinking capabilities?3. How do systems-thinking capabilities vary across students?4. Here is a scenario-based assessment tool we developed. What competencies would be required to complete each section?5. What do you think is missing from the scenario-based assessment tool to make it more useful for measuring systems-thinking?6. What do you think does not belong in the scenario-based assessment tool so that it measures systems-thinking?7. How might the scenario-based assessment tool contribute useful information for your class or program? |
|---|

Concurrently, a more in-depth study than that presented in Manuscript 2 can be performed to better understand student perceptions of the instrument. In particular, focus groups could be used after the various phases of the assessment tool such that one group completes phase 1 of the measure (*processing*), a second group completes phases 1 and 2 (*critique*), and the third group completes phases 1, 2, and 3 (*revision*). Table 4.2 presents sample questions that could be a part of this focus group protocol.

Table 4.2
Sample interview questions of groups of students who took the scenario-based assessment tool

- | |
|--|
| <ol style="list-style-type: none">1. How did you interpret phase {1-3, depending on the group} of the scenario-based assessment tool?2. What did you think you were being asked to do in phase {1-3, depending on the group} of the scenario-based assessment tool?3. Explain your answer to phase {1-3, depending on the group} of the scenario-based assessment tool.4. How would you have answered differently knowing what you know now?5. How could we have worded the prompt differently to get you to think in that way?6. What does it mean to have systems-thinking abilities?7. What did you think of completing the scenario-based assessment tool?8. What suggestions do you have for improving the scenario-based assessment tool? |
|--|

These two concurrent studies with faculty and students would serve to iteratively improve the tool while also better establishing its construct validity. Ultimately, as a scoring rubric to accompany the tool is developed and refined, it can then be used to explore variations in systems thinking competency across specific populations and associated curriculum or experiences. Adding the quantitative data from the scoring rubric will allow for further qualitative studies to explore how and why variations in systems thinking competency occur and the degree to which it is related to actual differences in ability versus instrument misinterpretation or bias. This iterative approach seeks to improve the validity of the instrument at each pass. Tables 4.3 and 4.4 below show sample interview questions for both student respondents and relevant faculty and

administrators after a significant data set of scores has been obtained on a wide range of students across distinct disciplines and experiences.

Table 4.3

Sample interview questions of individual students who took the scenario-based assessment tool after scoring rubric has been used

1. What do you think you were asked to do in each section of the scenario based-assessment tool?
2. Explain your thinking as you completed the scenario-based assessment tool. (use their responses to enhance recall)
3. How did you draw on your personal characteristics or experiences when you completed the scenario-based assessment tool?
4. Here's how different groups of students varied in scores on the scenario-based assessment tool. Can you explain the differences?
5. What is your overall reflection of the experience after completing the scenario-based assessment tool?
6. How would you have answered differently knowing what you know now?
7. How could we have worded the prompt differently to get you to think in that way?
8. What does it mean to have systems-thinking abilities?
9. What suggestions do you have for improving the scenario-based assessment tool?

Table 4.4

Sample interview questions for faculty and administrators following quantitative data analyses

1. What does it mean to have systems-thinking abilities?
2. Here is the scenario-based assessment tool. What competencies would be required to complete each section?
3. Here's how different groups of students varied in scores on the scenario-based assessment tool. Can you explain the differences?
4. What do you think is missing from the scenario-based assessment tool to make it more useful for measuring systems-thinking?
5. What do you think does not belong in the scenario-based assessment tool so that it measures systems-thinking?
6. How would knowing your own students' scores on the scenario-based assessment tool inform your class or program?
7. How could the scenario-based assessment tool be embedded in your current class or program?
8. What are potential barriers to widespread uptake of the scenario-based assessment tool by you or your colleagues?

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Appendix A: Village of Abeesee Scenario and Prompts

Scenario

The Village of Abeesee has about 50,000 people. Its harsh winters and remote location make heating a living space very expensive. The rising price of fossil fuels has been reflected in the heating expenses of Abeesee residents. In fact, many residents are unable to afford heat for the entire winter (5 months). A University of Abeesee study shows that 38% of village residents have gone without heat for at least 30 winter days in the last 24 months. Last year, 27 Abeesee deaths were attributed to unheated homes. Most died from hypothermia/exposure (21), and the remainder died in fires or from carbon monoxide poisoning that resulted from improper use of alternative heat sources (e.g., burning trash in an unventilated space).

Processing Phase

1. Given what you know from the scenario, please write a statement describing your perception of the problems and/or issues facing Abeesee.
2. What additional information do you need before you could begin to develop a response in Abeesee? Consider both detail and context of the problems/issues you identified.
3. What groups or stakeholders would you involve in planning a response to the problems/issues in Abeesee?
4. Please briefly describe the process you would use planning a response to the problems/issues in Abeesee.
5. What would you expect a successful plan to accomplish?

Response Phase

1. Given what you know and a budget of \$50,000, develop a plan that would address the Abeesee situation maximizing the impact of your \$50,000. Use a numbered, step-by-step guide, recipe-style to explain your response plan. For example: Step 1: Buy the noodles. Step 2: Boil water. Step 3: Add the noodles. Step 4: Drain the noodles.
2. On the previous page, you developed a plan. Without specifically changing your plan, reflect on it. What challenges do you see to implementing your plan? What are the limitations of your approach?

Critique Phase

Below, you will have been provided a plan for Abeesee that was developed by someone else.

Plan #46A

1. Develop an application process to allocate up to 100 grants of \$500 ($100 \times \$500 = \$50,000$) to low-income Abeesee residents.
2. Form a review committee comprised of 5 representatives from Abeesee stakeholder groups.
3. Distribute \$500 grants that can be used to make improvements to homes and residences to reduce exposure to low temperatures and/or make heating sources safer. Do not allow residents to use grants to pay heating costs.
4. Request documentation of improvements.
5. Track “days without heat” and “deaths attributed to unheated homes” to see if there is a decline.

Please read the plan above and respond to the questions that follow.

1. Will Plan #46A solve the problems in Abeesee? Why or why not?
2. Please describe any unintended consequences that you think might result from this plan.
3. What other factors do you think might influence the success of this specific plan?
4. How would you know if this \$50,000 was used effectively?
5. One of the steps in Plan #46A is the formation of a review committee. What factors are important to consider in the formation of the committee?

Instrument Feedback

1. Please use the space below to tell us anything you would like us to know about the scenario, the questions, and the survey interface. We are particularly interested in knowing about places where question phrasing or terms were not clear.

Appendix B: Rights Information for Lou Ambers Tips His Hat Image

Below is a screenshot of the rights information for the Lou Ambers Tips His Hat Image used in Manuscript 1 that indicates that there are no known copyright restrictions for using the image.

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Lou Ambers tips his hat as he accepts a sandwich from a hand reaching out of a doorway

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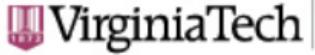
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Appendix C: IRB Approval Letter

Below is a screenshot of the IRB Approval Letter covering research in Manuscript 2.



Office of Research Compliance
Institutional Review Board
North End Center, Suite 4120, Virginia Tech
300 Turner Street NW
Blacksburg, Virginia 24061
540/231-4606 Fax 540/231-0959
email irb@vt.edu
website <http://www.irb.vt.edu>

MEMORANDUM

DATE: November 10, 2014
TO: Jacob Richard Grohs, Gary R Kirk, David Knight
FROM: Virginia Tech Institutional Review Board (FWA00000572, expires April 25, 2018)
PROTOCOL TITLE: Developing a Direct Measure of Systems Thinking Competency
IRB NUMBER: 14-1068

Effective November 10, 2014, the Virginia Tech Institution Review Board (IRB) Chair, David M Moore, approved the Amendment request for the above-mentioned research protocol.

This approval provides permission to begin the human subject activities outlined in the IRB-approved protocol and supporting documents.

Plans to deviate from the approved protocol and/or supporting documents must be submitted to the IRB as an amendment request and approved by the IRB prior to the implementation of any changes, regardless of how minor, except where necessary to eliminate apparent immediate hazards to the subjects. Report within 5 business days to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

All investigators (listed above) are required to comply with the researcher requirements outlined at:

<http://www.irb.vt.edu/pages/responsibilities.htm>

(Please review responsibilities before the commencement of your research.)

PROTOCOL INFORMATION:

Approved As: Exempt, under 45 CFR 46.110 category(ies) 2
Protocol Approval Date: November 5, 2014
Protocol Expiration Date: N/A
Continuing Review Due Date*: N/A

*Date a Continuing Review application is due to the IRB office if human subject activities covered under this protocol, including data analysis, are to continue beyond the Protocol Expiration Date.

FEDERALLY FUNDED RESEARCH REQUIREMENTS:

Per federal regulations, 45 CFR 46.103(f), the IRB is required to compare all federally funded grant proposals/work statements to the IRB protocol(s) which cover the human research activities included in the proposal / work statement before funds are released. Note that this requirement does not apply to Exempt and Interim IRB protocols, or grants for which VT is not the primary awardee.

The table on the following page indicates whether grant proposals are related to this IRB protocol, and which of the listed proposals, if any, have been compared to this IRB protocol, if required.

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