Interest Theory, Identity, and Expertise in a Social Constructivist Learning Environment

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What Is Interest?

What is interest? How is interest utilized, nurtured, and promoted in the STEM (Science, Technology, Engineering, Mathematics) social constructivist classroom? How is interest related to STEM learning outcomes? (Krapp, 2005). New interests are possible at any time during any stage of a person's life (Renninger & Hidi, 2016), but the flipside of that is students can also lose interests at any time. This paper will explore the nature of interest, expertise, and identity in learning, especially in a social constructivist STEM classroom or school library. Pedagogical recommendations are offered to educators and instructional designers based on viewing learning through the lens of interest development in a social constructivist environment.

Interest drives our vocations and avocations. It influences what we do and enjoy at home, at school, at work, at play, at love and at war. Renninger & Hidi (2016) define interest as the state in which, when people interact with an activity, they “…voluntarily engage in thinking about it, happily prioritize the problems that arise . . . and are willing to persevere to address them” (p. 1). People are hardwired for interest (Renninger & Hidi, 2016). Interest has two components, situational and individual. The first refers to a person’s psychological state while he or she is engaging with content, while the second is connected to a more longstanding affective and cognitive desire to reengage with the same content over time (Krapp, Hidi, & Renninger, 1992; Renninger & Hidi, 2016). The first type of interest originates from outside of the individual and is called extrinsic or situational interest, while the second type, intrinsic or individual interest, originates within the individual. Person X has recently become engaged with zines because he thinks they are cool (situational interest, triggered by context-rich zines and/or sharing and encouragement from friends), while Person Y is an avid collector who spends much of her free time reading and trading zines (individual interest, triggered by her frequent previous engagement and long-standing, context-rich relationship with zines and their communities)—both people are interested in zines, but Person Y expresses a deeper, richer, and longer-lasting level of interest than Person X. Those levels are further defined in the Four Phases of Interest Development (Hidi & Renninger, 2006) (see Table 1 below).

Empirical research on interest triggers has mainly consisted of experiments using specific novelties or challenges, referred to here as triggers (Renninger & Bachrach, 2015). In the early stages of interest, perhaps for Person X, learners may not even know that their interest has been triggered; the power of interest is manifested when behavior changes based on the interest (Renninger & Bachrach, 2015). However, triggered situational interest can also be fleeting (Renninger & Riley, 2013; Renninger & Hidi, 2016); a volcano eruption, author visit, or worm dissection can be exciting today but forgotten tomorrow (Crouch, et al, 2018). Additionally, seductive details, distracting information and/or events that deter learning (Garner, et al, 1992; Wade, 1992; Wang & Adesope, 2016), are ready to steal learners’ attention with misreadings, ancillary facts, too much focus on graphics in a text or documentary, or even changeable weather.

In deeper interest levels, learners provide their own triggers (Renninger & Bachrach, 2015; Renninger & Hidi, 2016); they persevere with the task and even see themselves performing the task as part of their career (Renninger & Riley, 2013). However, at lower levels of situational interest, engagement and involvement may be fleeting without personal connection and perceived value, often manifested merely as “interestiness” (Hidi & Anderson, 1992; Patall, 2013). Although people tend to have 4 or 5 well-developed interests, there is always room for shifting and changing; focus on interest changes regularly (Renninger & Bachrach, 2015; Renninger & Hidi, 2016; Renninger & Riley, 2012). Engagement is an element of interest, but they are not interchangeable. One can be engaged but not interested, but one cannot be interested without being engaged (Renninger & Bachrach, 2015). Engagement in this respect can be seen as some level of involvement in an activity, a prerequisite for interest, but that is in this educational context only; the field of engagement research is not addressed here.

Interest can represent both a psychological state experienced in a particular moment situationally, and an enduring predisposition to reengage with an object or concept/topic over time (Harackiewicz, Smith, & Priniski, 2016). The state of being interested is experienced as flow (Csikszentmihalyi, 1990; Renninger & Hidi, 2016) and if maintained, interest leads to enhanced academic performance, or maybe to enhanced performance across many measures. Interest must be consistently nurtured to be retained, and students in different stages of interest development along the Four-Phase Interest Development model (see below) require different types of interventions, featuring personalization and authenticity whenever possible. Harackiewicz, Smith, & Priniski (2016) offer three dimensions of personalization:
Depth—quality of the personal connections to learners’ interests; how authentic to the student are uses of popular and personal topics;

Grain size—size of the reference group; is it individualized instruction for an IEP (one student or a couple of students), or is it the type of individualized instruction a teacher would offer in a certain situation (many students);

Ownership—the degree of autonomy (Ryan & Deci, 2017) in generating the personalization. As expected, the more students self-determine, the deeper their connection gets to the content, and, it is hoped, the higher they rise in the Four Phases of Interest Development.

Interest development is a rich field that has shifted considerably since the publication of the Four Phases of Interest Development (Hidi & Renninger, 2006). However, the possibility to be interested in STEM is not available to all students.

Table 1. Hidi & Renninger’s (2006) Four Phases of Interest Development.

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<th>Less-Developed (Earlier)</th>
<th>More-Developed (Later)</th>
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<td><strong>Phase 1:</strong></td>
<td>Triggered Situational Interest</td>
<td>Maintained Situational Interest</td>
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<td><strong>Definition</strong></td>
<td>Psychological state resulting from short-term changes in cognitive and affective processing associated with a particular class of content</td>
<td>Psychological state that involves focused attention to a particular class of content and/or persists over time</td>
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<td><strong>Learner Characteristics</strong></td>
<td>• Attends to content, if only fleetingly</td>
<td>• Reengages content that previously triggered attention</td>
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<td>• May or may not be reflectively aware of the experience</td>
<td>• Is developing knowledge of the content</td>
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<td>• May need support to engage from others and through instructional design</td>
<td>• Is developing a sense of the content’s value</td>
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<td>• May experience either positive or negative feelings</td>
<td>• Is likely to be supported by others to find connections to content based on existing skills, knowledge, and/or prior experience</td>
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<td>• Is likely to have positive feelings</td>
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Understanding how and why students become interested in STEM subjects can generate improved strategies for creating more students prepared for, and self-interested in, pursuing STEM careers, which is not only necessary (Aschbacher, Ing, & Tsai, 2014; Falk & Dierking, 2016), but also just and fair to all students and citizens. Interest development has been linked in past work to digital literacy and STEM educational pathways; e.g. in the work of Reynolds’ exploration in a 2-year-long after school computer club (Reynolds, 2008); the work of Shumei Zhang & Callahan (2014) using Science Fiction Prototyping, through which students can create a relevant and authentic STEM-based item, real or imagined; and Ito’s (2010) research that resulted in the connected learning and HOMAGO models. However, digital inequality, whether it is derived from socio-economic, gender-based, or racially-based policies or beliefs, is a reality that must be addressed and corrected (Cooke, 2017; Riegle-Crumb, Moore, & Ramos-Wada, 2011). Generating interest in all students is the educational goal, and while some students
seem to be predisposed to appreciation of STEM activities and thinking, many students simply do not like STEM subjects and their related concepts. STEM interest development and literacy, the social constructivist connection between STEM subject interest and involvement, and their implications for curricular development and enhancement of STEM-subject instruction and pedagogy, are represented in this study by the cross-pollination of Kuhlthau’s (1991) 6-stage, 3-domain, Information Search Process (ISP) and Hidi & Renninger’s (2006) Four Phases of Interest Development demonstrated later.

Educational interventions can be useful in promoting learning, and STEM triggers can be utilized and combined in such interventions. Depending upon the target audience, lessons will probably employ situational triggers and/or appeals to mastery and individual interest, since those have been demonstrated to more frequently lead to STEM interest. The greatest challenge is the actual measurement of interest levels and changes.

**Importance of Identity and Expertise in Interest Development**

Interest is a complex blend of learner context, competing cognitive goals, cross-schema connections, affect, behavior, and desire. In her landmark study “The Case for Motivated Reasoning,” Kunda (1990) establishes that, “The motivated reasoning phenomena under review fall into two major categories: those in which the motive is to arrive at an accurate conclusion, whatever it may be, and those in which the motive is to arrive at a particular, directional conclusion” (Kunda, 1990, p. 480). This has profound implications for learning, since students must be convinced that either a subject and its associated activities and involvements should be engaged because it is socially appropriate and acceptable based on established standards, or because involvement is personally desirable due to a variety of social and inter-generalizable, contextual factors. Walsh & Tsurusaki (2017) note that, “Learners engage with social and material entities that mediate development and the transfer of knowledge, practices, and identities across an ecosystem and through time . . . forging connections between settings” (p. 6). It is those connections that drive engagement and interests, and potentially learning. One of the goals of triggering and/or maintaining STEM interest and involvement is to capitalize upon and expand student contexts and interests, incorporating the authentic, meaningful, relevant content considered most appealing to the students, making it normal and appropriate to envision working with future technology by reading and practicing: “Learners’ experiences within a particular environment are shaped by both their prior participation in particular communities as well as the structures, supports, norms, and expectations of the current environment” (Walsh & Tsurusaki, 2017, p. 36). Scaffolding, the raising of students’ abilities through mentorship, facilitation, etc., and helping students to achieve their zone of proximal development (the area between what a person believes she knows about a subject and what she actually knows, and the space in which mentorship is enabled) (Vygotsky & Cole, 1978; Reiser & Tabak, 2014), can be very supportive of enriching personal and group contexts by expanding and interconnecting schema through the development of expertise (Goldman, 2001). Connecting to context to motivate students is a significant piece of this puzzle, but certainly not the only one.

The process to connect students to STEM-related disciplines, interests, and activities is not simply an academic exercise; it is an effort to inspire future generations to continue the innovative spirit that John F. Kennedy invoked when he insisted that Americans land on the moon by the end of the 1960s. It is the crucial work of forging, through STEM education, the next Steve Jobs, Mae Jemison, Neil deGrasse Tyson, or Marie Curie, of guaranteeing future generations the technological advances that postwar generations have enjoyed. Van Horne & Bell (2017) answer that call with social practice theory in an effort to, “. . . analyze how moments of interaction related to scientific practice advance (or constrain) learners’ trajectories toward becoming socially recognized and networked participants in disciplinary work” (Van Horne & Bell, 2017, p. 442). The more students identify with a discipline such as science or mathematics as a part of their identity, the deeper their potential involvement in related activities.

Incorporating identity construction around content can account for potential student motivation to pursue STEM-related interests and activities, and there are ample opportunities within the theories for interventions throughout the process. In this manner, triggering becomes an essential element of learning and motivation. As Van Horne & Bell summarize, “. . . material, relational, and ideational identity resources and qualities of the learning environment mediate multiple entry points for different students” (p. 471). Recent STEM pedagogy links interest development, particularly for marginalized and stereotyped youth, to a social, interactional process that is “. . . often mediated by how students perceive the valued ways of knowing and being of a given practice or discipline in
relation to the ways of knowing and being with which they already identify” (Pinkard, et al., 2017, p. 481). This perception of a subject area like STEM can be enhanced through self-actualization by pursuing expertise in a particular STEM-related field.

Identity construction is crucial to engagement in STEM subjects. As students gather and process seminal STEM-related experiences, informal (non-school related) elements become increasingly important. Maybe students should be afforded more opportunities to visit science-related sites, in-person, online, or both, during school hours (Subramaniam, et al., 2013). Legitimate Peripheral Participation (Lave & Wenger, 1991) suggests that as participants, in this case STEM students, become more involved in an activity or organization such as a Coding Club or a Conservation Team, they move towards the center of that activity and assume more ownership and responsibility in the organization and the activity. Sometimes “it takes a village” to bring scientific literacy to all students; for example, Ahn, et al’s (2018) project to increase awareness of science topics, fields, and information using public, neighborhood displays so young people became more engaged with STEM subjects.

Expertise increases and more understanding becomes possible as context is built in a subject area. Background knowledge of content influences meaning construction through intertextuality, enabling students to more easily recognize similar topics, genres, and text features (Leinhardt & Young, 1996). Laypeople generally trust experts who are presented as such if they can establish a consensus concerning the data. Students are eager to seek and accept expert information, hence their willingness to accept the information in Google Answer Boxes as factual with little or no vetting (Miklosik & Dano, 2016). Uncertainty is important in a search (Chowdhury, Gibb, & Landoni, 2011); it is one of the main factors in enabling the user to make good decisions. Uncertainty decreases as the information seeking progresses until it virtually disappears at the end, but there is not uncertainty to eliminate if it never appears from the beginning (Chowdhury, et al., 2011). Replacing healthy uncertainty in favor of an answer box is a questionably valid school research option, since students, depending on their ages, are taught to use multiple, trusted sources to write papers when doing research; answer boxes are not always cogent or relevant.

Students are much more inclined to achieve expertise if they can connect personally to the material, since they are already socially instructed to accept that speakers talk about what they know, and laypeople tend to accept expert consensus as factual or at least sensible (Goldman, 2001). Therefore, expertise plays a crucial role in motivation and identity construction, since people identify with what they know and believe, and are only able to scaffold on to what knowledge and learnings they already have (Kuhlthau, 1991; Reiser & Tabak, 2014). Students building expertise in a subject area, expanding context and deepening associations with specific disciplines like computing and engineering, are key to building STEM interest and involvement (Pinkard, et al, 2017; Van Horne & Bell, 2017). Additionally, there are specific storylines or narratives that are prevalent within societies and they can be utilized for learning new subjects (Pinkard, et al., 2017). The use of triggers to STEM education can not only enhance involvement and interest, it can also build context as it connects to already-existing narratives with which many students are familiar and comfortable (Kuhlthau, 1991; Reiser & Tabak, 2014). This approach is ideal for at-risk students who may not have as many inherent potential entry-points as other students with stronger support systems outside of the classroom; for example, narratives can spark interest in STEM learning activities for middle school girls (Pinkard, et al., 2017), a population long-neglected in STEM fields.

Personal agency is critical for students, and hopefulness and pride result from its successful implementation (Ely, Ainley, & Pearce, 2013). The range of positive feelings associated with interest offered no surprises or unexpected results; kids are more likely to respond with positive affect concerning the stuff they like, and they are more likely to respond with negative affect concerning the stuff they do not like. However, identifying the specific emotions is less impactful on practitioners than simply knowing that positive and negative affect surrounding interest affects learning, and emotions combine with cognition, behavior, and ecology to form holistic information search procedures specific to those ecologies (Kuhlthau, 1991).

STEM Interest Development and Information Search Processes

In discussing information needs and desires, and the sense-making that should result from their pursuit, Case (2007) describes two poles of user approaches: Objective and Subjective. Objectivists view information as a reflection of a tangible reality, and the information search as a rational method to fill a specific need for information
that is expected to somehow improve one’s life or situation, such as researching two seemingly equal job offers to determine which will be a better fit. The goal of the search is often cognitive gap-filling, such as finding that the commute to one of the jobs is shorter, making that job more lucrative and therefore better. Subjectivists represent information search much like Kuhlthau in her landmark 1991 model of the information search process (ISP) (see Figure 1). Subjectivists have a personal experience, enduring varying degrees of uncertainty and doubt through the first half of the ISP. Their goals range from simply filling an information gap, like finding out travel times and distances between locations, to reflecting an affective and behavioral process as well, such as deciding whether or not to get a divorce, to pursue a controversial medical treatment, or to go sky diving, in which there are existential threats to be considered and anguished over. Subjectivists allow sense-making of a situation to act as powerfully and dominantly as a definite, measurable answer; there is not necessarily a right or wrong answer to whether one should sky dive or divorce one’s spouse—those decisions are based on a combination of influences from all three domains Kuhlthau (1991) represents in her ISP.

Carol Kuhlthau is among the most cited and discussed researchers in the information behavior field (Todd, 2003). Innovating beyond the cognitive-affective models and theories that preceded her, Kuhlthau insists that a model of a user’s sense-making process during the engagement in the ISP, “...ought to incorporate three realms of activity: physical, actual actions taken; affective feelings experienced; and cognitive, thoughts concerning both process and content” (Kuhlthau, 1991, p. 362). Objectivists are binary—either the information is satisfactorily found through cognitive methods or it is not—while Subjectivists allow for a range of responses across multiple domains (Case, 2007). The theories to be discussed here are Subjectivist. This approach will enable students’ emotional and behavioral responses to stimuli to be considered a part of the information search and enable another avenue for strategic interventions, and provide a lens for a social constructivist view of the process. Students often settle for sense-making over knowing, such as seeing and acknowledging the myriad changes they undergo during adolescence but not actually understanding the ways in which all of those factors gel together (or do not in the case of dysfunction) to eventually create an adult; or watching the night sky and having a sense of the cosmic forces at play without acutely understanding Einsteinian physics, choosing awe and wonder as adequate sense-making over definitive astronomical and gravitational explanations.

Figure 1. Kuhlthau’s (1991) 6-stage, 3-domain ISP Model

The reason Kuhlthau’s work is so important in this space is her acute understanding of the roles that behavior and emotions play in information search. Kuhlthau accepts that searchers feel human emotions and experience human behaviors. They are frequently not the bold information-adventurers educators strive to create, opting for safety, ease, and comfort over completeness and thoroughness, choosing the known over the unknown. This is supported by the epistemology of Scaffolding theory (Reiser & Tabak, 2014) that asserts knowledge is only usable as an extension of previous knowledge, added-on to the original knowledge and integrated based on context and pre-existing schema. Kuhlthau recognizes that and boldly makes it one of the features of her model:

Since people have a limited capacity for assimilating new information, they purposefully construct meaning by selectively attending to that which connects with what they already know. The active process of forming meaning from information is the task of the user in the ISP. An information search is a process of
construction which involves the whole experience of the person, feelings as well as thoughts and actions. (Kuhlthau, 1991, p. 362)

Activating and building rich contexts for interpreting information using familiar concepts and constructs is the user’s natural tendency, so the richer and more diverse the students’ contexts, the more potential connections can be made. Additionally, Kuhlthau’s foundational incorporation of personal construct theory, describing the affective experience that accompanies meaning construction, into the ISP model represents a leap in information search understanding as the fields of information processing, education, and psychology blend in the final representation. The implication for students is powerful: if a particular student is not cognitively connecting, enjoying, or appreciating a STEM subject, field, or lesson, there is a model to express that cognitive, affective and/or behavioral experience, target that moment of disconnection in the process, and potentially influence it with a STEM-based intervention. Kuhlthau (1991) provides the beginning of a theoretical foundation for such interventions.

When students search for information, they engage in “forming new constructs and altering those previously held” (Kuhlthau, 1989). As students realize the problem they face, the information they lack to complete their assignment, they encounter a “. . . recognized anomalous state of knowledge (ASK), which, further modified by linguistic and pragmatic considerations, becomes a request put to the IR [Information Retrieval] system” (Belkin, 1980, p. 135). Thus, a communication is established between the technology that retrieves the information and the user who requests the information (Belkin, 1980). Information, content, and experiences translated internally into language is scaffolded upon previous, related schema, enabling completion of increasingly complex tasks (Reiser & Tabak, 2014). With a tutor, facilitator, mentor, teacher, or other trained collaborator, students achieve their zone of proximal development which enhances their abilities (Vygotsky & Cole, 1978; Reiser & Tabak, 2014). Students must learn to navigate difficult terrain in the technology-rich, answer box era, acting and being acted upon by forces both inside of their personal experience and from external, societal forces (Schutz & Luckmann, 1973).

As students encounter gaps in their “stock of knowledge” (Schutz & Luckmann, 1973, p. 100), learning and attempt to fill those gaps becomes the primary goal. However, there are limiting factors to the stock of knowledge such as situation, spatiality, temporality, and social arrangements (Schutz & Luckmann, 1973). Temporality suggests that time is a factor in information behavior concerning searches, and that the search and the searcher are interrelated (Beheshiti, et al, 2015), creating space for both chronos, or chronological time, and kairos, time defined by shared experience, social constructivist time. Since searchers can only assimilate a certain, finite amount of information in a search session, they purposefully construct meaning by choosing those slices of information they know and connecting new information to them (Kuhlthau, 1991).

Kuhlthau continues to address the Affective element as having a significant effect on cognition: “Affective aspects, such as attitude, stance, and motivation, may influence specificity capability and relevance judgments as much as cognitive aspects, such as personal knowledge, and information content” (1991, p. 363). Personality traits are an active element of Kuhlthau’s Affective medium: “As personality forms an inclination towards certain characteristic reactions in any given situation, personality traits are likely to influence attitudes and behavior in an information-seeking context” (Halder, Roy, & Chakraborty, 2010, p. 43), creating a multi-domain effect and exemplifying the interrelatedness of the three domains.

**Cross-Pollination of Kuhlthau’s ISP (1991) and Hidi & Renninger’s Interest Model (2006)**

This paper introduces a new element to interest development research: a cross-pollination of Kuhlthau’s (1991) 6-stage, 3-domain ISP Model with Hidi & Renninger’s (2006) Four Phases of Interest Development. The hypothesized connections are demonstrated in the model below (see Figure 3):
In Figure 3, as students collaboratively search, retrieve, and utilize information, increasing relatedness between themselves and the content, the initial uncertainty and vague sense of a new content area is reflective of *triggered situational interest*, the first interest phase. During the *Initiation* phase of the ISP, new information is assimilated in a series of phases, scaffolding upon existing context (Kuhlthau, 1991; Reiser & Tabak, 2014). Short-term changes in affect and cognition lead to mixed results; students may or may not persevere and develop relatedness and begin to develop competence and they may need collaborative support to “stay in the game” (Hidi & Renninger, 2006). If they stay engaged in the material and develop optimism about their potential for success, working through their vagueness concerning this still-new topic, possibly with their classmates (Kuhlthau, 1991), students can develop *maintained, situational interest* in which they develop increased focus and attention on the information seeking and retrieving task, increasing scaffolded content information, sharing and confirming relevance with other students, and generally feeling positive about the project (Hidi & Renninger, 2006). As questions become requests, reflecting an active cognitive engagement with the content (Belkin, 1980), students approach *Formulation*, the “. . . turning point of the ISP” (Kuhlthau, 1991, p. 367), in which affect and cognition grow from frustration and confusion to clarity and greater focus. This point is comparable in the ISP journey to *emerging individual interest* in interest development, during which students begin to seek information for themselves and their own budding interests, not just those related to the school project (Renninger & Hidi, 2016). They have been successfully triggered and are on their way to *well-developed, individual interest*, featuring personal connections to the content that transcend the immediate context (Renninger & Hidi, 2016). This phase is represented in the ISP by *Collection*, “. . . when interaction between the user and the information system functions most effectively and efficiently” (Kuhlthau, 1991, p. 368). The seamless transition described represents ideal conditions; there are many issues and distractors such as seductive details and technology lapses (Wang & Adescope, 2016) that can interfere with this process. The scaffolding that has been dynamically expanding throughout this process has been serving students well, offering real-world problem-solving abilities, reducing frustration while increasing interest potential, offering multiple foci for future exploration, and thereby enabling reflection and reflexivity (Reiser & Tabak, 2014). It could be suggested that it is this lack of cognitive load that enables the positive feelings that often accompany *Collection*. This connection between the work of Hidi & Renninger (2006) / Renninger & Hidi (2016) and Kuhlthau (1991) will be explored and clarified further in future research.
Social Constructivism and School Librarians

Students share information, view of triggers and their transference to STEM interest through a constructivist lens, more specifically Piaget’s radical constructivism and Vygotsky’s sociocultural constructivism. Steffe & Kieren (1994) offer a particularly lucid explanation of radical constructivism by pitting it against Chomskyian innatism. In this light, Chomsky argues that all subject structure comes from within individual cognition, while Piaget posits that cognitive structures continue to be constructed and deconstructed throughout childhood and possibly adulthood. This offers STEM teachers a difficult path, since in a constructivist classroom, there are no pregiven, prescribed ends toward which this construction strives, and assessment and proof of learning become paramount. If a constructivist learning environment is assumed, then educators should be required to offer easily apprehensible models of content-based concepts, because the outcomes processes students use to get to the answer and the outcomes themselves may differ (Cobb, Yackel & Wood, 1992). In Piagetian terms, “... students’ informal mathematical activities constitute a starting point from which the teacher can guide their problem-solving efforts and thus facilitate their acculturation into the mathematical ways of knowing of wider society” (Cobb, Yackel & Wood, 1992, p. 13). Since radical constructivism is highlighted by students who individually create and re-create their identity from initial assimilatory structures, teaching for conceptual understanding takes precedence over content-based or unauthentic activities (Fosnot, 1992).

Vygotsky’s sociocultural constructivism differs from Piaget’s radical constructivism in that, for Vygotsky, social experience shapes the ways of thinking and interpreting the world. Even individual cognition is a social activity, especially when it involves language and other semiotics (Jaramillo, 1996); every element of human experience that involves interaction with people and/or the environment is social. Sociocultural theories tend to focus upon how individuals learn and the cultural influences on those processes, while constructivist theories describe how epistemologies function in learning environments in general (Dolberry, 2015). Furthermore, since learning extends over multiple years, educators can consider and re-consider how topics are presented at each grade level each year, building on prior understanding and supporting increasingly complex concepts (Next generation, 2013). The only alternative to a constructivist approach to information and knowledge dissemination is a transmission approach (Kuhlthau, Caspari, & Maniotes, 2015), the current equivalent of “chalk and talk,” a method that may be effective in some university classrooms but almost never in middle school classrooms. Vygotsky’s theories of higher-order thinking call for authentic learning, so it is incumbent upon school librarians to provide a constructivist learning environment that empowers students to explore content and processes drawn from their own experience and meaningful to them (Kuhlthau, Caspari, & Maniotes, 2015). Constructivist learning can be perceived by students as a very complex situation, and it can at times be overwhelming to “buy in” to an unfamiliar methodology (Perkins, 1992). Also, school librarians and subject area teachers are faced with particular challenges in maintaining a constructivist learning environment, especially when it comes to assessment: Is using only one assessor an unbiased approach? Can a question ever have less than several correct answers? How are skills, not knowledge, assessed? (Jonassen, 1992).

As much as educators may want to offer choices to their students and facilitate their constructionist journey through them, curricula, instructional strategies, and objectives are often imposed on students and staff from outside. However, this non-constructivist approach cheats students of opportunities for self-efficacy and identity construction (Winn, 1992). The work of Piaget supports construction of identity and self-efficacy through interaction with the environment, growing, developing, and evolving within it, reinventing and reorganizing information and understanding along the way (Fosnot, 1992). As students progress through Piaget’s stages—from concrete understandings, to symbolic representations of those understandings, to abstract models—they learn structure, order, and reflection. Then, through interactions with others, their understandings change again (Fosnot, 1992). This is the process through which students come to own their research and their skills, fostering a growing curiosity that serves students well (Kuhlthau, Caspari, & Maniotes, 2015). All information search has a social constructivist element in general insofar as the information individuals encounter is embedded within the culture and its norms, language, economic opportunities, and regional idiosyncrasies (Subramaniam, et al, 2015). Therefore, even without calling it constructivist, the elements of constructivist education emerge.
Guided Inquiry

Supporting a dynamic social constructivist STEM classroom or school library requires pedagogies and practices that support both abstract and concrete understandings of content and processes that, through scaffolding, become usable learning (Reiser & Tabak, 2014; Kuhlthau, 1991). Employing guided inquiry is one effective method of having students collaborate in a social constructivist environment while progressing through the stages of Kuhlthau’s (1991) 6-stage, 3-domain ISP (Kuhlthau et al., 2015). In Guided Inquiry (Kuhlthau, Maniotes, & Caspari, 2015), the goal is deep understanding of relevant content while constructing and developing content-area literacy and social skills, leading to constructivist, sociotechnical, “third space” (Kuhlthau, Maniotes, & Caspari, 2015, p. 4) learning environments. Sociotechnical systems are “places” in which humans and/or organizations interact with technology (Hu, Mostashari, & Xie, 2010). It is connected to Kuhlthau’s (1991) information search process and therefore particularly relevant in this study. It is intended to be collaborative, engaging, reflective, and iterative, as students explore new ways to solve problems, answer questions, and create artifacts. Motivation, interest, relevance, and affect are primary factors in engaging in guided inquiry learning. Figure 3 is an updated version of the original ISP in a guided inquiry setting. Students use multiple information sources, researching both individually and as part of an Inquiry Community, a team of researchers/presenters. The end products are almost always concrete artifacts based upon the process the students experienced. Even virtual creations are concrete insofar as they can be transformed into an object if needed. These artifacts can shed light upon both the process and the learning that occurred (Kuhlthau et al., 2015). Guided inquiry is also closely connected to motivation and interest, and analysis of both the research process (with videotaping and field notes) and the artifacts produced in the planned intervention should inform the research concerning learning, literacy, and the potential cross-pollination of Kuhlthau’s ISP with Hidi & Renninger’s (2006) interest development model. Since all of this action is occurring in a group setting, not in isolation, a project-based pedagogy is also needed.

Educators may be partially responsible for not engaging students enough with real-life experiences communicated in a style that both students and educators can relate to (Pauw, et al, 2015). Even if students build more science-related context and experience, they still need impetus to make connections to previous funds of knowledge which are not always activated. Many learners have the skills to make meaningful connections but choose not to. However, social media platforms are a bridge to such connections, and online groups should be organized around science learning to enhance the possibility of critical connections (Mills, et al, 2018). Social media can help students further craft their identities as future scientists by discussing and sharing their experiences, affirming their choices with their peers (Subramaniam, et al, 2012). Achieving these goals takes dedication by both students and staff, and it helps if they both like the material, and equally importantly, if staff stay current in their fields (Mills, et al, 2018).

Figure 4. Guided Inquiry Design Process (Kuhlthau, Maniotes & Caspari, 2015)

Arrows indicate social constructivist collaboration opportunities
Guided inquiry is both grounded in best practice and research and crucial for successful living and transition to the workplace (Kuhlthau, Maniotes, and Caspari, 2012). Guided inquiry is authentic to students because they work with peers and with chosen, not assigned, subjects, or at least chosen sub-topics within a curricular theme. Technology and its ability to simultaneously create and share plays an important role in successful critical skill building in students, the ultimate goal of guided inquiry design.

In order to map out the information search process using guided design theory, Kuhlthau, Maniotes, and Caspari (2012) designed a new 8-step ISP model to augment the previous 6-step ISP cited above (see Figure 4). The newer model includes opportunities for students to practice the guided inquiry behaviors of analysis and sharing. The added arrows represent the times at which students collaborate, discuss, debate, explore, question, and assert, all important steps to knowledge, socially constructing while learning. In a sociotechnical view, the “third space” that Kuhlthau describes, demonstrated in Figure 3 above, is a significant part of the knowledge.

**Conclusion**

Every middle schooler is entitled to the tools she needs to succeed in an uncertain future. STEM interest, and the teachers and school librarians who promote STEM, need to be a part of that future. They do not merely create an environment in which higher standardized test scores become more likely (Lance & Hofschire, 2012). The school librarian may be the only individual in the building “...tasked with building and maintaining a collection of diverse, high quality, current resources that support curriculum, complement adopted texts, enable professional learning, and pique student interest” (Mardis, 2014, p. 250). AASL defines the five primary roles of school librarians: information specialist, instructional partner, teacher, program administrator, and leader (American Association of School Librarians, 2014). No one else in the building is capable of this range of capabilities. Additionally, and probably in response to a growing movement, they describe librarians’ possibilities of creating semi-formal learning environments in school libraries, excellent choices for librarian collaboration since they can offer more media, more guidance, and more interest-driven topics and themes.

Without guidance, students often approach the process as a simple collecting and presenting assignment that leads to copying and pasting with little real learning. With guidance, students are able to concentrate on constructing new knowledge in the stages of the inquiry process to gain personal understanding and transferable skills. Students’ feelings play an important part in the constructive process of inquiry that indicates a zone of intervention for teachers and librarians. For example, students get frustrated in the exploration stage of inquiry and need encouragement to take time to read and reflect and guidance in making sense of information that does not fit together smoothly. Guided Inquiry provides essential intervention at critical points in the inquiry process that fosters deep personal learning (Kuhlthau, 2010). Guided Inquiry prioritizes and defines that space for students and staff alike by providing opportunities for engagement and reflection (Kuhlthau, Caspari, & Maniotes, 2015), especially since students often mis-assess their searching skill and then wrestle with the cognitive, affective, and behavioral ups and downs predicted by Kuhlthau (St. Jean, et al, 2015). Self-reflection helps students and teachers during this time, and both benefit from activities like log-keeping (Harada, 2016). Guided inquiry is a response to the increasing need for school transformation; the Internet alone does not create a 21st Century learning space (Kuhlthau, Caspari, & Maniotes, 2015). Facts run the risk of becoming fluid in this era of rapid technological change. The Internet provides unparalleled access, and offers a voice to all who want to have one, but, as Kuhlthau (2015) warns, “...this also produces an abundance of misinformation and misunderstandings, intended or not. Questions arise of what is accurate, reliable, important and wise. There is confusion between what is enduring and what is ephemeral” (p. 2). The Internet makes fake news possible. Kuhlthau accurately predicts that with voice comes responsibility, and people approach their newfound voice with different motives: some to inform and assist, but also some to sell, some to prey, and some to ignobly persuade. Middle schoolers often have a difficult time distinguishing online fact from fiction, conflating the power of a story with its truth value; advertisers and predators know that (Gretter, Yadav, & Gleason, 2017). It is possible that no amount of media literacy education can counter the effects of disinformation (boyd, 2018), though Hobbs (2018) reminds boyd that media literacy is more than simply deconstructing communication; it involves reflection, meaning-making, and authentic action. These processes often involve triggering interest and/or engagement, and they often occur in a social constructivist learning environment.


