Motivation, Engagement, and Interest

"In the End, It Came Down to You and How You Think of the Problem"

K. Ann Renninger, Yanyan Ren, and Heidi M. Kern

This chapter addresses the similarities and differences between motivation, engagement, and interest and their implications for learning science research. For example, it is possible for a person to be motivated or engaged, but not interested, whereas, when something is of some interest to a person, it is always motivating and engaging. Understanding these variables and the relations among them can contribute to the effective design, facilitation, and evaluation of learning environments as wide-ranging as everyday experiences (e.g., TV programming, family interactions, Facebook), designed settings (e.g., museums, online courses, zoos), and out-of-school programs (e.g., scouting, sports, music lessons).

"Motivation" concerns individuals and their response to their social and cultural circumstances; specifically the will to engage, and the influence of will on individuals' setting goals and working to accomplish them (Hidi & Harackiewicz, 2000; Wigfield, Eccles, Schiefele, Roeser, & Davis-Kean, 2006). "Engagement" typically deals with the context of participation and individuals' cognitive, affective, and behavioral responses to it, which reflect their beliefs about the possibility of their participation (Christenson, Reschly, & Wylie, 2012; Fredricks, Blumenfeld, & Paris, 2004; Shernoff, 2013). Finally, "interest" describes individuals' participation with particular content (e.g., computer science, ballet)—individuals' psychological states during engagement with that content, as well as the likelihood of their independent and voluntary reengagement with it over time (Hidi & Renninger 2006; Renninger & Hidi, 2016).

Consider the case studies of Nasir and Emily (Figure 12.1). They demonstrate how a learner's motivation and level of engagement can change depending on factors such as their interactions with other people and the structure of the task or environment. The cases also show the motivation and level of engagement that can characterize persons in different phases of interest development (Nasir with less, Emily more).

Nasir describes himself as motivated by the open-ended assignments he is given in his computer science (CS) courses, compared to the tight structure of chemistry assignments. He finds that his CS teachers put him in charge of his own learning by asking him to set and achieve realistic goals. He describes having fun working on rich problems alongside his friends. It may also be important that they may all be doing different things in order to accomplish their goals.

In contrast, Emily reports thriving on the structure and discipline of ballet once she understood that the intense practice required to master harder steps put her closer to being a "real" ballerina.

Case 1: Nasir*	Case 2: Emily
Nasir's eyes lit up when asked about his major in computer science (CS). Coming into college, Nasir had no idea what CS was. He assumed that he would be pursuing chemistry and only decided to take an introductory CS course because his friends were signing up for it. He explained, "CS [computer science] feels like art, like drawing." He described the first course, saying, "We all worked on designing a slot machine that worked. In the end, they did, and they were all different. We would look at each other's efforts to build a slot machine and laugh (even when it wasn't working). There wasn't a better or best answer. In the end, it came down to you and how you think of the problem." He explained that the project focus was novel for him and a contrast to the advanced chemistry course in which he was also enrolled. He said, "The [chemistry] lab journal felt unreasonably strict, and everything felt like a procedure," and noted that even though chemistry had been his intended major, he switched to major in CS after taking more classes and doing a summer internship as a software engineer. He described CS as challenging and at the same time doable, and the kind of thing that he and his friends had fun hanging around thinking and talking about.	Emily says that dance is an important part of who she is, but reports that it was not always this way. She started taking ballet classes at the age of 5. She looked up to the older dancers as role models, and worked hard in class to impress her teacher, who challenged and encouraged her. Each year Emily took more classes and performed more roles. Age 10 was a critical year for her. "I remember when I was 10, my teacher moved me into the advanced class, and I felt so out of place. I didn't think I'd ever be as good as the older girls. The steps were too hard for me, and I wanted to quit." She explained that instead of boosting her confidence, being moved into the advanced class lessened her self-efficacy. She left most classes feeling discouraged, but continued to attend them because of her mother's encouragement. That spring, her teacher announced that the following fall Emily would be ready for her first pair of pointe shoes (which she knew everyone got at age 12, not 10). "When my teacher said I was ready for pointe, my whole perception changed. I came to class every day working hard to make her proud and prove that I could do it. With pointe shoes, I could show everyone that I really was a ballerina." Emily persevered through the challenging exercises and continued into company classes and pointe work, earning more lead roles in the annual performances.

Figure 12.1 Case Studies

Note: Pseudonyms have been used for both cases.

She needed to figure out for herself that she could master the movements, even though other indicators might have shown her that this was the case (she was moved into the advanced class; she would be receiving pointe shoes in the fall).

In the sections that follow, we provide working definitions and findings in the study of motivation, engagement, and interest, and use Nasir's and Emily's cases for purposes of illustration. We review methods employed to assess these variables, consider their relation, and use the literature to suggest design principles for learning. We suggest that these variables are central to supporting deeper learning.

Working Definitions and Research

Motivation

Motivation is a broad term that encompasses both engagement and interest, as well as other topics such as: perceptions or beliefs about achievement, capability, or competence; expectancy (likelihood of benefit from one versus another action); value; and choice. These factors are addressed by a person's consideration of the possibility, utility, importance, and benefit of participating and belonging. Motivation can address learners' mindsets about whether learning or being able to understand new content/skills is possible; future time perspective; beliefs about self-efficacy, or the ability to work with a specific task, and/or their self-concept of ability, their sense of their ability to work with the types of tasks that characterize a domain, subject area, or field of study (e.g., science). Studies of motivation may focus on goals that individuals set for themselves and their readiness to take initiative

and/or to self-regulate in order to achieve these goals. Topics in motivation may also include consideration of boredom, as well as incentive salience or reward.

Topics in motivation are distinct variables and areas of study, but they often co-occur. In Nasir's and Emily's case material, for example, several topics in motivation are evident.

In his CS class, Nasir wants to (or has the motivation or will to):

- make the slot machine work (an identified goal);
- complete the homework (achievement motivation); and
- be successful in comparison to his classmates (expectancy value, the expectancy that this project is worth the time it is requiring).

Nasir's motivation for CS is informed by his work on the initial assignment to design a slot machine, the appeal of additional CS courses, and opportunities outside of class, such as the summer internship, to develop his ability to program. His motivation is supported by his belief that he had the coding skills needed to build the slot machine, a project with clear outcomes and goals. He kept coding even though he ran into some obstacles in the process, requiring him to take initiative and self-regulate in order to accomplish his goals. At any given point he might have been identified as being in a flow state (Csikszentmihalyi, 1990), and as interested. He did not find the same challenge in chemistry; he found the assignments procedural and constraining, which led him to lose interest.

Nasir's perseverance illustrates how the right level of challenge serves as motivation: he uses his knowledge to solve the problems, gains a sense of accomplishment, and gets ready to solve more complex problems. As a result, Nasir found CS rewarding. His interest in CS had begun to develop; he was both motivated and engaged.

Considering Emily's case along with Nasir's reveals the similarity of their motivation, despite differences in their disciplinary focus and interest level.

In her advanced class, Emily has the motivation to:

- do well (short-term goal);
- become a ballet dancer (long-term goal);
- take on more roles in the annual performance to impress friends and family in the audience (performance goal); and
- master ballet for the sake of art (mastery goal).

Emily's motivation for ballet is influenced by the structure and discipline of ballet, as well as the ballet class she is taking. She has developed her ability to dance in the context of successively challenging classes, and is influenced by role models like her teacher and older classmates. Knowing that the advanced class was for the older and more developed dancers, Emily was very motivated to get into it (achievement motivation). But when she was asked to master steps she did not yet know, participation felt overwhelming, and the challenge affected her self-efficacy. Emily's motivation and her interest in ballet began to wane. Her mother's encouragement was critical to Emily's continued participation in the class, and the promise of pointe shoes signaled that her teacher thought the challenges of the class were within her reach.

Emily's case portrays the mix of goals that underlie learner motivation: short-term and long-term, performance and mastery (Vedder-Weiss & Fortus, 2013). Even though getting pointe shoes made her feel accomplished, it is her mastery of the dance sequences—the development of her knowledge and corresponding value for the dance sequences as integral to ballet—that is motivating. Emily's case also provides insight into how transitional support from other people and possible attainments such as pointe shoes can contribute to continued motivation, even for those with more developed interest.

Nasir's and Emily's cases highlight people's different needs for support in recognizing and engaging with opportunity (e.g., new disciplinary pursuits, advanced coursework). It is through interactions

with others that they determine whether they think that they can be successful (self-efficacy), set goals for themselves, and self-regulate.

Engagement

Although many topics either individually or together can be used to describe motivation, engagement is a meta-construct that describes the context of participation (e.g., school, sports team, family) and individuals' cognitive, affective, and behavioral responses to it. Moreover, as Fredricks et al. (2004) point out, the cognitive, emotional, and behavioral components of engagement co-occur and, unlike topics in motivation, overlap.

Cognitive engagement describes how invested people are in a given task, their conscientiousness and/or willingness to exert effort in order to master challenging content and difficult skills. Both Nasir and Emily are cognitively engaged, because they are receptive to support from other people and the structure of the tasks on which they are working. They are able to work with challenge and persevere to set and achieve their goals. Nasir and Emily are emotionally and behaviorally engaged, as well. Their emotional engagement refers to their attitudes about the learning environment, including their feelings that they can engage. Their behavioral engagement includes their continuing participation in CS and ballet, respectively, and their subscribing to rules, expectations, and norms of these learning environments.

Nasir's developing interest in CS and Emily's interest in ballet distinguish them from those who lack motivation and interest, and whose disengagement and ensuing school dropout rates have motivated much of the research on engagement (Reschly & Christenson, 2012). When learners have not yet made a connection to the assignments, tasks, or contexts in or on which they are supposed to be working, they may engage superficially, and can benefit from support to evaluate their situations, rules, and expectations. Their situations differ radically from those of students like Nasir who are meaningfully engaged, even if their interest is not fully developed.

Nasir was excited to engage deeply with the CS assignment. He saw that the assignment was not just an opportunity to earn a grade, but allowed him to learn to code. The learning environment gave him the chance to work with challenging content and collaborate with others for strategies, yet follow his personal design ideas, creating a unique slot machine that he was proud of. Nasir's meaningful engagement is similar to that of the youth Boxerman, Lee, and Olsen (2013) describe, who used video to document science on their outdoor field trip, and those who participated in the structured and collaborative version of Gutwill and Allen's (2012) museum program, *Inquiry Games*.

Interest

Interest describes meaningful participation with particular content: people's psychological state during engagement, as well as the likelihood that they will continue to re-engage that content over time. In their four-phase model of interest development, Hidi and Renninger (2006) describe interest as developing through four phases: triggered situational interest, maintained situational interest, emerging individual interest, and well-developed individual interest (Table 12.1).

Neuroscience has established that triggering, or activation, of interest is associated with reward circuitry in the brain (Berridge, 2012). This means that once interest is triggered and begins to develop, engaging the content of interest becomes its own reward. It also indicates that interest can be triggered, regardless of a person's age, gender, previous experience, and personality. The goal in working with those who have less developed interest or none at all is to make engagement feel rewarding.

Interest can be triggered or introduced by other people (e.g., teachers, coaches, peers), by the tasks and activity of the learning environment, and by a person's own efforts to deepen understanding. The process is one in which attention is piqued, and present knowledge and value is then

Table 12.1 Learner Characteristics, Feedback Wants, and Feedback Needs in Each of the Four Phases of Interest Development

	Less developed (earlier)		More developed (later)	
	PHASE 1 – Triggered Situational Interest	PHASE 2 – Maintained Situational Interest	Phase 3 – EMerging Individual Interest	PHASE 4 – WELL-DEVELOPED INDIVIDUAL INTEREST

Learner characteristics	Learners:
	• Attend to content, if only fleetingly
	• Need support to engage content:
	  ○ From others (e.g., group work, instructional conversation)
	  ○ Through instructional design (e.g., software)
	• May experience either positive or negative feelings
	• May or may not be reflectively aware of the experience.
		Learners:
		• Re-engage content that previously triggered attention
		• Are supported by others to find connections between their skills, knowledge, and prior experience
		• Have positive feelings
		• Are developing knowledge of the content
		• Are developing a sense of the content's value.
			Learners:
			• Are likely to independently re-engage content
			• Have curiosity questions that lead them to seek answers
			• Have positive feelings
			• Continue developing knowledge and value for what they understand
			• Are very focused on their own questions
			• May have little value for the canon of the discipline and most feedback.
				Learners:
				• Independently re-engage content
				• Have curiosity questions
				• Self-regulate easily to reframe questions and seek answers
				• Have positive feelings
				• Can persevere through frustration and challenge in order to meet goals
				• Recognize others' contributions to the discipline, as well as the presence of additional information/skills/ perspectives to be understood
				• Actively seek feedback.

Feedback wants	Learners want: • To have their ideas respected • Others to understand how hard work with this content is • To simply be told how to complete assigned tasks in as few steps as possible.	Learners want: • To have their ideas respected • Concrete suggestions • To be told what to do.	Learners want: • To have their ideas respected • To express their ideas • *Not* to be told to revise present efforts.	Learners want: • To have their ideas respected • Information and feedback • To balance their personal standards with more widely accepted standards in the discipline.
Feedback needs	Learners need: • To feel genuinely appreciated for the efforts they have made • A limited number of concrete suggestions.	Learners need: • To feel genuinely appreciated for the efforts they have made • Support to explore their own ideas.	Learners need: • To feel that their ideas and goals are understood • To feel genuinely appreciated for their efforts • Feedback that enables them to see how their goals can be more effectively met.	Learners need: • To feel that their ideas have been heard and understood • Constructive feedback • Challenge.

stretched. Novel information can trigger interest by calling attention to gaps in or differences from previous understanding, enabling the development of new knowledge. Triggers for interest can be included in lectures or in discussion, and can also be embedded in assignments, tasks, or activities.

Nasir's and Emily's cases illustrate interest development. In describing his developing interest in CS, Nasir points to support from his friends, the challenge (and doable nature) of the task, differences between the assignments in CS and chemistry, and his feelings about them. Even though Nasir had entered college with an interest in chemistry, this interest had fallen off, at least in part because of the procedural nature of the assignments, and presumably because neither his professor nor peers had supported him to understand the importance or utility of the procedural nature of the tasks, nor had he asked questions about this. In contrast, the connections that Emily had developed to ballet were deep. However, the difficult period that she described is common even for those who have a developed interest. Emily needed support in order to persevere. In Emily's case, her mother's and teacher's encouragement served as critical triggers for her continued study of ballet, and the promise of pointe shoes enabled her to continue to work on what at the time probably felt like the procedural details of the dance steps she needed to master.

The four-phase model describes phases (not stages) because an initial triggering of interest may, or may not, lead to the development of a well-developed interest. If interest is not supported to develop, it will fall off, go dormant, or possibly disappear altogether (Bergin, 1999). Interest continues to develop depending on the quality of a person's interactions with other people and/or the design of tasks in the learning environment (e.g., Linnenbrink, Patall, & Messersmith, 2012; Renninger et al., 2014; Xu, Coates, & Davidson, 2011).

The development of interest is coordinated with the development of other motivational variables and with a person's self-representation, or identity (Renninger, 2009). Those with less developed interest like Nasir may need scaffolding from others and/or their tasks in order to know how to work with new content. They do not identify as persons who pursue the potential interest (e.g., computer scientists); they may not even think that developing an interest is possible. Their self-efficacy and their ability to self-regulate may be low. These people need scaffolding and feedback to enable them to make connections to the content to be learned (Table 12.1).

On the other hand, those with more developed interest, like Emily, are typically able to deepen their knowledge independently, as long as they continue to feel challenged and have confidence. Emily identifies as a ballerina, and has well-developed self-efficacy and self-regulation ability. However, if the tasks on which they are working feel impossible, their situation is not unlike those with less developed interest. They, too, need support to find continued engagement rewarding.

Methods, an Overview

Studies of motivation primarily address basic research questions such as how and why a particular variable works as it does. As such, they tend to focus on one or two motivation topics as independent variables, and analyze their relation to outcomes such as performance on standardized achievement measures. The different topics in motivation are typically targeted for study as though they were distinct from one another, although in practice they co-occur, as Nasir's and Emily's case material indicates. With the exception of studies of engagement and to some extent those addressing interest, motivation research does not usually report on, or include analyses of, the learning environment.

Because studies of engagement often focus on understanding disengagement and how to enable the disengaged to become productive participants, they are concerned with how people engage in the learning environment. The learning environment is typically studied as a dependent variable, and participants' engagement, as reflected in their cognitive, affective, and behavioral responses, is studied in relation to it. Researchers have conducted both survey-based quantitative studies (e.g., Martin et al., 2015) as well as more qualitative studies (e.g., Dhingra, 2003; Rahm, 2008) that

provide descriptions of learning environments and participants' cognitive, affective, and behavioral responses to them. Although some researchers investigating engagement do not conduct interventions, the forms of descriptive data that are collected can be used to enable school psychologists and educators to intervene to increase the likelihood of meaningful engagement (e.g., Christenson & Reschly, 2010).

Studies of interest are by definition both studies of continuing motivation and studies of meaningful engagement. As such, they have focused on interest as both a dependent and independent variable. When interest is studied as a dependent variable, the focus is often on topics of interest or the development of interest through interactions with the learning environment. When interest is studied as an independent variable, investigations consider the effect of interest on other variables such as attention, memory, or school performance.

Researchers studying motivation, engagement, and interest often use self-reports from surveys (e.g., Patterns of Adaptive Learning Scales [PALS; Midgley et al., 2000]), Likert-type anonymous questionnaires (Vedder-Weiss & Fortus, 2013), or semi-structured, in-depth interviews (e.g., Azevedo, 2013). These data provide descriptive information about the frequency (or amount) and/or quality of the variable under study, and are often analyzed as influences on the learning environment (as independent variables).

Because self-reports are dependent on how self-aware and reflective participants are, coupling self-report data with other data sources may be important in ensuring the accuracy of self-reports, especially when participants lack motivation, engagement, or interest. Examples of such data sources include: ethnographic data (e.g. Ito et al., 2010); observational or video data (e.g., Barron, Gomez, Pinkard, & Martin, 2014), artifact analysis (e.g., Cainey, Bowker, Humphrey, & Murray, 2012), and experience sampling (e.g., Järvelä, Veermans, & Leinonen, 2008).

As sampling permits, and research questions specify, age, gender, race, and status as a first generation student are likely to be addressed in each of these literatures. As described in the previous section of this chapter, the motivation, engagement, and interest of all individuals have similar characteristics. However, groups of individuals with similar demographic profiles also can vary in the frequency, intensity, or development of their motivational or engagement profiles or topics of interest. Such differences may require different support for learning.

For example, work on competence and achievement indicates that, even at very young ages, children are aware of their performance and care about it (Wigfield et al., 1997). At approximately 8–10 years of age, they begin engaging in self-other comparisons (Harter, 2003) and, as Renninger (2009) points out, these have implications for the kinds of support that they may need to seriously engage content that they have not already mastered (Table 12.1). It is because of this that learners roughly below the age of 8 are more likely and readily able to work in and explore different content areas than are those who are older. This does not mean that those who are older cannot develop interest, but it does affect the nature of the supports that may need to be in place for that to happen.

Gender is another variable that can affect performance, and appears to be related to the context of the tasks provided. Topics such as health and caring for humans have been found to be more girl-friendly. For example, Hoffmann and Häussler (1998) reported that girls' learning is benefited if heart pumps rather than oil pumps are used to provide the context for physics instruction, and that boys work with either context effectively. Another finding from this project was that, given that girls often have little experience with mechanical objects, it made a difference when teachers focused units dealing with force and velocity on cyclists' use of safety helmets (Hoffmann, 2002). Similarly, self-perception (e.g. "I love math") plays a more important role for women than men when they are deciding to pursue a computing-related education (Hong, Wang, Ravitz, & Fong, 2015).

Ethnicity too has been found to affect patterns of engagement and participation (e.g., Huang, Taddese, & Walter, 2000). For example, in the sciences, Latino and Asian families have been

identified as communicating stronger and clearer messages about participation than either white or African American families (e.g., Archer et al., 2012).

Participation of underrepresented students and first generation students who are at risk for school success is also positively influenced by utility value, or relevance, interventions (see Hulleman, Kosovich, Barron, & Daniel, 2016). These interventions are relatively simple, involving supporting students to articulate and reflect on their connections to subject matter, frequently through writing. This type of intervention has been repeatedly demonstrated to improve course performance, likely pursuit of additional courses, and increased interest in the subject matter for those who are at risk, with no detriment to those who are not.

Implications: Design Principles for Learning Informed by Motivation, Engagement, and Interest

In the course of reviewing the literature on motivation, engagement, and interest for this chapter, and again in working with Nasir's and Emily's cases, we identified three design principles for learning:

1   Learners need to work with relevant disciplinary content in order for it to become rewarding. They need to work with the language and tasks of the content, and begin to develop an interest in it in order to develop their abilities to work with its challenge and through this extend their current understanding.
2   Support for learners to work with the content can be provided through scaffolding by another person or by the design of tasks and activities. Moreover, learners in earlier and later phases of interest development are likely to need different types of interactions and/or support to engage disciplinary content.
3   The structure of tasks, activities, or the learning environment may need to be adjusted for learners in different phases of interest development to enable them to focus on relevant aspects of the tasks and be challenged to pursue understanding.

We set these design principles out as generalized principles (not "fix-all" step-by-step formulas) and encourage subsequent studies, with replications, of each principle (Makel & Plucker, 2014). We also note the importance of reporting studies with insignificant results, as these data are as critical for moving the field ahead as those that are significant: they can flag questionable assumptions and balance others reporting the same studies (Rothstein, Sutton, & Borenstein, 2006).

Nasir's and Emily's cases illustrate these design principles. Both Nasir and Emily need to make their own connections to content. They also both need support from others or the tasks themselves, despite differences in what they are prepared to work with. The nature of the interactions they have with others, or the tasks and challenges that they are given, need to be aligned to their phase of interest development.

In his Network of Academic Programs in the Learning Sciences (NAPLeS) webinar, Hoadley (2013) describes working to identify design principles that can be generalized across contexts. Each of the questions he identified involve either motivation, engagement, or interest, or would be informed by considering them. It would be a mistake to overlook the centrality of motivation, engagement, and interest in individuals' participation and learning: it could affect whether a project's goals will be achieved, and/or whether a research project is likely to inform practice. Understanding the design implications of research on these terms could significantly improve equity of resource allocation, the quality of support provided to youth, and so forth. Nasir's and Emily's motivation, engagement, and interest were influenced by how each thought about their respective problems, and this influenced their participation and learning. As Nasir observed, "In the end, it came down to you and how you think of the problem."

Acknowledgments

Further Readings

Gutwill, J. P., & Allen, S. (2012). Deepening students' scientific inquiry skills during a science museum field trip. *Journal of the Learning Sciences, 21*(1), 130–181. doi:10.1080/10508406.2011.555938
This article describes the creation and study of the museum program *Inquiry Games*, designed to enhance students' inquiry skills at interactive science museums. It reports on the measurement of engagement (*holding time*, or how much time students chose to spend at an exhibit), outcomes of meaningful engagement, and the role of chaperones in a field trip group.

Hidi, S., & Harackiewicz, J. M. (2000). Motivating the academically unmotivated: A critical issue for the 21st century. *Review of Educational Research, 70*(2), 151–179. doi:10.3102/00346543070002151
This article provides a comprehensive review of the literature on goals and interest and explains why reference to dichotomies such as extrinsic and intrinsic motivation, or mastery and performance goals is problematic.

Ito, M. S., Baumer, S., Bittanti, M., boyd, d., Cody, R., Herr Stephenson, B., et al. (2010). *Hanging out, messing around, and geeking out: Kids living and learning with new media*. Cambridge, MA: MIT Press.
This volume reports on the "connected learning" approach, which combines interest-driven learning with interpersonal support and a link to academics, career success, or civic engagement. It also addresses how media can support learning environments to foster connected learning.

Renninger, K. A., & Hidi, S. (2016). *The power of interest for motivation and engagement*. New York: Routledge.
This volume provides an overview of interest research and includes detailed notes for researchers at the end of each chapter. It explains how interest can be supported to develop its measurement, the relation between interest and the development of other motivational variables, studies of interest across in- and out-of-school topic areas, and declining interest.

Vedder-Weiss, D., & Fortus, D. (2013). School, teacher, peers, and parents' goals emphases and adolescents' motivation to learn science in and out of school. *Journal of Research in Science Teaching, 50*(8), 952–988. doi:10.1002/tea.21103
This article reports on students' motivation and engagement: how parents' perceptions of goals predict students' motivation, how school structure influences students' goal setting, and how the peer network affects students' levels of motivation.

NAPLeS Resources

Hoadley, C. *A short history of the learning sciences* [Video file]. In *NAPLeS video series*. Retrieved October 19, 2017, from http://isls-naples.psy.lmu.de/intro/all-webinars/hoadley_video/index.html
Renninger, K. A., Ren, Y., & Kern, H. M. *Motivation, engagement, and interest* [Video file]. *Introduction and discussion*. In *NAPLeS video series*. Retrieved October 19, 2017, from http://isls-naples.psy.lmu.de/video-resources/guided-tour/15-minutes-renninger/index.html

References

Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B., & Wong, B. (2012). Science aspirations, capital, and family habitus how families shape children's engagement and identification with science. *American Educational Research Journal*, *49*(5), 881–908. doi:10.3102/0002831211433290
Azevedo, F. S. (2013). Knowing the stability of model rockets: An investigation of learning in interest-based practices. *Cognition and Instruction*, *31*(3), 345–374. doi:10.1080/07370008.2013.799168
Barron, B. Gomez, K., Pinkard, N., & Martin, C. K. (Eds.) (2014). *The Digital Youth Network: Cultivating digital media citizenship in urban communities*. Cambridge, MA: MIT Press.

Bergin, D.A. 1999. Influences on classroom interest. *Educational Psychologist*, *34*, 75–85. doi:10.1207/ s15326985ep3402_2

Berridge, K. C. (2012). From prediction error to incentive salience: Mesolimbic computation of reward motivation. *European Journal of Neuroscience*, *35*, 1124–1143. doi:10.1111/j.1460-9568.2012.07990.x

Boxerman, J. Z., Lee, V. R., & Olsen, J. (2013, April). *As seen through the lens: Students' encounters and engagement with science during outdoor field trips*. Paper presented at the Annual Meeting of the American Educational Research Association, San Francisco, CA.

Cainey, J., Bowker, R., Humphrey, L., & Murray, N. (2012). Assessing informal learning in an aquarium using pre- and post-visit drawings. *Educational Research and Evaluation*, *18*(3), 265–281.

Christenson, S. L., & Reschly, A. L. (2010). Check & Connect: Enhancing school completion through student engagement. In B. Doll, W. Pfohl, & J. Yoon (Eds.). *Handbook of youth prevention science* (pp. 327–348). New York: Routledge.

Christenson, S. L., Reschly, A. L., & Wylie, C. (Eds.). (2012). *Handbook of research on student engagement*. New York: Springer. doi:10.1007/978-1-4614-2018-7

Csikszentmihalyi, M. (1990). *Flow: The psychology of optimal experience*. New York: Harper & Row.

Dhingra, K. (2003). Thinking about television science: How students understand the nature of science from different program genres. *Journal of Research in Science Teaching*, *40*(2), 234–256. doi:10.1002/tea.10074

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research,* *74(*1), 59–109. doi:10.3102/00346543074001059

Gutwill, J. P., & Allen, S. (2012). Deepening students' scientific inquiry skills during a science museum field trip. *Journal of the Learning Sciences*, *21*(1), 130–181. doi:10.1080/10508406.2011.555938

Harter, S. (2003). The development of self-representation during childhood and adolescence. In M. R. Leary & J. P. Tangney (Eds.), *Handbook of self and identity* (pp. 610–642). New York: Guilford.

Hidi, S., & Harackiewicz, J. M. (2000). Motivating the academically unmotivated: A critical issue for the 21st century. *Review of Educational Research*, *70*(2), 151–179. doi:10.3102/00346543070002151

Hidi, S., & Renninger, K. A. (2006). The four-phase model of interest development. *Educational Psychologist*, *41*(2), 111–127. doi:10.1207/s15326985ep4102_4

Hoadley, C. (2013, September 30). *A short history of the learning sciences* [Video file]. In *NAPLeS video series*. Retrieved October 19, 2017, from http://isls-naples.psy.lmu.de/intro/all-webinars/hoadley_video/ index.html

Hoffmann, L. (2002). Promoting girls' interest and achievement in physics classes for beginners. *Learning and Instruction*, *12*(4), 447–465. doi:10.1016/s0959-4752(01)00010-x

Hoffmann, L. & Häussler, P. (1998). An intervention project promoting girls' and boys' interest in physics. In L. Hoffmann, A. Krapp, K.A. Renninger, & J. Baumert (Eds.), *Interest and learning* (pp. 301–316). Kiel, Germany: IPN.

Hong, H., Wang, J., Ravitz, J., & Fong, M. Y. L. (2015, February). Gender differences in high school students' decisions to study computer science and related fields. *Symposium on Computer Science Education* (p. 689), Kansas, MO.

Huang, G., Taddese, N. & Walter, E. (2000). *Entry and persistence of women and minorities in college science and engineering education* (Research and Development Report NCES 2000-601). Washington, DC: National Center for Education Statistics. Retrieved January 24, 2018, from https://nces.ed.gov/ pubs2000/2000601.pdf

Hulleman, C. S., Kosovich, J. J., Barron, K. E., & Daniel, D. B. (2016). Making connections: Replicating and extending the utility value intervention in the classroom. *Journal of Educational Psychology*, *109*(3), 387–404. doi:10.1037/edu0000146

Ito, M. S., Baumer, S., Bittanti, M., boyd, d., Cody, R., Herr Stephenson, B., et al. (2010). *Hanging out, messing around, and geeking out: Kids living and learning with new media*. Cambridge, MA: MIT Press.

Järvelä, S., Veermans, M., & Leinonen, P. (2008). Investigating learners' engagement in a computer-supported inquiry—A process-oriented analysis. *Social Psychology in Education*, *11*, 299–322.

Linnenbrink-Garcia, L., Patall, E. A., & Messersmith, E. E. (2012). Antecedents and consequences of situational interest. *British Journal of Educational Psychology*, *83*(4), 591–614. doi:10.1111/j. 2044-8279.2012.02080.x

Makel, M. C., & Plucker, J. A. (2014). Facts are more important than novelty. *Educational Researcher*, *43*(6), 304–316. doi:10.3102/0013189X14545513

Martin, A., Papworth, B., Ginns, P., Malmberg, L., Collie, R., Calvo, R. (2015). Real-time motivation and engagement during a month at school: Every moment of every day for every student matters. *Learning and Individual Differences*, *38*, 26–35.

Midgley, C., Maehr, M. L., Hruda, L., Anderman, E. M., Anderman, L., Freeman, K. E., et al. (2000). *Manual for the Patterns of Adaptive Learning Scales (PALS)*. Ann Arbor, MI: University of Michigan.

Rahm, J. (2008). Urban youths' hybrid positioning in science practices at the margin: A look inside a school–museum–scientist partnership project and an after school science program. *Cultural Studies of Science Education*, *3*(1), 97–121. doi:10.1007/s11422-007-9081-x

Renninger, K. A. (2009). Interest and identity development in instruction: An inductive model. *Educational Psychologist*, *44*(2), 1–14. doi:10.1080/00461520902832392

Renninger, K. A., Austin, L., Bachrach, J. E., Chau, A., Emmerson, M. S., King, R. B., et al. (2014). Going beyond the "Whoa! That's cool!" of inquiry. Achieving science interest and learning with the ICAN Intervention. In S. Karabenick & T. Urdan (Eds.), *Motivation-based learning interventions*, Advances in Motivation and Achievement series (Vol. *18*, pp. 107–140). United Kingdom: Emerald Publishing. doi:10.1108/S0749-742320140000018003

Renninger, K. A., & Hidi, S. (2016). *The power of interest for motivation and engagement*. New York: Routledge.

Reschly, A. L., & Christenson, S. L. (2012). Jingle, jangle, and conceptual haziness: Evolution and future directions of the engagement construct. *Handbook of research on student engagement* (pp. 3–19). New York: Springer. doi:10.1007/978-1-4614-2018-7_1

Rothstein, H. R., Sutton, A. J., & Borenstein, M. (Eds.). (2006). *Publication bias in meta-analysis: Prevention, assessment and adjustments*. Hoboken, NJ: John Wiley.

Shernoff, D. J. (2013). *Optimal learning environments to promote student engagement*. New York: Springer. doi:10.1007/978-1-4614-7089-2

Vedder-Weiss, D., & Fortus, D. (2013). School, teacher, peers, and parents' goals emphases and adolescents' motivation to learn science in and out of school. *Journal of Research in Science Teaching*, *50*(8), 952–988. doi:10.1002/tea.21103

Wigfield, A., Eccles, J., Schiefele, U., Roeser, R., & Davis-Kean, P. (2006). Development of achievement motivation. In R. Lerner & W. Damon (Series Eds.), N. Eisenberg (Vol. Ed.), *Handbook of child psychology*, Vol. *3*, *Social, emotional, and personality development* (6th ed., pp. 933–1002). New York: Wiley.

Wigfield, A., Eccles, J. S., Yoon, K. S., Harold, R. D., Arbreton, A. J. A., Freedman-Doan, C., & Blumenfeld, P. C. (1997). Change in children's competence beliefs and subjective task value across the elementary school years: A 3-year study. *Journal of Educational Psychology*, *89*, 451–469.

Xu, J., Coats, L. T., & Davidson, M. L. (2011). Promoting student interest in science: The perspectives of exemplary African American teachers. *American Educational Research Journal*, *49*(1), 124–154. doi:10.3102/0002831211426200