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Interest, Cognition, and the Case of L- and Science

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In her most recent interview, 15-year-old L – comments: "Every year they ask me, do I want to be a scientist? And, every year I tell them no, I don't want to be a scientist. I don't like science. It's not for me." Yet participant observation notes indicate that L – has been staying after the workshop every day to work on her lab notebook and to help get materials ready for the next day. She also uses this time to engage in discussions and to ask questions. She seems to like thinking about connections between the day's focus and those of previous days. She appears to want to understand how the experiments they have been doing fit together. (Interview, Year 5)

Interest is a cognitive and affective motivational variable that is dependent on cognition. A learner typically has four to six reasonably well-developed interests and can develop new interests at any age – although the types of supports that are likely to be needed may vary based on age and experience (Renninger, 2009).

In order to engage, a learner needs to perceive the features of particular content such as science as something to which to attend. Although interest may be supported to develop through use of metacognitive strategies such as questioning and prompted reflection, it is often an unreflective state or process. When engaged due to interest, a person is not necessarily thinking about his or her interest but rather about the particulars of the activity or content of interest. Interest can be triggered without a learner being aware of its occurring, and interest is not always something that learners (especially younger learners) can simply will themselves to experience (Renninger, Sansone, & Smith, 2004). However, when the learner is aware of his or her interest, this can support interest to develop (Sansone & Thoman, 2005a, 2005b; Renninger & Su, 2012).

It is now generally accepted that when interest is present, learner attention, goal setting, and strategy use are positively influenced (Hidi & Renninger, 2006): interest, as James (1890) wrote, "schools attention." In her model of

domain learning, Alexander (2004) described interest as linked to knowledge and strategic efforts, and suggested that competence can be nurtured by immersing learners in meaningful learning experiences. Thus, for example, calling learners' attention to the meaning that a writing task holds for them has been found to improve learners' connections to tasks and yield improved performance (Hulleman et al., 2008). Type of activity (e.g., group work, computers, and novel tasks) has been shown to have an influence on learner engagement (Mitchell, 1993; Palmer, 2009). Inserting interest into tasks in reading or math has also been shown to affect the depth of learners' processing (Renninger, Ewen, & Lasher, 2002; Schiefele & Krapp, 1996). It appears that interest is not only dependent on cognition but that it also influences the "what" of cognition: to what the learner attends and how he or she engages.

Yet until relatively recently, interest was often described and studied as if it were dichotomous – a learner either has or does not have interest – suggesting to some (sometimes including the learner) that interest does not and is not likely to develop. This is not the case, however. There is now research evidence to confirm that interest in its earliest phases needs to be supported by other persons and requires ongoing support if it is to develop, placing responsibility for whether interest develops on other people and the types of opportunities that are available to the learner (Gisbert, 1998; Renninger & Hidi, 2002; Tsai et al., 2008). In the neuroscientific literature, interest-based activities are referred to as "seeking behavior" (Panksepp, 1998; see discussion in Hidi, 2006). Brain reactions have been found to differ when a learner is and is not engaged with content (Ashby, Isen, & Turken, 1999; Hidi & Ainley, 2008). Learner attention is triggered and sustained depending on (a) what a person perceives when presented with disciplinary content (see Renninger, 1990, 2000, 2009; Renninger & Lipstein, 2006); (b) his or her interactions with others; and/or (c) the conditions of the environment (Azevedo, 2006, 2011; Barron, 2006; Cobb & Hodge, 2004; Sansone & Thoman, 2005a; 2005b).

The present chapter describes research that bears on the relation between the development of interest and cognition. As such, although interest is elsewhere conceptualized as an attitude, belief, reward, or vocational pursuit, interest is here discussed as *both* a psychological state and a predisposition to return to engagement with particular disciplinary content (e.g., music, softball, science; Hidi & Renninger, 2006; see also discussions in Ainley, 2006; Alexander, 2004; Barron, 2006; Renninger & Hidi, 2011; Sansone, 2009; Silvia, 2006). Based on the empirical literature, phases in the development of interest have been identified as ranging from an initial triggered situational interest that may only last for a few moments to a well-developed individual interest that is relatively long-lasting (Hidi & Renninger, 2006; see Table 17.1).

TABLE 17.1. *Learner Characteristics and Needs in Interest Development*

	Phases of Interest Development			
	Triggered Situational	**Maintained Situational**	**Emerging Individual**	**Well-Developed Individual**

Learner Characteristics	• Attend to content, if only fleetingly
	• Need support to engage
	  • From others
	  • Through instructional design
	• May experience either positive or negative feelings
	• May or may not be reflectively aware of the experience
		• 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
			• Are likely to independently re-engage content
			• Have curiosity questions that lead them to seek answers
			• Have positive feelings
			• Have stored knowledge and stored value
			• Are very focused on their own questions
				• 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
				• Actively seek feedback

Needs/More Closed Learning Environment	• To have their ideas respected • To feel genuinely appreciated for their efforts • To have others understand how hard work with this content is • Limited concrete suggestions	• To have their ideas respected • To feel genuinely appreciated for their efforts • Support to explore their own ideas	• To have their ideas respected • To feel genuinely appreciated for their efforts • To feel that their ideas and goals are understood	• To have their ideas respected • Information and feedback • To balance their personal standards with more widely accepted standards in the discipline • To feel that their ideas have been heard and understood

	Phases of Interest Development			
	Triggered Situational	**Maintained Situational**	**Emerging Individual**	**Well-Developed Individual**
			• Feedback that enables them to see how their goals can be more effectively met	• Constructive feedback • Challenge
Needs/More Open Learning Environment	• To have their ideas respected • To feel genuinely appreciated for the efforts they have made • To know that they understand the content	• To have their ideas respected • To feel genuinely appreciated for the efforts they have made • To know what they have learned and what they still want to learn	• To have their ideas respected • To express their ideas • *Not* to be told to revise present efforts • 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 were met	• To have their ideas respected • Information and feedback • To balance their personal standards with more widely accepted standards in the discipline • To feel that their ideas have been heard and understood • Constructive feedback • Challenge

Interest develops through a process of triggering: interactions or circumstances that result in the reorganization of learner thinking and activity (Alexander, 2004; Renninger & Hidi, 2002). Triggers for interest have been described as promoting uncertainty, surprise, novelty, complexity, or incongruity (Berlyne, 1960; see also Durik & Harackiewicz, 2007; Renninger, Bachrach, & Posey, 2008). For example, in earlier phases of interest these might include group work in the classroom or content that is personally meaningful (Hidi et al., 1998; Mitchell, 1993); in later phases, triggers could stem from instructional conversations (Yamuchi, Wyatt, & Carroll, 2005), content-informed scaffolding (Renninger et al., 2005), or self-generated curiosity questions (Renninger, 1990, 2010).

As interest develops, the learner's evolving knowledge about, valuing of, and feelings for content change. The earliest phase of interest may be easily identified by positive or negative affect, but the development of principled knowledge about the discipline and the accompanying recognition of value account for changes in the learner's phase of interest (Nolen, 2007; Renninger, Bachrach, & Posey, 2008). In later phases of interest, the learner's commitment to, skills with, and identification with content are readily distinguished from those in earlier phases of interest (Azevedo, 2006, 2011; Barron, 2006; Renninger, 1990, 2009, 2010; Renninger et al., 2002; Renninger & Hidi, 2002). In later phases, the learner generates, reflects on, and pursues his or her curiosity questions – questions that are novel to the learner but not necessarily new to those who have more information (Renninger 2000, 2010; Renninger & Su, 2012).

The case of L – illustrates the process of interest development and presents a context for its further examination. L – was 10 years old when we first began studying her cohort of 8 (5 girls, 3 boys) participants in the Science-for-Kids Workshop, an out-of-school, inquiry-oriented science workshop for at-risk youth.

> She was a child who appeared extremely moody and presented as a disengaged learner; she alternately seemed to enjoy and resist workshop activities. Her engagement seemed linked to whatever she wanted to know more about. (Notes, Year 1)

The participant observation notes and her interviews indicated that she thought about science the way she would think about anything else; she was more philosophical than scientific.[1] For example, her questions during the week she and her workshop group learned about worms included: "What do worms die from?" "What kind of culture do they have?"

Five years later, L – asked to be a teaching assistant in the Chemistry Workshop, a position that had not previously existed.

She was now aware that science was fun for her. After some deliberation, the workshop programming was adjusted to allow her to help out with the younger children as a peer tutor. She worked with the younger children alongside a college student. Even before the workshop addressed acid-base neutralization, and only two weeks into the workshop, she asked to take an experiment further by combining an acid and base and observing the resulting solution. The instructors suggested that she share this idea with the group of children to whom she was assigned. She did and engaged them all in thinking with her about each of the trials (and, as it turned out, all of the other children's groups decided to explore this issue as well). (Notes, Year 5)

L – 's thinking about science had clearly changed, as had that of her peers. She had a broader perspective. She now focused on patterns in phenomena and how they could provide explanation. She was willing to think about content generally and to explore new materials.

The studies in which L – and her peers were participants focused on what needs to be in place in order for children with little to no background knowledge in a discipline to seriously engage and learn. Data from L – 's participation in the workshops are congruent with those of her peers, and allow consideration of the interplay between interest development and cognition. For the first few summers of workshop participation, L – had a triggered situational interest in the scientific material. Her affect could be heightened; she clearly was attending and had some questions, but it was not until the fourth year that her phase of interest began to shift, signaled by her independent efforts to understand.

Although L – was aware and engaging in the workshop during the first several years, she had not yet made the kind of connection to science content that leads to asking curiosity questions and wanting to seek out, reflect on, and raise more questions. Thus, although L – and her peers engaged excitedly at times in the inquiry-informed workshop activities (e.g., group work to dissect a mink) during their first years, five weeks following the workshop they only retained an impression that science could be fun, with little if any science-related content (Renninger et al., 2008). It was not until L – shifted from simply engaging with the activities of the workshop to focusing on thinking about and wanting to explore their content that her interest changed; her interest shifted in relation to its shifting focus, her cognition.

INTEREST AND COGNITION

With few exceptions, the relation between interest and cognition has received little explicit attention in the recent theoretical or empirical literature. In early

theorizing, the relation between interest and cognition concerned the development of attention. James (1890), for example, described interest in terms of the organization of experience. He suggested that interest improved the ability to discriminate, and noted that interest, along with practice, improved attention. Baldwin (1911), on the other hand, described interest in terms of the activities in which a learner engaged. He focused on the cognitive structures that the learner brings to activity, the competence that is experienced, and its accompanying affect. Dewey (1913) elaborated on this relation by suggesting that interest was in the content itself, suggesting that the interest value of activities was related to whether they led to continuous engagement. Finally, Piaget (1968) linked interest to both cognition and motivation, suggesting that, "Interest is the proper orientation for every act of mental assimilation" (p. 34). Taken together, the early theorists suggested that interest organizes experience and channels attention, and they highlighted the roles of both knowledge and value as components of interest.

The differing (and complementary) foci of the early theorists on the relation between interest and cognition also characterize the discussions and studies that followed. The research has focused on the role of interest in cognitive processing; the text, task, or people who contribute to the generation of interest; and the relation of knowledge and value as components of interest. Findings from each are reviewed briefly.

INTEREST AND COGNITIVE PROCESSING

Research that addresses both interest and cognitive processing has focused on the same issues, albeit in different contexts: free play in the nursery and work with text, math problems, or representational design. Building on the findings of early theorists whose work suggested that interest had a reciprocal relation with attention (e.g, Arnold, 1910; Bartlett, 1932), Renninger and Wozniak (1985) studied the effects of interest on young children's attentional shifts, recognition, and recall memory. They identified play objects (e.g., trains, dolls) of high and low interest for each child based on naturalistic observation of interest similar to that used in the study of L –, and inserted these into experimental tasks in order to assess the effect of interest across cognitive processing. Their findings revealed that interest exerted a strong influence on shifts in focal attention; interest was found to influence the likelihood that an item would be correctly recognized and recalled, and that the item would be recognized and recalled first. Renninger (1990) further demonstrated that patterns in the children's naturally occurring free play mirrored those of the experimental tasks; with identified objects of interest, the

children were more likely to play longer, use more types of play, shift between types of play, employ more types of action, and repeat particular sequences of action than with other objects that were familiar and of less interest. Krapp and Fink (1992) replicated these findings, and in discussing them, pointed to the differentiation of interest based on experience. They reported data showing that two children engaged in interest with the same play object would not necessarily engage the object similarly. They and Neitzel and her colleagues (Neitzel, Alexander, & Johnson, 2008) also documented that the interest object could serve as a transition object as children moved from one learning context to another (e.g., from the preschool to kindergarten).

Another line of research on interest and attention focused more specifically on text. During the 1980s, two hypotheses emerged in studies of text: (a) that increased interest might increase attention and lead to better memory (Anderson, 1982); and (b) that increased interest might require fewer cognitive resources for basic text processing, freeing up resources for higher-order processing (Hidi & Baird, 1988; see Hidi 1990, 1995). In order to test these hypotheses, McDaniel et al. (2000) conducted studies of undergraduates reading stories that they rated as being of higher or lower interest. Their findings confirmed that more interesting text requires fewer cognitive resources than less interesting text, and that text-based interest results in qualitative differences in the kind of information that is processed and encoded. In conclusion, they suggested that optimal learning of text might require assignment of study strategies aligned with the particular level of interest for text. As with the studies of young children's play, it appears that what was of interest for one person was not necessarily of interest to another. This then indicated that although interest might free up resources for higher-level processing, the expectation that one topic, for example, would be of similar interest to all students was not appropriate.

Renninger et al.'s (2002) findings corroborate the conclusions of McDaniel et al. (2000) regarding likely processing differences and instructional needs introduced by the presence of interest. Renninger et al. (2002) studied within-student differences in both the reading of text and work with mathematics problems, using interviews, think-alouds, and artifact analysis. Passages and problems presented to middle-school–aged students were individualized with contexts of interest and adjusted for level of difficulty. Their findings suggested that well-developed interest served as a scaffold for working with assigned tasks. It allowed students to focus on meaning and task demands. Well-developed interest also appeared to mask the level of passage and/or problem difficulty, enabling the students to persevere to work with difficult tasks.

Similarly, in a qualitative analysis of high school students' engagement, Azevedo (2006) reported that opportunities to explore and prioritize activities resulted in distinctively different and enhanced problem solving. He pointed to four findings from this work that provided support for interest: students' feelings of competence, task features that promote feelings of competence, time to explore, and a flexible learning environment.

THE GENERATION OF INTEREST

Studies that have addressed the features of text or sources of interest in classroom activity do not typically reference the role of cognition or problem solving in the generation of interest. Rather, they point to the impact of interest on engagement, where engagement refers to some form of connection to the task, including, for example, a grade that has been assigned, a positive attitude, achievement goals, feelings of competence, or specificity of writing. In these studies, learners have been assessed as having more or less interest for the feature or task. Thus, for example, in a high school math class, group work, puzzles, and computers have been identified as triggers for interest, and the presence of meaningfulness or personal relevance and involvement of students may result in sustained engagement (Mitchell, 1993; see also Laukenmann et al., 2003; Palmer, 2009).

Based on Laukenmann et al.'s (2003) suggestion that situational interest promotes learning, Palmer (2009) interpreted his high school science students' spontaneous reporting of "learning" as a source or trigger for interest. He described the novelty of the information they were referencing as the trigger for their interest. Novelty, one of the collative variables that Berlyne (1960) originally identified, has been repeatedly identified as a feature of text and tasks that generate interest (Silvia, 2005a, 2005b; Turner & Silvia, 2006). However, that Palmer's (2009) high school students mentioned learning as the source of their interest is also consistent with Arnold's (1910) suggestion that interest is reciprocally related to attention and learning; that in addition to situational interest promoting learning, learning may promote situational interest. This line of analysis is also consistent with findings reported by Chen and Darst (1999, 2001), who found that increased cognitive demand (based on a comparison of activities) was related to learners' experiencing novelty, challenge, attention, and increased situational interest.

Harackiewicz and her colleagues (Harackiewicz et al., 2002; Harackiewicz et al., 2008) have similarly suggested that mastery goals have a reciprocal relation to later and earlier phases of interest. They also report that mastery goals may provide conditions through which interest can be triggered (Senko

& Harackiewicz, 2005) and demonstrate that when participants are asked to write out an explanation of the importance of a task they are assigned, this triggers interest for the task (Hulleman et al., 2008). Their work on achievement goals and interest is complemented by studies demonstrating that when participants are provided with goals such as trying to become experts (Hidi et al., 1998) or participating in a community (Cobb & Hodge, 2004; Nolen, 2007), that this, too, results in increased interest.

Research has also indicated that the quality of social interactions (eye contact, verbalization) influences the experience of interest and whether interest is generated (Thoman, Sansone, & Pasupathi, 2006). Talking together after an activity, for example, was found to increase interest, and the responsiveness of a listener was more powerful than differences in interest in determining interest in the activity (Thoman et al., 2006). Findings such as these further extend those from both studies of talent development, in which changes in the teacher and music-student relationship have been documented, and those pointing to a reciprocal relation between interest and identity development (Krapp, 2007; Renninger, 2009).

Based on retrospective interviews with accomplished musicians, for example, Sloboda (1996; see also Sosniak, 1990) reports that the musicians' first experiences included having fun with music without being pushed to be systematic or to have specific skills. The first teacher was ideally friendly and enthusiastic, able to communicate well, and to share a love of music. The teachers could be said to be triggering and helping to maintain their students' interest. As the prospective musicians were ready to focus on skill acquisition, Sloboda notes that they also required more support from others to sustain their skill development and positive feelings. During this phase of instruction, many of their peers decided not to continue to study music. This was a time when Sloboda observes that both teachers and parents encounter difficulty knowing how to provide music students with support. In terms of interest theory, they could be said to have difficulty helping music students maintain their situational interest for music. Those who continue to study music reportedly came to identify with music, and eventually studied with a master teacher who enabled them to become artists. In other words, their interest had developed to the point that they identified as musicians. With interest, they were better able to self-regulate and needed less oversight than they had in earlier phases of interest.

In describing the interest experience, Sansone and Thoman (2005a, 2005b) suggest that motivation and interest fluctuate in relation to the value a person places on the goals of particular activities and any expectations about attaining those goals. They suggest that interest can be regulated both

intra-individually and interpersonally. In earlier phases of interest development, learners may self-regulate activity in order to productively engage content that is of little interest, or they may need to have the learning context adjusted so they can connect to it, just as the first music teachers made music fun and something to which those who eventually became musicians could connect. In later phases of interest development, on the other hand, learners who have their own identification with curiosity questions and the questions of the domain generally are more likely to self-regulate, to seek out and reflect on answers that then lead to other questions. Interpersonal support in later phases of interest is not necessarily about engaging with the activity per se, but rather with the specifics and challenges of the content of the activity (Renninger, 2009, 2010). In both earlier and later phases of interest development, the generation and regulation of interest is a function of both the individual (his or her goals or lack of goals) and the learning context.

KNOWLEDGE AND VALUE

As noted earlier, interest has been and can be conceptualized in a number of different ways. When it is conceptualized as a variable that develops over time, it has three components: stored knowledge, stored value, and feelings (Renninger & Su, 2012; see also Häussler & Hoffmann, 2002; Hidi & Renninger, 2006; Renninger, 1990, 2000). This conceptualization of interest has been explored in studies that have assessed the impact of earlier and later phases of interest, revealing an impact of differing levels of stored knowledge, stored value, and feelings on participation and learning (Durik & Harackiewicz, 2007; Frenzel et al., 2010; Katz et al., 2006; Lipstein & Renninger, 2007; Tsai et al., 2008).

In earlier phases of interest development, it appears that knowledge and value may be limited to recognition, and affect may be either positive or negative. With interest development, knowledge provides a basis for reflecting and questioning that in turn supports the development and deepening of interest (Hidi & Renninger, 2006). Thus, the development of knowledge is also understood to contribute to the development of value for and feelings about engaging with content (Renninger, 2000; Renninger & Su, 2012).

Before the four phases of interest were identified, however, affect had been the focus of some conceptualizations of interest, and was used to assess interest (Alexander, Jetton, & Kulikowich, 1995; Alexander, Kulikowich, & Jetton, 1994; Tobias, 1994). In these studies, interest was examined in relation to knowledge and/or value (Schiefele & Krapp, 1996). Tobias (1994), for example,

suggested that there was a linear relation between interest (defined as positive affect) and prior knowledge. He concluded that interest made more of a contribution to comprehension and emotional associations than prior knowledge, but also observed that as students develop familiarity, the development of knowledge could be assumed. In an investigation of undergraduates in statistics and psychology classes, Lawless and Kulikowich (2006) examined this premise and reported that interest (defined as affect) and knowledge were correlated with each other regardless of domain. They also found that the relation between interest and domain knowledge changed based on academic level and preparation. Consistent with these findings, Alexander (1997, 2004) described interest development in terms of developing expertise. Although she described the relation of affect and cognition as distinct across each of the stages of developing expertise, she and her colleagues began to use liking and participation (which requires knowledge) to make distinctions between types of interest (Alexander, 2004).

Schiefele and Krapp's (1996; see also Krapp, 2003, 2007; Krapp & Prenzel, 2011; Schiefele, 2009) work has increasingly centered on feelings and value in their discussion and assessment of interest, although they, too, have begun to acknowledge the role of experience or knowledge in the development of interest. Feelings and value are considered essential to personal significance: "Positive evaluation results from the degree of identification with the object of interest" (Krapp, 2003, p. 63). Krapp (2003) explains that although a person may learn something new without being aware of this growth (and, as such, knowledge), they are aware of personal significance. For this reason, he argued that emphasis on feelings and value in interest development is needed.

SUMMARY

The relation between interest and cognition has been examined in terms of attention and cognitive processing, characteristics of the learning environment, and the components of knowledge and value. Each of these foci points to the impact of differences in interest. The work on attention and cognitive processing suggests individual variation in the types of questions and/or topic interest of the learner. The work on the characteristics of the learning environment calls attention to the role of others and objects as supports for engagement and likely differences in learners' needs for support in their interest development. The work on knowledge and value as components of interest underscores potential differences in the contributions of each to interest and also to their coordination as interest develops.

How interest develops within individuals and how interest can be supported to develop are critical questions for interest research. Although research on interest generation or sources of interest has pointed to one or another potential triggers for interest, these studies have largely been descriptions of particular phases without consideration of what learners need in order to shift from one phase of interest to another and begin asking curiosity questions, seeking resources, and making use of feedback. As a result, learners such as L –, who initially have little to no interest for learning content such as science, pose a challenge for educators as well as researchers. Their interest can be triggered, but little interest means little affect and/or knowledge. As they age, they develop greater awareness that others have more developed skills with respect to particular content than they do, making it even more difficult for them to persevere to master that content even though it is possible for them to do so (see discussion in Renninger, 2009). There is the possibility that their attention, and as a result interest, can be triggered by some external event (e.g., the excitement created by burning marshmallows and other foods to see which burns faster), but it is also recognized that this type of triggering may result in only momentary attention (Renninger et al., 2008). Sustaining interest for unknown content and supporting engagement is difficult, because there is too little knowledge to set goals or to know what questions to ask. Happily engaging in an activity is not the same as reflecting on the content of the activity, asking questions, exploring, and reorganizing understanding (Flum & Kaplan, 2006).

INTEREST DEVELOPMENT

Interest always refers to one or another of four phases in a learner or group of learners' cognitive and motivational engagement with particular content: triggered situational, maintained situational, emerging individual, and well-developed individual interest (Hidi & Renninger, 2006; see Table 1). Interest may reference a domain such as science or a more focused topic such as structure and function, and always co-exists with a number of other interests and potential interests.

People typically think of the most developed phase – well-developed individual interest – when they reference interest. Learners with a well-developed individual interest for science, for example, can be expected to be attentive, goal-oriented, and strategic (Renninger, 2000). Their feelings or affect are generally positive (Ainley, 2006); they have a sense of possibility (Markus & Nurius, 1986); and they know that they can be successful (Bandura, 1997). Learners with developed interest have enough knowledge about their subject

of interest to make effective choices (Flowerday & Schraw, 2003), and they need little prodding to take advantage of opportunity and make use of the feedback they receive (Lipstein & Renninger, 2007). When faced with the need to revise a plan or practice, they persevere (Prenzel, 1992). As their interest continues to develop, they are increasingly likely to self-identify with the discipline – to think of themselves as someone who can do science, and as someone who could be a scientist (Renninger, 2009). In the classroom, however, learners in this phase of interest are exceptions. For example, in a study of 178 academically oriented middle school students, only 4 students were identified as having a well-developed individual interest for writing (Lipstein & Renninger, 2007). The other students were almost equally likely to be in one of the three earlier phases of interest development.

Lipstein and Renninger (2007) used structured in-depth interviews and questionnaires to compile representative descriptions or portraits of students in each phase of interest development for writing. Here, these characteristics are compared to those of L – and to data chronicling her engagement in the science workshops.[2] Comparison of the writing students' experiences with those of L – and her peers in the science workshops provides further insight into the relation between interest development and cognition. The experiences:

(a) confirm that in each phase of interest, learner perceptions influence what learners are able to connect to, whether they pick up on concepts and are led to ask questions, or whether they do tasks just to get them done even if they do not really understand why they are doing what they have been asked to do;
(b) highlight the amount of time that a learner might be in the earliest phases of interest development, even though the learning environment is rich with possibilities;
(c) underscore the impact of the learning environment on interest development, here revealed in the comparison of data from studies of students' phases of interest both in and out of school; and
(d) point to the critical role of others (instructors, peers) as supports for engaging potential triggers for interest and developing confidence and a sense of possibility about engagement.

TRIGGERED SITUATIONAL INTEREST

Students with a triggered situational interest for writing were likely to have their interest captured in the moment by, say, the assignment to write about

a topic of interest (e.g., basketball), but their interest was also likely to extend only to completing the task. They did not identify as writers and would not revise what they wrote, and for the most part they wanted to be told what to do. They did not want to have to think about or work with feedback. Although they might have heightened affect when their interest was triggered – when working to write about basketball, for example – they were not aware that their interest had been triggered, and did not seem to have enough knowledge about writing to make choices about how to effectively provide details and organize the information that they included about basketball.

Over the first three years of the workshop, L – is identified as having only a triggered situational interest:

> One day, for example, she and the other participants are looking at worms under the microscope. At the end of the session, they put their worms back and as everyone is packing up and preparing to leave, L – suddenly turns, runs back and picks up a worm and takes it into the corner to look at it. Told that it is time to put the worm back, she obliges but does not want to leave and sits on the steps of the science building pouting. (Notes, June Year 1)

Similar to the student writer who had only a triggered situational interest for writing but was momentarily excited to focus on an assignment to write about basketball – a well-developed individual interest – L – experiences heightened affect in the session focusing on worms and then does not follow through to re-examine the worms in subsequent workshop sessions.

A few weeks later, during the week in the biology workshop on skulls, notes on L – suggest that she chooses not to look at skulls or what animals they must have come from based on size and teeth. Rather, she wanted to know if "these [skulls] are real"; "how the skull fits with the rest of the animal"; and "how it could move around."

> She had difficulty asking her questions though. She began to ask a question several times, beginning with: "Not to be retarded or anything…" but had some difficulty making herself clear and was seemingly frustrated by the other children talking. By the time it was quiet enough for her to ask her first question, she initially forgot what she was trying to ask but then remembered. Although the purpose of the activity was identification of species, L – wanted to know about structure and function, and how this one part of the animal fits with the other parts. (Notes, July, Year 1)

L – does not think of herself as a scientist and really only wants information specific to her questions. Although her and her peers' interest is triggered by the worms and the skulls, she has difficulty learning with her peers. She has trouble listening to others' questions and issues and making her own connections to these as a member of the group.

In terms of interest development and its relation to cognition, the learner's relation to a triggered situational interest is idiosyncratic and tentative, especially when the content of the triggering interest is a more developed interest (e.g., basketball) that is being used as a scaffold for working with content that is not of interest and challenging (e.g., writing). Data from L – and the other workshop participants' case material suggest that being encouraged to personalize content is critical to the ability to make connections to it, and that connections are essential to both interest development and cognition.

MAINTAINED SITUATIONAL INTEREST

Similar to the students with a triggered situational interest, students with a maintained situational interest for writing were primarily dependent on others to tell them to write. Their interest for writing was sustained in the sense that the students would return to class and the activities of the class feeling positive about their engagement and confident that they could do well. They felt this way because of the instructional activities (e.g., group work) (Hidi et al., 1998; Mitchell, 1993) and personally meaningful topics (Mitchell, 1993) that their teacher employed. They did little writing outside of class, yet they self-identified as writers. Because they sought to please the teacher, this meant that they were receiving good grades. From their perspective, their grades indicated that they were successful and that writing was an identity, even though they only did writing when it was assigned in class. However, it was difficult for the writing students to ask and pursue questions of their own in their writing (e.g., to try out different voices, to experiment with words), and they were not comfortable with choice; they preferred learning the rules for writing and being told what to do. They used feedback as a set of rules, not as a resource for thinking about writing.

Unlike the writing students, by the fourth year, L – had ideas about what she wanted to know, although these topics were not always linked directly to the plan for the day.

> During the fourth year of the workshop, following the "celery experiment," in which a stalk of celery is placed in water dyed with food color, L – interrupts discussion of why the leaves change color to focus on the stalk: "Excuse me, isn't that decent?" She points to the red coloring of the "veins" in the stem and breaks open the stem to look at how the inside of the stalk was affected. (Notes, July, Year 4)

L – and her peers are not dependent on others in order to engage with the content to be learned, but rather for making this content available to them and supporting them to engage with it, even if what they engage with is not necessarily what the instructors had anticipated as the focus of the activity.

By this point, L – was increasingly comfortable asking questions in the group, and seemed more able to think about her peers' questions, especially if they informed her understanding of the phenomena with which she and the others were working. She did not yet really understand the scientific process, as her question about whether they could collect data and then predict what would happen suggests.

By the second day of this workshop, L – chose to hang around after each workshop session, helping to clean up and do lab set-ups for the next day. She also would question and think with the instructors about the day's experimentation. (Notes, June, Year 4)

Unlike the writers with a maintained situational interest, L – did not have a need to please the instructor in order to receive better grades. She and her peers were not in school and were not being graded (see Brophy, 1999). The opportunity to log more time alongside the instructor was her choice, and this (together with the structure and facilitation of the workshops) appeared to enable L – to further solidify her connections to science. Within a few days during the fourth year, she shifted into and out of the phase of maintained situational interest and into the phase of emerging individual interest.

There were at least three features of the fourth-year workshop that may have contributed to the development of L – 's interest. Modeled on Springer's (2006) description of a democratic classroom, fourth-year participants helped build the curriculum for the workshop by identifying questions to which they wanted answers. They kept records of what they understood (responses to *ICAN* probes[3]) in their lab notebooks. They were also engaged in tutoring the younger children of the first-year workshop. Thus, in addition to triggers for engaging science implicit in inquiry-oriented project-based learning, the curricular structure included multiple opportunities for L – and her peers to both make connections to and then reflect on these triggers (CTGV, 1997).

For L –, generating questions to help build the curriculum was not a difficulty. Documenting what she understood in her lab notebook was something on which she often worked in the time that she remained after the workshop sessions were over. The tutoring component of the workshop did pose a challenge for her, however. In order to prepare for tutoring, L – and her peers practiced talking about how they would introduce the properties of Oobleck (a mixture of cornstarch, water, and green food coloring). L – seemed to enjoy squishing the goo and the prospect of sharing the activity with the younger children, but the next day, she did not engage with the younger children at all.

She looks on, sitting at the side of the table, leaving any "tutoring" to her teaching partner. Her affect suggests that she is not comfortable with the tutoring role. (Notes, June, Year 4)

The course of L – 's interest development suggests that a person who is supported to have questions early in the triggering process may transition through the phase of maintained situational interest quickly because his or her interest does not continue to need another person to facilitate it. In other words, when the perceived learning environment offers opportunities to attend and engage, is not over-specified, and has rich content, it appears that knowledge and value develop, and that the learner may easily engage in a process of pursuing his or her own curiosity questions. Such questions are not novel to those who have more information, but are novel for the learner and allow the learner to build knowledge (Renninger, 2000). On the other hand, as L – 's case suggests, the ability to engage in asking curiosity questions may not extend to sharing these with others – at least initially.

EMERGING INDIVIDUAL INTEREST

The students with an emerging individual interest for writing had curiosity questions. They had their own ideas about writing and expression, and had developed some facility in using writing for communication. They had begun to identify themselves as writers presumably because they invested free time in writing and liked it (not because they received good grades for their work). In school, they enjoyed having choices about assignments, but they often posed and sought answers to their own questions that could lead them to deviate substantially from their assignments. They were not particularly interested in the canon of the discipline or in receiving feedback that required revision. They were self-assured about their work and its quality.

By the third week of the fourth-year workshop, L – 's interest had shifted to an emerging individual interest. Because the curricular structure of the workshop focused on the participants' questions, there was little oppositional behavior like that characterizing the students with an emerging individual interest for writing. Instead, L – re-engaged the questions she had raised in other contexts, appeared to feel positive about her work with others in her group, and seemed responsive to feedback that allowed her to understand how she and her group were addressing their goals.

One of the questions that L – 's group decides to study is, What is in lip gloss? L – 's group makes vanilla-scented lip gloss, following a set of procedures that include combining several components (coconut oil, petroleum jelly, aloe vera gel) and heating the mixture in order to facilitate mixing, as it was easier to combine in a liquid state. They decide to use food coloring to add color and try adding food coloring to the already prepared mixture. However, because the food coloring is water-based and the lip gloss contains oil, the two do not mix. There are small beads of food coloring in the lip gloss. Following this discovery, discussion

focuses on hypothesizing about what went wrong and experimental design. L – 's group decides to revise their procedure by adding the food coloring before melting the components. This revision works and produces pink lip gloss. It does not matter that the science in which they are engaging is more about chemistry than biology. (Notes, June, Year 4)

L – appeared able to refocus and explore her questions along with those of the others in the hypothesis-generating and testing of their work to produce colored lip gloss.

Differences between L – and the others are also evident. In addressing a question about how sleep affects the amount of energy a person has, L – and her peers decide that they should keep a sleep log over a long weekend, detailing the times they go to sleep, wake up, and how they feel at each time point. No one remembers to do this except L –, possibly because she thinks of the assignment as an experiment, and the others think that it is work (like school). (Notes, July, Year 4)

With the development of interest, L – appeared to have a broader range of topics in which she was interested. She was increasingly willing to explore novel content and, unlike her peers, did not appear to think about workshop-related content as work, even if it did extend into the weekend. In turn, it also seemed that she was more able to be open to her peers' ideas, and was more confident about her ability to work with the younger children.

Despite more willingness to work with the younger children, L – continued to be anxious about this part of the workshop.

In the second week, they are working on measurement, documenting the length of each person's leg and then the length of their jump to answer the question: "How do our legs affect the height and distance of a jump?" She forgets that they are to use centimeters. In disgust, she exclaims, "Man, I took the measurements in inches. My first day as a teacher and I ruined the experiment." The others in her group tell her that she can convert them; but she is so frustrated that she withdraws from the group for almost 10 minutes, repeating, "I feel so stupid, so stupid." When one of the younger children approaches for help calculating the average distance jumped, she is able to help. She seems to regain her self-confidence as she helps a group of the younger children to graph their data. (Notes, June, Year 4)

The participation observation notes provide a number of instances in which it is L – who helped the younger children to think in terms of their predictions and why they think their prediction "came through," or who reached out to help one of the younger girls to spell "calculator," saying, "I mess up spelling that all the time."

Lipstein and Renninger (2007) reported that it was only those with developed interest for writing who liked to work in groups. In earlier phases of interest, the students in the writing classrooms primarily wanted to be told what to do and were not interested in engaging in conversations about options. They also had little interest for learning the canon, and little opportunity to generate the questions on which their writing would focus. They were given opportunities to do "free writes" or choose the topic on which they would write, but not only was the structure and the form of their writing specified, there were also expectations about format, development, and content. The students who were in the phase of emerging individual interest were described as wanting to establish autonomy so they could work on the kind of writing that they themselves defined.

In the workshop context, L – not only helped develop the curriculum, but was also free to refocus it with her questions. This type of context was enabling (see related discussion in Cobb & Hodge, 2004). She generated curiosity questions based on her knowledge, the other things she knew and valued, and her developing knowledge for this new content. This meant that she needed less direct support to participate and engage than she did in the earlier workshops, and less than the writing students needed. She also further developed her willingness and ability to work with others, but she was concerned about how she engaged with others in relation to the content of this work and felt anxious about doing it correctly.

L – and her group were not constrained by the canon in science. They were asked to generate questions and were encouraged to understand the science in them. L – 's approach to working with the younger children did suggest that she had formed some sense of the way in which this work could unfold, however. Presumably, her understanding was modeled on the way in which her instructors had worked with her. [4]

WELL-DEVELOPED INDIVIDUAL INTEREST

Students with a well-developed interest for writing sought feedback that would allow them to continue to develop their understanding of writing. For them, the feedback process was an opportunity to deepen their interest (Azevedo, 2006; Barron, 2006; Hidi & Ainley, 2008; Lipstein & Renninger, 2007). These students had identified as writers and had positive feelings about writing that appeared to sustain them even when writing posed difficulties for them. They spent time outside of school writing, and appreciated having choices about assignments.

Neither L – nor the others in her group had yet reached the phase of well-developed individual interest in her last year of workshops.

By the fifth year, when L – volunteers to work as a teaching assistant in the Chemistry Workshop, she has a good understanding of what it means to do science and its process and likes taking experiments one step further by testing additional substances or mixing chemicals. Moreover, she is able to help the younger students to fill in the ICAN statements in their lab notebooks even though she is not doing the experiments herself. (Notes, June, Year 5)

L – was not yet independently pursuing her own questions. Nor did she seem aware that there were generally accepted disciplinary standards for science beyond those of the workshop context. She appeared to need the support of the workshop environment that provided resources and opportunities for learning in order to know how her goals were met.

SUMMARY AND DISCUSSION

L – and the others in her group did not bring any formal experience with science to the workshops. The curricular structure of the workshop sessions was explicitly inquiry, and the instructors' goals for them centered on understanding that they could do science and that science is fun. They wanted L – and her peers to feel that they are capable of doing and enjoying science and worked to ground the activities in L – and her peers' prior experience. The instructors provided time and opportunities for them to question and reflect, and all questions were taken seriously. The science workshop as a learning environment is a contrast to that of the writing students. The writing students' classes included open-ended opportunities (e.g., free writes), but they also included instruction in the cannon of the five-paragraph essay and analysis, content to which only those with well-developed individual interest were receptive. The learning environments of each varied; the workshop was more open and the writing classes were more closed. Comparison of the participants in each suggests that the phase of learner interest influences to what and also how he or she attends (see Table 17.1).

The data from L – 's case provide further details about the nature of the questions with which a learner engages and the shift in such questions over time. Although her questioning appears to have focused on structure and function, there was a shift from wanting to understand how the skull connects to the body of the animal (a question that was not in the workshop plans) in year one to wanting to use experimentation to explore the acid-base relation (a question that anticipated upcoming workshop plans) in year five.

Not only do these data document a particular focus in her questioning over the years, they reveal an increasing capacity to think and do science.[5] They also call attention to the time that this type of development can take, even when the conditions of the learning environment include rich content, supportive others, and opportunities to self-structure questions and engage. It was four years before L – 's interest began to shift from a triggered situational interest to a maintained situational interest. It then took three weeks for her interest to shift from a maintained situational interest to an emerging individual interest.

The data from L – 's case also highlight differences between learning environments and the way in which learners engage content in each environment, and their needs in this process. As summarized in Table 17.1, L – and her group seemed to benefit from and need additional information from others, whereas in earlier phases of interest the student writers wanted to be told only what they needed to know and no more – unless this information acknowledged what they did. Only those student writers identified as having a well-developed individual interest sought out and seemed positioned to work with feedback.

There were differences in the participants' perceptions of these learning environments, in the goals and roles of the teachers and the instructors, and in the backgrounds of the participants. Whereas the writing classrooms focused on supporting the students to learn the rules of academic writing, the science workshop environment was open-ended and did not have grades; it was designed to promote fun and engagement with science. Although the writing students' teachers thought of themselves as supporting their students in the same way that the instructors supported L – and her peers, this was not the way that the writing students understood the expectations of their teachers. The goals and roles of the workshop instructors changed, depending on the activity and L – and her group's responses; they provided information and resources, asked and answered questions, stood back and allowed L – and her group to explore, make mistakes, and reason.

The two groups of participants varied, as well. The writing students had had instruction in writing throughout their schooling and came from families that valued education and had placed them in an academically oriented school. L – and her group were learners new to science; only in the last two years of the workshops had there been science instruction in their schools; they came from families and a community with few or no scientists. Although it is inappropriate to simply point to one or another feature of these environments as accounting for differences, it is possible to note that the two participant groups engaged content differently and that their perceptions

influenced their engagement. It also appears that differences in their perceptions informed what they needed from others who were supporting them to learn.

CONCLUSIONS AND QUESTIONS

Current research suggests that a learner can be supported to develop an interest for any content, through interactions with others and the texts, tasks, and opportunities in the environment (Renninger, 2010). However, this same research suggests that due to the nature of a person's interactions with the environment and, by implication, the quality of these interactions, interest may or may not develop or deepen, and may instead regress or disappear altogether (Bergin, 1999; Renninger, 2000). In other words, although interest can be supported to develop, the phases of its development are termed "phases" rather than "stages" because interest develops in relation to the environment and can fall off if support is not available (Hidi & Renninger, 2006).

Findings from existing research on interest indicate that it is the opportunities and experiences available to learners early in their work with a subject that affect the kinds of connections they make to that subject, and, as a result, their readiness to begin to engage it independently (Nolen, 2007). The others with whom learners come into contact contribute to the connections that are made – by providing feedback and supporting learners early in their work to have fun and enjoy the content in ways that also build knowledge and enable them to know that they know. Later in the development of interest, the needs of learners in the out-of-school environment continue to include support, but also include opportunities to explore and work with knowledge, know what they have learned and what they have still to learn, and provide feedback that enables them to know when goals have been met.

Based on the data from L – 's case, it appears that shifts in the development of interest can be expected but are not likely to be immediately obvious to an interviewer, although patterns of engagement – such as the kinds of questions asked and the extent to which these questions map onto the questions of the discipline – and behaviors can be tracked. The quote from L – 's interview at the opening of this chapter in which she says that she does not like science came from her year-five interview. In contrast to what she said to the interviewer, she has just requested and been granted a role as a teaching assistant for a younger group in the Chemistry Workshop. Her response to the interviewer (a familiar adult) reflects the same attitude that L – presents during the first days of the first year of the workshop; it suggests that she is uncomfortable talking about herself. It is possible that L – has difficulty

reconciling her successes in this out-of-school workshop with her experience of school science. She may not believe that a summer workshop can result in change, although her workshop instructors can see otherwise.

Prior findings have suggested that with the development of interest, learners need less direct support to participate and engage and more opportunities to stretch what they know. The presence of the ability to ask and seek answers to curiosity questions coupled with learners' apparent resistance to information in the academic context seemed to suggest that indirect methods of support might be most useful (e.g., instructional conversations, resources, and opportunities to work with others) (see Lipstein & Renninger, 2007; Mitchell, 1993; Palmer, 2009). Findings from L – 's case qualify this understanding by suggesting that learners with more developed interest might be more responsive to receiving the kind of information that could help them further develop their interest were the learning environment more open, the learner feeling sure of him or herself, the need to master particular forms of information unspecified and untimed (Azevedo, 2006; Springer, 2006), and the environment responsive (Thoman et al., 2006).

With the development of interest, it appears likely that L – and her peers have attentional resources that are freed up. L –, for example, began thinking about science with her peers and the younger children. Before this, it appears that her own questions took so much of her energy that she did not have the capacity to fully benefit from her peers, although it is in the workshops with them that she continues to grow.

The workshops and their content were new to L – and her peers. Their design involved full participation, no explicit comparisons among the participants, and no specific expectations about content to be mastered.[6] L – learned through her participation. It appears that autonomy, per se, is not what L – needed. Learners such as the writing students may need to strive for autonomy because they are responding to academic demands or pressure. The questions and engagements of L – and her peers, on the other hand, appear to be increasingly aligned with the disciplinary goals and skills of science over the course of the workshops.

Comparing the data from the writing students and those of L – and her peers underscores the complexity of the interest development and cognition relation. It seems that the more open yet structured form of inquiry in the workshop context led L – to build her knowledge, and this in turn was motivating. Of importance is the fact that L – determined the "what" of the content with which she engaged. Her peers were not focused on structure and function in their questions, although they, too, could be said to have been consistent in the framing of the questions that they held.

Data from the writing students and those of L – and her peers also raise questions about the interplay between interest development and cognition in the learning environment. Is the interest of L – and her peers subject to the kind of regression and possible change as that of the writing students? Is it possible that L – and her peers have grown into thinking and doing science in such a way that they internalize the questioning, predicting, experimenting, modeling, applying, and identifying additional questions, and that these experiences and the enjoyment of the process of engaging them cannot fall off?

Does what triggers interest vary if learners are free to respond to the opportunities and resources that are available to them, rather than feeling that their engagement is controlled? Is it possible that in more open learning environments, learning does serve as a trigger for interest?

What are the differences in the nature of goals that learners set for themselves as opposed to those that are set for them? Could L – have developed her interest for science without the group of peers who also participated in the workshop – other learners who not only shared the experience but talked with her about the workshop and listened to her?

When did L – start to realize that she was indeed learning science? What were the supports that were in place for her that made a difference? How different would the experience of the writing students have been had they been participants in a more open learning environment – and would it have made a difference if they had been in an earlier phase of interest for writing?

How do knowledge and feelings work together to provide a basis for deepening value? How do affect and value change as interest develops? What does L – perceive science to be? What types of interactions would be needed in order for L – to claim that she enjoys science or that she might want to be a scientist?

L –'s case and the experiences of her peers together with data from the writing students indicate that the phase of learner interest and his or her perceptions of the learning environment are likely to affect whether one or another content is something to which to attend – how he or she engages and whether interest is likely to develop. They also underscore the importance of knowledge building and reflection as supports for and outcomes of interest development, an interaction that is as critical for education as it is for theory and research.

ACKNOWLEDGEMENTS

We would like to acknowledge the role of many in the data reported in this chapter and our thinking about it. We appreciate: the ongoing encouragement and involvement of Elizabeth Vallen and the participants of the Science-for-Kids

workshops over the years; the help of Jessica Bachrach, Robin Collin, Melissa Emerson, and Alicia Niwagaba, who collected interview data and participant observation notes that provided the basis of the data reported in this chapter; editorial support from Nadine Kolowrat and Melissa Running; student fellowship support from the Howard Hughes Medical Institute to Swarthmore College; and for work on this chapter from the Swarthmore College Faculty Research Fund.

Notes

1. Participant observation notes were collected continuously throughout the five weeks of the workshop each summer; these were continuous anecdotal observational records (Carini, 1975) that were collected by one researcher who was blind to study questions. The records chronicled instructors' and participants' conversations and observable behaviors.

   Interviews were conducted with workshop participants at three points during each of the summers: before the workshop began, at the end of the workshop, and five weeks following workshop completion. The interviews were used to identify participant interest, feelings of self-efficacy, experience of the workshop, and abilities to work with adaptations of established science tasks.
2. Data on L – 's workshop participation included participant observation notes and interviews before and after each of the workshops. The participant observation notes consisted of running records of all classroom activities on each day of the workshop. They chronicled instructor and participants' conversations and behaviors. To the extent possible, individual participation was systematically tracked. Following each workshop session, the instructor(s) and the observer reviewed each day's session, at which time the observer adjusted the records to clarify confusion and/or record additional information (e.g., things that happened on the other side of the room).

   Identification of L – 's and her group's phase of interest was informed by both the interviews, whose questions were an adaptation of the questionnaire items completed by Lipstein and Renninger's (2007) writing students, and by an adaptation of Renninger and Wozniak's (1985) analysis of young children's behavioral records – the likelihood of their voluntary reengagement, engagement overall, independent engagement, and complexity of engagement.
3. *ICANs* (adapted from Chaconas; see Renninger & Nekoba, 2010) are a lab notebook activity that involves reflecting on the concepts and skills of the day's instructional objectives in relation to those that have preceded. The day that the celery experiment was set up, the *ICAN* probes in the lab books were:– I CAN use simple observations about light to explain why we see rainbows and why the sky is blue.

   – I CAN use chromatography to find out what is in markers.
4. In other discussions, the workshop participants drew clear lines between schoolwork and the workshops, along lines of the tasks, discipline, and interactions with instructors.
5. Control data were collected and no such shifts were identified.
6. The workshop instructors were professors and their students in the particular field of science (biology, chemistry).

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