33 Designing for Learning: Interest, Motivation, and Engagement

Sanna Järvelä and K. Ann Renninger

In order to be productive at home, school, or work, and in their free time, learners are constantly involved in communicating, collaborating, problem solving, and thinking critically. They need to master these skills to participate fully and effectively in society (McLaughlin, 2008). International organizations (e.g., OECD, EU, UNESCO), public-private partnerships (P21, ACTS), educational organizations (e.g., ISTE, NAEP), and researchers have formulated frameworks describing the skills necessary to contribute to the 21st century, and how to design learning environments to foster these skills (e.g., Trilling & Fadel, 2009). However, the roles of interest, motivation, and engagement that enable the development of these skills has not been carefully examined.

In general, learners elect to engage in tasks and activities in which they feel competent and confident, and avoid those in which they do not (e.g., Bandura, 1997). Challenging tasks can lead some learners to feel they are not able to learn; for others, challenge is a reason to persevere. However, only those who believe that their actions will result in the consequences they desire have the incentive to engage (Schunk, 1995). Decades of research have shown that learners with a strong sense of their own competence approach difficult tasks and situations as challenges to be mastered, rather than as threats to be avoided (Zimmermann & Schunk, 2011). Past experience solving problems and individual interest impacts their ability to work with challenge or failure (Tulis & Ainley, 2011). Research on group learning, for example, has shown that learners' interpretations can be positive and lead to increased motivation and engagement for group activities; and, alternatively, that learners' perceptions can be negative and lead to de-motivation and withdrawal (Van den Bossche, Gijselaers, Segers, & Kirchner, 2006).

When we think of engaged learners, we typically think of learners who have more developed interest and are motivated to learn. They are involved behaviorally, intellectually, and emotionally in learning tasks (Fredricks, Blumenfeld, & Paris, 2004). Learners who are not engaged, by contrast, lack interest and are unmotivated. Understanding how to support both groups of learners is critical. Learners with developed interest are ready to engage deeply with content and to master higher-level skills, but at the same time, those with less interest need to be supported (see Renninger, 2010). As such, there are two core questions for the learning sciences regarding the roles of interest, motivation, and engagement in designing for learning:

1. How do we enable those who are not yet engaged to develop their will and skill for learning? How can we help unmotivated learners become motivated to learn?
2. How do we design in order to continue to support those who are already engaged, such that they continue to deepen their interest and, as a result, their motivation to learn particular disciplinary content?

In this chapter, we survey the current state of research to address these questions. We begin by defining interest, motivation, and engagement as distinct and complementary influences on learning. Following this, we identify a set of key themes that emerge from the research, and we review a sample of studies that address interest, motivation, and engagement and focus on differing participant groups across a variety of learning environments. We conclude by proposing potential design principles that emerge from this review.

On Conceptualizing Interest, Motivation, and Engagement

To design learning environments that foster deep learning (Mathan & Koedinger, 2005), it is important to distinguish among three constructs that in everyday use are often assumed to be identical: interest, motivation, and engagement.

Interest

While colloquial usage might suggest that interest is a simple matter of liking one or another type of activity or subject matter, research on interest more precisely defines interest as a psychological state, as well as a predisposition to reengage particular disciplinary content over time (see Hidi & Renninger, 2006; Renninger & Hidi, 2011). Interest is a cognitive and affective motivational variable that develops through four phases, beginning with a triggering of interest that may or may not be sustained (e.g., the opportunity to look through a telescope at cloud formations), and extending to a more well-developed individual interest (e.g., a relatively enduring predisposition to begin looking for a telescope with a larger aperture because of the possibility to track cloud belts). As such, a learner may find weather fascinating and be excited to learn about lightning or different types of clouds, but his or her phase of interest could really vary.

In their Four-Phase Model of Interest Development, Hidi and Renninger (2006) indicate that a learner's phase of interest may be in one of four phases. An interest in weather could be:

- a *triggered situational interest*, meaning that the learner's attention is piqued by information acquired about weather; he or she may, but also may never, return to or make use of this information again;
- a *maintained situational interest*, meaning that other persons or the task to learn about cloud formations itself may help to sustain interest, but the learner may not yet be electing to reengage this content voluntarily. If, for example, the experience of classroom learning is primarily a social experience for the learner, he or she might only work with information about weather when in the classroom with other learners;
- an *emerging individual interest*, meaning that the learner has his or her own questions about weather and, to the extent that the classroom discussion maps onto these, the learner is ready to be a constructive participant in the discussion. Because learners in this phase of interest have some basic knowledge about weather and value this, the classroom could trigger them to ask another question, for example, a question about whether there can be lightning without clouds. This question is an example of a curiosity question, a type of question that characterizes the focus of learners' attention, is novel in terms of learners' own understanding, and may or may not be verbal (Renninger, 2000). Such questioning, in turn, often leads the learner to seek his or her own answers by excitedly asking questions or voluntarily doing research outside of the classroom context to address them. It is also possible that the connection that he or she has made is the only aspect of the classroom discussion that is of interest to him or her, however. Thus, learners with an emerging individual interest have curiosity questions but the scope of these is constrained.
- a *well-developed individual interest*, meaning that the learner has his or her own curiosity questions, is involved in addressing these, and can also think about alternate approaches to them or even varied additional information. Thus, in the class context, others' questions and perspectives on the relation between lightning and clouds and experiments would be enthusiastically and seriously engaged – possibly looking like excitement, and of course interest, but excitement that is qualitatively different than that of the learner who in an earlier phase of interest development.

Learners in each of the phases of interest may look excited; however, their excitement is not an indicator of the phase of their interest nor is it sufficient as an indicator of interest given developments in neuroscience (e.g., Berridge, Robinson, & Aldridge, 2009; Hidi, 2013). Instead, a learner's feelings, value, and knowledge are indicators that together can predict the likelihood of voluntary reengagement with particular content over time (see discussion in

Renninger & Su, 2012). Interest can be triggered for learners of all ages and in all phases of interest – even for learners with little initial interest. Interest can be triggered by the collative variables: novelty, challenge, surprise, complexity, and/or uncertainty (Berlyne, 1960; see related findings in Durik & Harackiewicz, 2007; Hidi & Baird, 1988; Mitchell, 1993; Palmer, 2009).

The phase of a learner's interest is predictive of both motivation and engagement. When learners have a more developed interest, they are motivated to learn, able to self-regulate and set goals for themselves, and to achieve (see Harackiewicz, Durik, Barron, Linnenbrink, & Tauer, 2008; Hidi & Ainley, 2008). They also are likely to begin to identify with the disciplinary content of interest and related occupations (Krapp, 2007).

In later phases of interest, when learners begin to make meaningful connections to the discipline and to ask curiosity questions (e.g., What is the relation between lightening and clouds?), they begin identifying connections between what is known and what still needs to be figured out. They also begin seeking their own answers to their questions and assuming responsibility for what is learned.

Interest is supported to develop through interactions with others (peers, educators) and the tasks (e.g., software, exhibits, worksheets) of the learning environment. In this sense, interest is malleable. Interest can be triggered and supported to develop at any age; however, triggers for interest are needed. Regardless of phase of interest, a learner's interest is sustained and continues to develop in relation to the novelty, challenge, surprise, complexity, and/or uncertainty – the collative variables that lead to the asking of curiosity questions. Without such triggers, or support for learner interest (e.g., if a teacher or parent assumes that the learner is interested in science and there are no opportunities to continue to grow knowledge), interest may fall off, go dormant, or disappear altogether (Bergin, 1999; Hidi & Renninger, 2006).

Motivation

Motivation is a broader construct than interest and is not specifically linked to learning of particular disciplinary content. Motivation comes from the Latin word *motivare*, meaning *to move*. Like interest, motivation involves a complex blend of the environment, cognition, and affect (Volet & Järvelä, 2001); however, while interest is always motivating, what is motivating is not always of interest (Renninger, 2000).

Note that while the literature on motivation has been parsed and studied in terms of intrinsic motivators (personal desires) and extrinsic motivators (such as grades), neuroscience has shown intrinsic and extrinsic motivation to be complementary aspects of motivation that do not exist in isolation (see discussion in Hidi & Harackiewicz, 2000). Here we discuss motivation in relation to achievement, or the will or movement needed to succeed: the initiation, guides for, and maintenance of goal-oriented behavior (e.g., Wigfield, Eccles, Schiefele, Roeser, & Davis-Kean, 2006). According to Eccles's (2009) *expectancy-value theory*, a learner chooses to take on a challenging task if he or she both expects success and values the task; in other words, if the cost of involvement will yield a benefit. As such, being motivated to succeed is likely to be accompanied by feelings of self-efficacy, appreciation of possibilities or expectancy regarding the utility of engagement, and/or consideration of cost (Wigfield et al., 2006).

Support for changing the motivation of learners is likely to need to start with the triggering of interest, whether this is the trigger provided by a developing understanding of discipline or task utility (e.g., Harackiewicz, Rozek, Hulleman, & Hyde, 2012) or the piquing of attention that occurs, for example, when someone runs into the room and yells, "sex" (Schank, 1979). However, motivation is not a developmental construct in the same sense that interest is, meaning that while interest can be supported to develop through the triggering process and meaningful connections and curiosity questions can be promoted, a learner is typically described as having more or less motivation based on their personal characteristics: their self-efficacy, ability to self-regulate, and/or their expectancy-value. As such, motivation is typically assessed relative to others and learners are described as being more or less motivated, meaning that they may or may not self-regulate to accomplish goals and/or understand the utility of engagement. A learner's present designation as less motivated than others does not preclude the possibility that his or her interest could be triggered for a particular discipline (e.g., science) and be supported by others and/or purposeful design to develop (Renninger, 2010). The quality of the support provided to the learner has implications for changing learner motivation (see Eccles & Midgley, 1989).

When learners are able to persevere on a task independently, they self-regulate their behaviors, whether this involves figuring out how to do an assigned problem set, developing the ability to explain equations in everyday English, or practicing use of a micrometer (e.g., Järvelä, Järvenoja, & Malmberg, 2012). Self-regulated learning involves strategically adopting and adapting tools and strategies to optimize task performance and learning; monitoring progress and intervening if results deviate from plans; and persisting and adapting in the face of challenges (Hadwin & Winne, 2012).

When learners are able to self-regulate effectively, they are also considered to be motivated learners. Being self-regulated does not necessarily suggest that a person has a developed interest for the content to be learned. Having a developed interest for content can mean that a learner is likely to self-regulate without supports to do so, even at very young ages, because he or she wants to master, figure out, or persevere to address curiosity questions (Renninger, 2009). However, older learners who have little interest can and do self-regulate their behaviors effectively (Sansone & Thoman, 2005; Sansone, Weir, Harpster, & Morgan, 1992).

Zimmerman's (1989, 2001) social cognitive model of self-regulation points to promoting the development of self-regulation through: modeling, scaffolding, and other regulation such as support provided by peers, teachers, and parents. Models facilitate self-regulation by providing learners with information about possible actions, processes, and consequences (e.g., Zimmerman & Kitsantas, 2002). Scaffolding refers to supports provided by peers, teachers, and/or parents that promote conceptual understanding by promoting metacognition, strategy use, and study procedures such as how to use resources or perform tasks (see Järvelä & Hadwin, 2013).

This line of research has also addressed features, factors, and characteristics of contexts that support the development of self-regulated learning (e.g., Malmberg, Järvelä, & Kirschner, 2013; Perry, VandeKamp, Mercer, & Nordby, 2002). For example, Perry (1998) reported that second- and third-grade writing instruction could be categorized as high or low in support for self-regulation or based on inclusion of the following: choice about types of tasks and the challenge they provide, self-evaluation, and opportunities to receive support from both teachers and peers. Her study demonstrated that students in classrooms with high levels of support were more likely than those in classrooms with low levels of support to have the skills and attitudes of self-regulated learners.

Engagement

The concept of *engagement* has informed study of whether and the ways in which learners respond to learning environments less as a psychological construct and more as a description of learners' connections to the learning environment. First undertaken as a focus for study in relation to concerns about school disengagement and time on task, studies of engagement have now been undertaken at different levels of granularity ranging from schooling generally to engagement with one or another task type (see Christenson, Reschly, & Wylie, 2012; Tytler & Osborne, 2012).

Skinner and Belmont (1993; see also Skinner & Pitzer, 2012), for example, study engagement in terms of learner initiation of action, effort and persistence in academic tasks, as well as the learners' emotional states during activities. Fredricks, Blumenfeld, and Paris (2004) describe engagement as a multifaceted construct that includes behavior, affect, and cognition. Ainley (1993, 2012) describes engagement as the extent to which a learner is actively involved with content, where "active involvement" suggests that the person acts to maintain or extend their contact in order to increase their knowledge of it.

For the purposes of this chapter, engagement is understood to include socioemotional and cognitive aspects of the learning environment; it is not a psychological variable, per se. Conceptualizing learner engagement in this way acknowledges its multiple facets: the frame of the experience (Engle, 2006), the design and expectations that are facilitated and communicated (Gresalfi & Barab, 2011), as well as the roles of psychological variables such as interest and motivation as contributing to whether engagement is productive (the learners' willingness and/or ability to persevere when a task is challenging and to self-regulate his or her behaviors in order to complete assignments or attain goals). It also describes the learner's lack of response when he or she does not yet recognize expectations as set out by the environment and needs support to do so.

The Learning Environment and the Individual

Interest, motivation, and engagement are products of learners' interactions with the environment. Interactions can occur with the classroom, museum exhibits, videogames, books, or integrative projects, for example, as well as with other people, such as educators, parents, and peers. As a result, interactions have an idiosyncratic quality that both constitute and shape the experiences of the learner. Some environments promote exploration that encourages innovation and the development of problem-solving skills; in others, exploration is constrained by time, the design of the task and/or its facilitation (see related discussions in Azevedo, 2006; Flum & Kaplan, 2006).

Interactions that are responsive to variations in the strengths and needs of learners enhance the possibility for learning (see Eccles & Midgley, 1989; Volet & Järvelä, 2001). Some learners are able to prioritize, to persevere when tasks are difficult, and to plan their work and lives strategically. These learners also tend to be those who have learned to self-regulate, to focus and adapt their actions to fit the demands of the situation (Hadwin, Järvelä, & Miller, 2011). These same learners could be described as engaged or as having made connections to the materials and tasks with which they are to work. Their interest has been triggered and maintained, and they have begun to ask questions that lead them to seek answers (Renninger, 2000). They are likely to regulate their activity so that they can find those answers (Renninger, 2010). In this sense, motivated behavior emerges from the triggering of interest that is then maintained, and from the learners' ability to self-regulate because they want answers to the questions they have generated.

Research suggests that learners may need different types of scaffolding to engage tasks that are set out for them depending on their interest, motivation, and engagement. Research on scaffolding further indicates that beginning learners need more support than more knowledgeable learners (see Reiser & Tabak, Chapter 3, this volume). For those with little interest or understanding about particular content to be learned, scaffolds can promote the making of connections to the content that, in turn, will lead to learners asking curiosity questions about the content and self-regulating so that they can find answers (Renninger & List, 2012). Content can be scaffolded by inserting topics into passages and problems (Renninger, Ewen, & Lasher, 2002; Walkerdine, Petrosino, & Sherman, 2013). Content can also be scaffolded by promoting utility value. For example, Hulleman and Harackiewicz (2009) found that encouraging ninth grade learners with little interest in biology to identify the utility of learning biology enabled them to successfully engage their biology class, whereas learners in the same class with more interest for biology have not benefited by the utility intervention, presumably because they already recognize the utility of learning the content and are ready to work with and be challenged by biology as a discipline.

Although the design of the learning environments is adaptable, the open question is how to design so that the necessary supports are in place to (a) promote the development of interest for those in earlier phases of interest so that they are motivated and engaged, and (b) continue to challenge those in later phases of interest development so that they continue to develop and deepen their interest, maintaining their level of motivation and engagement.

Studies of Interest, Motivation, and Engagement

In this section, we overview methods and findings from five studies as exemplars of those addressing interest, motivation, and/or engagement in the learning sciences. The studies were parsimoniously selected to represent a range of participant groups and learning environments. Although the studies address different research questions and use varied methodologies, they provide convergent evidence for suggesting both that designing for learning requires (1) attending to the possibility that interest, motivation, and/or engagement will vary across learners and (2) supporting learners through content-informed interactions and, in particular, scaffolding that focuses on disciplinary content.

Falk and Needham (2011): Science Center Visits, Interviews, and Sampling Participants and the Broader Community

Visitors to museums make their own choices about which exhibits to visit and how long to stay at one exhibit before moving along to the next (see Crowley, Pierroux, & Knutson, Chapter 23, this volume). Like other out-of-school contexts, the museum environment is considered "free choice" because there are no requirements for participation and, as such, is also assumed to be of interest, motivating, and engaging. To understand visitor attendance and the impact of a science center on its community, Falk and Needham (2011) interviewed visitors and the broader community. They collected data using two semi-structured in-depth telephone interviews of a random sample of Science Center visitors (n= 832, n= 1008) approximately nine years apart. The second interview followed the renovation of the Science Center.

The results show that Science Center visits increased visitors' interest and motivation to learn about science. People who participated in leisure free-choice learning activities (e.g., read books about science or went to a science club) were significantly more likely to visit the science center. Those who had visited believed that the Science Center strongly influenced their science and technology understanding, attitudes, and behaviors. For example, adults reported that a visit to the Science Center resulted in their children engaging in science-related activities following their visit. Adults themselves reported a range of positive outcomes of their visits to the Science Center, such as increased positive attitude toward science or learning one or more things they did not know before the visit.

Falk and Needham used an "outside-in" approach to survey the broader community. Self-reported impacts were slightly higher for cognitive outcomes (e.g., increased understanding and thinking about science) than for affective outcomes (e.g., increased interest and attitudes), which may, as Falk and Needham explain, be because people who choose to visit a science center are likely to already possess higher interest in science. Their findings suggest that visits to a science center help make authentic connections to the disciplinary understanding of science and thus strengthen existing interests. They report that museum visits increased interest among those who had been less engaged in science and that living in a community that had a new science center meant that learning from others' visits to the science museum also had an impact on those who had not yet visited. These findings also point to the connections that visitors and members of the community make to the disciplinary content of the exhibit, providing content-informed interactions and scaffolding for the development of interest and motivation, and, as a result, for engagement.

Ainley and Ainley (2011): PISA, Large-Scale Assessment of Specific Science Topics

International studies comparing learning gains provide the basis for evaluating educational systems and their practice. In the Programme for International Learner Assessment survey (OECD, 2006), the achievement of 15-year-old learners across OECD and partner countries was assessed in multiple disciplinary contents. In their 2011 article, Ainley and Ainley report on analyses of student responses to science problems that emphasize understanding and application of knowledge in real-life situations using data from samples of more than 4,000 learners from Colombia, the United States, Estonia, and Sweden each (total N = 19,044). The assessment contained items that allowed them to examine how overall enjoyment of science contributes to learners' interest in finding out more about specific topics. These items chronicled learners' reactions to the specifics of the topic on which the learners were working.

Ainley and Ainley found correlations between the students' reported enjoyment and their PISA science scores; they also found correlations between their interest for science and their PISA science scores. When learners finished working on the science problems (interest assessments were embedded to the science problems assessment), they were asked to complete a questionnaire assessing measures, such as personal value of science and enjoyment of science. The findings confirmed the expected association between enjoyment of science and interest in learning science and predicted learner interest in learning about specific topics. Path analyses further indicate that the relation between personal value and interest in science is partially mediated through enjoyment of science, and also that the relation between enjoyment and embedded interest is mediated through a strong positive relation between interest in learning science and embedded interest.

These findings are interpreted as suggesting both that learners need to have (a) connections to the content on which they are working in order to experience enjoyment and engagement, and (b) interactions with, and possibly scaffolding from, others such as educators or peers, or from the embedded context of tasks. Such interactions enable learners to identify meaning and relevance in the content of science, possibly leading to reevaluation of their perceptions of science learning.

Patrick, Ryan, and Kaplan (2007): The Role of the Social in Fifth-Grade Mathematics Classrooms, Survey and Achievement Data

The impact of the social context of classroom learning is typically assumed to be beneficial, but its impact on learning is not well understood. Patrick, Ryan, and Kaplan (2007) studied fifth-grade learners' (N=602) perceptions of classroom social environment, their motivational beliefs, and their engagement in a mathematics class. Using survey data and learner achievement data (math grades from learner records), three questions were asked: (a) How do learners' perceptions of various aspects of the classroom social environment (teacher and learner support, promotion of mutual respect, and task-related interaction) relate to their engagement in math? (b) Do measures of engagement (use of self-regulation strategies and task-related interactions with peers) correlate with math achievement? (c) Do learners' motivational beliefs (whether their goals were mastery oriented, and their feelings of academia and social efficacy) mediate the associations hypothesized in questions (a) and (b)?

Briefly, findings from this study help to detail the role of the classroom social environment in learner engagement. They indicate that classroom interactions with teachers about mathematics are related to learners' mathematics achievement beyond what might have been expected based on prior achievement. They also suggest that social interaction can enhance learners' focus on mastery and feelings of efficacy, and in this way, facilitate engagement.

Finally, they underscore the relation among the social environment, the content to be learned, and learner motivation and engagement and suggest that interactions focused on disciplinary content contribute to learning of that content.

Järvelä, Veermans, and Leinonen (2008): CSCL, Case Analysis Using Observations, Interviews, Artifact Analysis, and Experience Sampling

Motivational profiles of learners during classroom computer-supported collaborative learning (CSCL) were the focus of Järvelä, Veermans, and Leinonen's (2008) study of two 14-year-old Finnish girls' work with a science fiction project on Knowledge Forum (see Scardamalia & Bereiter, Chapter 20, this volume). The two learners were selected for study based on differences in their motivational profiles during classroom work that did not involve CSCL. Mixed methods including observations, interviews, content analysis of computer notes, and an experience-sampling questionnaire were employed.

Findings reveal that even though the two learners had different motivational tendencies in a more traditional classroom – one was high and the other low – each benefited and continued to develop as learners in the CSCL context. It appears that both girls were able to succeed because CSCL involves interacting with the content to be learned, and scaffolding that supports the construction of goals consistent with capacities, in turn structuring activity and enabling self-regulation and engagement. The findings further suggest that when learning tasks are authentic and meaningful, learners are likely to work to resolve difficulties that surface because they have made connections to them: they have identified something for which they want an answer, a curiosity question, and are working to address it. Moreover, the process of identifying a research problem related to personal experience served to trigger and sustain the interest of learners identified as having differing levels of motivation.

Renninger, Cai, Lewis, Adams, and Ernst (2011): Motivation and Learning in an Online Unmoderated Workshop, Descriptive Surveys, Artifact Analysis, Logfile Analysis, and Interviews

The role of mathematics teachers' motivation and learning during their work with unmoderated modules developed by the Math Forum (mathforum.org) for online professional development was undertaken by Renninger, Cai, Lewis, Adams, and Ernst (2011). Three questions guided their study: (a) What characterized the mathematics teachers who are working online in the workshop and what are their goals? (b) What is the nature of teacher participation in terms of motivation and learning in an online mathematics workshop? (c) Can participation in an online workshop for teachers be predicted?

Methods to assess motivation and learning in the online workshop context were developed through 13 previous iterations of workshop data. Analysis focused on one workshop that included a total of 164 teachers. Data sources included pre- and post-test descriptive surveys, logfile analysis, workshop artifacts, and interviews including general and contextualized information about teachers' motivation.

Findings from the study indicate that the participants' entering level of interest, self-efficacy, and prior course work in mathematics predicted the quality of their work with nonroutine technology-enhanced challenge problems and journal assignments that prompted exploration and reflection. Three distinct clusters of teachers were identified: (a) teachers with low interest, high self-efficacy, and more background in math course work, (b) teachers with low interest, low self-efficacy, and less math background, and (c) teachers with high interest, high self-efficacy, and more math background. Differences in participation led to three general recommendations for the design of online workshops: (a) recognition that learners do not all enter the learning environment with the same motivational profile, despite their role, in this case as "teacher"; (b) initial tasks that enable all learners to enter and build community with others whose profiles and previous experience differ from their own; (c) a range of activities that allow participants to select from among them. These findings provide strong support for the possibilities and the benefits of tailoring the design of the environment, the unmoderated online course in this case, to learners' motivational profiles.

Potential Design Principles and Some Conclusions

These studies provide us with some answers to questions about the roles of interest, motivation, and/or engagement in designing for learning. There is strong evidence that learners bring different preparations and interest to their activity that results in variation in:

- their motivation and engagement,
- sense that they can be successful, and
- the types of supports needed for learning.

The literature suggests that learning environments can and should ideally enable learners with varying preparation and interest and motivation to work with disciplinary content and also that learning environments can be designed to provide learners with this type of support. Moreover, it appears that learners' levels of interest, motivation, and engagement are often proportional, meaning that with developed interest, there is increased motivation and more effective engagement. In other words, design teams could anticipate differences in the levels of learners' interest, motivation, and engagement and include project or problem features in their designs that are likely to be effective for each, increasing the likelihood that one or another of these features will feel possible to the learner, triggering interest, enabling motivation, supporting productive engagement and learning.

Some learners may of course need more support than others because they do not yet recognize what others regard as learning opportunities. For those with little interest or understanding about particular content, the design of the learning environment can be adapted to enhance the quality and possibility of learner participation. Those who have a more developed interest, however, can, through adjusted supports, continue to be challenged to develop and deepen their interest and understanding.

In summary, it appears that design principles for learning need to account for differences of interest, motivation, and engagement and do so by: (1) supporting content-informed interactions and (2) providing scaffolding for learners to think and work with content.

Supporting Content-Informed Interactions

Learners may be low on interest, motivation, or engagement because they are early in their work with the field or because they have not yet been able to make effective connections to it. If so, design needs to make clear the utility of the content to be learned, its relevance, and/or by triggering their interest for the content through novelty, challenge, surprise, complexity, or uncertainty; design needs to make connections between the real world and the content to be learned or between one and another topic in the domain.

Learners with more developed interest, motivation, or engagement can be expected to already appreciate the utility of the content to be learned and to recognize its relevance. Although their interest is also triggered by novelty, challenge, surprise, complexity, and/or uncertainty, what counts as novelty and so forth differs for those with less interest, motivation, or engagement. For them, design needs to support learners to continue to deepen their thinking about domain-specific content.

Designing activities and tasks that allow multiple ways of accessing content to be learned, and as such varied ways to think and work with content, can increase the likelihood of engagement. This type of design can occur in the museum, the out-of-school workshop, the classroom, and online. Computer-based tools, CSCL, online modules, and social media embedded in learning environments have shown particular promise for enabling the differentiation of learning and instruction because they can provide tailored support for self-regulated and active task interactions such as elaboration and articulation or managing and aggregating information (Dabbagh & Kitsansas, 2012; Gresalfi & Barab, 2011; Laru, Näykki, & Järvelä, 2012). Computer-based tools and online modules have proven particularly effective for supporting active task interactions when learners are expected to function independently with limited interaction with teachers or peers (e.g., Mathan & Koedinger, 2005; Renninger et al., 2011).

Scaffolding Interactions with Disciplinary Content

It is critical that learners in earlier or less developed phases of interest, motivation, and engagement find utility or relevance in the disciplinary content to be learned, or be positioned to have their interest triggered for the content. Like Patrick and colleagues (2007), Hijzen, Boekaerts, and Vedder (2007) reported that student opportunities for collaboration, belongingness, and social support were related to student engagement and the quality of learning. Kempler-Rogat and Linnenbrink-Garcia's (2011) qualitative analyses of group observations across six collaborative groups of upper elementary students further suggest that characteristics of positive interactions are active listening, respectful interactions, and group cohesion.

For learners with more developed interest, motivation, and engagement, scaffolding that directly engages them in the content on which they are working and supports them to stretch their understanding is essential. They need to continue to develop and deepen their thinking and be supported to identify and find answers to their curiosity questions. Scaffolding interactions that promote work with disciplinary content provide learners with a foundation for independently reengaging content – not because they have to but because they want to.

We have provided evidence that learning environments are enhanced by:

- the inclusion of content-informed interaction, and
- the scaffolding of learners' interactions with disciplinary content.

Learning environments with these design features are likely to trigger, sustain, and support the development of learners' interest. As a result, they also can be expected to positively impact learners' motivation and their engagement.

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