Canalization and Connectedness in the Development of Science Interest

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In this chapter, I use a sociocultural approach to consider two processes for framing interest development: canalization and connectedness. Discussion of these processes is used to articulate how interest in science may be triggered in both initial and subsequent phases of interest development. Various factors may characterize sources that trigger interest, including novelty, choice, and social involvement. In this chapter, I draw on qualitative data from a classroom-based study of Grade 5 students, engaged in learning two science and technology topics, to discuss how constraints and affordances of particular activities provide potential triggers for interest for students at different phases of interest development. The research focuses on how individual learners create meaning related to particular triggers, in terms of perceived connectedness to the task and topic and to their peers and teacher. In conclusion, a sociocultural approach highlights the need to consider the dynamic interdependence between social and individual processes when researching how interest in science may be triggered. Such an approach also emphasizes the importance of considering triggers over time, as interest may shift and become well developed. Implications for elementary classroom practice in science relate to teacher planning for (a) collaborative hands-on investigations that develop students' knowledge and skills, followed by (b) opportunities for inquiry based on curiosity questions, concluding with (c) tasks that allow students to apply, evaluate, and reflect on their understanding, such as designing and making.

Introduction

The role elementary schools play in supporting students' development of interest in learning more broadly (Hidi, Renninger, & Krapp, 2004), and in science learning more specifically (Krapp & Prenzel, 2011), is considered central for educators and researchers. Approaches to science education are threefold, relating to (a) ensuring that students are open-minded toward science and technology, (b) helping students clarify their interests, and (c) establishing connections between students' existing interests and the curriculum (Krapp & Prenzel, 2011). Questions thus arise concerning how teachers might design classroom-based learning experiences so that students' initial interest in particular science topics is triggered. In the case of students with existing interest, questions arise concerning how the *development* of interest is triggered. How do teachers create science learning contexts to promote students' interest? How do teachers establish rapport with students, to enhance learning by making connections with their emerging and existing interests? Is there a "ripple effect" when students see their peers interested in learning?

In my 1st year as a Grade 6 teacher, Kate was one of the students in my class. She had a keen sense of humor and an enthusiasm for life. Kate excelled in a range of sports and had been elected by her peers as a house captain. Despite such strengths, halfway through the school year, I found myself wondering how I could contribute to switching Kate onto learning in the classroom. She consistently performed at the lower end of the class in terms of academic ability, yet she had a spark and energy I believed could be harnessed. I just had not found the hook with which to connect her with classroom-based learning.

The final term in the school year arrived, and I began to plan a learning unit for science and technology. The unit focused on endangered Australian animals and incorporated a field trip to a natural history museum. The pedagogical approach on which the unit was based was a learners' questions approach (Faire & Cosgrove, 1988; Griffin, 1998). In the initial lessons, the students in my class engaged in activities that involved them in considering various endangered animals and reasons for their endangered status. As they read widely, each student made a choice of animal in which to specialize and posed curiosity questions to guide a research investigation. Kate selected the gastric brooding frog, an unusual frog that swallows its spawn after laying it, which at the time was highly endangered. The tadpoles hatch and develop in the stomach of the mother frog, which regurgitates them once they are froglets. Kate was fascinated. She read with an excitement and enthusiasm I previously had not thought possible. When she went on the museum field trip, Kate discovered that she knew more than the information conveyed in any of the exhibits. She began to see herself as an expert on the gastric brooding frog, as did her peers. The final stage in the unit involved the students in writing information reports to share their knowledge about their animals. They then made oral presentations to the class on the basis of their written reports, and the collated reports formed a class book, *Grade 6's Australian Endangered Animals*. Kate's interest in completing and presenting her report resulted in a higher standard of achievement than I had seen from her all year. She was highly focused and engaged in any aspect of the unit that related to her work on the gastric brooding frog. It seemed as though Kate was extending the boundaries of what she herself saw as possible in her learning.

I felt as though my role in connecting Kate with learning had happened by chance, rather than by design. I reflected on her interest during this unit, which had motivated her to achieve and to share her understanding and excitement for learning with others. If this was possible for Kate, how could I ensure that more of my students experienced and shared such interest in learning science?

Sources for Triggering Interest in Science

A number of researchers have focused on how interest is triggered, particularly in relation to initial interest in a domain. Dewey (1913) distinguished between *catch* and *hold* factors, which Mitchell (1993) drew upon in his study of mathematics lessons. Mitchell identified group work, computers, and puzzles as novel tasks that could spark or temporarily stimulate students' interest, while meaningfulness and involvement contributed to maintaining it by empowering the students. Renninger and colleagues (Lipstein & Renninger, 2007; Renninger & Riley, 2013; Renninger & Su, 2012) have focused on the interest-triggering process, with particular attention to the novelty of content, the teacher's role, the quality of social interactions and situations, personal significance and value, reflection on content, and self-generation of interest. Importantly, Renninger and Su (2012) highlighted that

> the presence of supports and intended triggers does not necessarily guarantee triggering. Instead, interest appears to be both triggered and supported to develop when a task such as an assignment to set a goal for class at the beginning of term leads to learners finding meaning for themselves, or when learners are allowed to take charge of shaping class activity. (p. 171)

They further emphasized that in the earlier phases of interest, triggers in classroom-based contexts support learners in making connections to content, and potential triggers in the learning environment may be especially critical. In the latter phases, triggers relate more to opportunities for continued development of understanding of content, when a learner is in a position to self-generate interest (Renninger & Su, 2012).

More specifically, research has established various factors that may characterize sources that trigger interest in science topics and in learning science. Hoffmann's (2000, 2002) instructional interventions in science classrooms aimed at generating students' interest. The program included opportunities to marvel, links to prior experiences, firsthand experiences, discussions and reflections on the social importance of science, application-oriented contexts, and references to the human body. Palmer (2004, 2009) studied situational interest in an inquiry-skills lesson in secondary classrooms and in an elementary science teacher education course. He identified sources of interest as novelty, choice, physical activity, meaningfulness, and social involvement.

More recently, Dohn (2011, 2013) studied situational interest triggers in authentic science learning contexts from a situative perspective (Nolen & Ward, 2008). In a study of the emergence of interest among high school students during a science field trip to an aquarium, Dohn (2011) focused on specific variables that trigger situational interest. He established five sources of situational interest: (a) social involvement related to interest stimulated by interpersonal interactions and feelings of belonging and (b) surprise, which related to the unexpected in terms of knowledge. The other three sources identified by Dohn (2011) were (c) hands-on activities; (d) novelty, in the sense of something new or different from the everyday; and (e) knowledge acquisition, in terms of acquiring knowledge and relating it to prior knowledge. Dohn (2011) concluded that field trips are important in activating interest and a range of other positive attitudes toward a topic. Subsequently, Dohn (2013) conducted a project focused on Grade 6 students engaged in an 8-week inquiry-based science and technology program. He found four main sources of interest: designing interventions, trial-and-error experimentation, achieved functionality of invention, and collaboration. The stimuli factors, or characteristics of these sources, Dohn (2013) identified were novelty, autonomy (choice), social involvement, self-generation of interest, and task-goal orientation.

With the exception of the recent studies of Dohn (2011, 2013) and Renninger and colleagues (Lipstein & Renninger, 2007; Renninger & Riley, 2013; Renninger & Su, 2012), which incorporated participant observation in learning contexts over time, a limitation of previous research focused on interest triggers is that it has tended to rely on self-report questionnaires or surveys of students' interest in the initial phase of development (Krapp & Prenzel, 2011). Renninger and Su (2012) highlighted that the learner may not be aware until much later that interest has been triggered, which has methodological implications for measures and approaches to studying triggering. In previous research reliant on self-report measures, the focus shifts away from the study of processes that trigger interest, as well as from triggers for shifts from one phase of development to another as interest deepens and is sustained (Renninger & Su, 2012). The need for consideration, and investigation, of such processes is thus highlighted, and suggests that an alternative approach may provide further elaboration of how triggers work. When interest is framed from a Vygotskian sociocultural perspective (MacCallum & Pressick-Kilborn, 2011; Pressick-Kilborn & Walker, 2002; Walker, Pressick-Kilborn, Sainsbury, & MacCallum, 2010), emphasis is placed on research that is conducted in real-life contexts over time, with a focus on how interest develops in person-environment transactions in which the individual and the field of participation are conceptualized as "inclusively separate" (Valsiner, 1998). The potential of two processes from a sociocultural perspective, canalization and connectedness, is considered in this chapter, as a frame for analyzing how students' interest is triggered in one elementary science classroom.

How Does a Sociocultural Perspective Offer a Frame for Thinking About Triggering?

A Vygotskian sociocultural perspective is theoretically distinctive because it conceptualizes the origins and nature of motivation as fundamentally social (Turner & Patrick, 2009; Walker, Pressick-Kilborn, Arnold, & Sainsbury, 2004; Walker et al., 2010). Interest, as a motivational construct, is thus conceptualized as originating in social interaction. Such interaction can be directly with others in real time, or with dialogic artifacts created by others, such as written texts, or with objects or activities that have sociocultural meaning or significance. Similarly to a sociocognitive perspective (Hidi & Renninger, 2006), interest is framed as developing toward expression and identity as an individual interest over time. Sociocultural theory draws explicitly on processes of transformative internalization and externalization to explain how such development can occur (Walker, 2010). The goal of participation in particular communities of practice, such as school classes or families, promotes interest development (Nolen, 2007). Two processes from a sociocultural approach to explaining development, canalization and connectedness, provide particular insight into explaining how interest triggers work.

Canalization and Connectedness: Explaining the Processes

Canalization is a concept used by Valsiner (1992, 1997) that can be incorporated in sociocultural theories to frame social guidance of the internalization and externalization process. As Valsiner and Lawrence (1997) explained, “People construct personal meanings for the events they experience, with the assistance and boundaries provided by social structures and other individuals" (p. 87). Canalization by the social world refers to the ways in which social structures and other people, consistent with their values and goals and those of the culture at large, channel a learner's activities in certain ways. As such, development is organized in some, rather than another, future direction (Valsiner, 1997). Resistance to the canalization of others can force changes in external constraint systems (Valsiner, 1997), which highlights the agency of the individual. *Self-canalization* refers to the learner's construction of "his or her own psychological functions in the process of social experiencing" (Valsiner, 1992, p. 34), and further emphasizes individual agency. As a process, self-canalization represents "the emergence of an intrapsychological self-constraining system" (Valsiner, 1997, p. 309). The notion of canalization has been used to frame interpretation of data (e.g., MacCallum & Pressick-Kilborn, 2011), and motivation researchers such as Nolen (2007) and Turner and Patrick (2009) have indicated that it is both theoretically and analytically useful. Self-canalization is the process that encapsulates Renninger's (2010) observation that "learners appear to become promoters and developers of their own interest" (p. 129), particularly in the transition from less to more developed phases of interest. To briefly illustrate the canalization process by returning to Kate's story from the beginning of this chapter, as the teacher, I decided to structure the classroom science program using a learners' questions approach. This approach promoted student inquiry and choice, and created opportunities for students to pursue their own lines of research and investigation in the classroom and on an excursion. Such pedagogical features created canalizing elements for Kate's interest development, in both affording and constraining possibilities for her participation. Books and other resources were available in the classroom for students to read widely. Kate's own emerging interest in the gastric brooding frog became self-canalizing, as she became increasingly directed by her own interest to engage with any resource or material relating to the frog. She was observed as placing focused effort into developing and sharing her own knowledge, and as a consequence, her interest.

In sociocultural theories, it is through the creation of intersubjectivity as people learn together that development becomes possible (Rogoff, 1990, 1998). For children and more experienced peers or adults to create zones of proximal development (Gallimore & Tharp, 1990; Vygotsky, 1978), mutual understanding or intersubjectivity needs to be negotiated among the people engaged in learning together. A sense of *connectedness* between people in the context of learning is a vital aspect of the creation of intersubjectivity (Cole, 1996). Walker (2010) emphasized the nature and quality of interpersonal relationships as being important to internalization and externalization processes. Intersubjectivity is continually being negotiated in relation to specific activities, including among children and adults with established relationships. The creation of intersubjectivity enables the negotiation of shared purpose, focus, and values (Rogoff, 2003). Connectedness is related to what Palmer (2009) and Dohn (2011) referred to as social involvement, which incorporates a sense of belonging, in terms of perceived relationships to teachers and peers and the associated positive feelings. The notion of connectedness, however, also extends to the personal meaning or relevance of what is being learned, and the sense of involvement with, and significance of, the knowledge of a particular domain or topic. There is thus a cognitive aspect to this concept: the individual learner experiences a sense of connectedness to disciplinary content, and actively engages in reflecting on it to ask questions, explore, and reorganize understanding (Renninger & Riley, 2013). It appears as though the desire for, and experience of, connectedness triggers and promotes interest development. To draw again on Kate's story, there was evidence of connectedness for Kate with the shared activities of the classroom, observed in her active participation in researching her chosen animal, and in preparing and presenting her written report, such that she was perceived as an expert in the classroom by her peers. Kate's focused engagement also was indicative of her sense of connectedness with the content, which was triggered through initial surprise about the tadpole phase in the frog's development, but sustained over the course of the unit. Her increasing knowledge acted as a trigger for deepening her interest and her sense of connectedness with the content; in this more open learning environment, learning itself appeared to serve as a trigger (Renninger & Riley, 2013) for Kate's interest development.

A Case Snapshot From a Qualitative Classroom-Based Research Project

To further illustrate the processes of canalization and connectedness in explaining how triggering works, I now share a case snapshot I selected from a qualitative classroom-based project I conducted, drawing on a design-based research methodology (Reimann, 2011) in the tradition of Brown (1992) and Guthrie and Alao (1997). Guiding instructional principles were developed during a 3-month pilot project, incorporating findings from studies of interest and motivation in classroom settings (Ainley, 2001; Bergin, 1999; Meyer & Turner, 2002; Mitchell, 1993) and studies of science classrooms as learning communities (Brown, 1997; Roth & Lee, 2006). The main phase of the project then involved a Grade 5 classroom teacher, Ms. Wheeldon, in collaboratively designing and implementing inquiry-based learning units in science and technology, on the basis of these instructional principles. I conducted this study in Ms. Wheeldon's Grade 5 elementary classroom in an independent fee-paying girls' school in Sydney, Australia. There were 26 students (ages 8–10 years) in the class, who were from families of middle socioeconomic status and ethnically diverse backgrounds, including Greek, Lebanese, Chinese, Indian, and Korean. Six students were purposively selected as "focus" participants in the research on the basis of initial observations of their expressions of interest, or lack thereof, in science. Ms. Wheeldon had been teaching Grade 5 for 3 years at the time of the study.

My role as the researcher in the study was as a participant observer during the students' weekly science lessons. I observed their learning about two topics: electricity and energy resource conservation (a 10-week unit, Term 1, February to April) and egg-laying animals and the role of zoos in animal conservation (a 10-week unit, Term 2, May to June). Data collected focused on the interaction among teacher actions, collaborative student activities, and individual student actions. The findings reported in this chapter are based primarily on data collected using student interest trajectories. All students were given a numbered list of all of the activities following the first six lessons of the unit on eggs and egg-laying animals. The students were then given a blank graph, with a 7-point, Likert-type scale of levels of interest on the vertical axis[1] and the activity number on the horizontal axis. They were asked to think back to each activity, and retrospectively chart

[1] Ratings ranged from 1 (*not interested at all*) to 7 (*very interested*).

how interested they remembered feeling in comparison with the other activities they had completed. Class discussion prior to charting trajectories revealed that the students considered themselves to be interested when they were "into it," "when it gets your attention," and "you like it" (students' responses during a class discussion); in each case, "it" appears to refer to an object or activity. This process of generating trajectories meant that particular aspects of pedagogical practice that have consequences for interest development were identifiable in the trajectory patterns across students. Trajectories were also used as a stimulus for discussion in interviews with focus students to explore their reasons for rating particular activities. Other strategies for data collection used in the wider project that are also sources for further contextual information in this chapter include researcher field notes, video- and audio-recorded classroom episodes, still photographs, semi-structured interviews with focus students during the main phase of the study, and then, 5 and 12 months later, and written student reflections.

In this chapter, one particular lesson is described from the unit on egg-laying animals.[2] The unit was based on the learners' questions approach (Faire & Cosgrove, 1988). The focus lesson took place during the "exploratory activities" stage and was designed to provide students in the class with a shared learning experience to develop their knowledge and understanding of the topic, upon which they could base their questions to guide further investigation. The salient features of this lesson are discussed in relation to canalization and triggering, with a specific focus on possibilities for and constraints on interest development. The participation of three of the focus students—

[2] Accounts and analysis of activities from the electricity (physics-based) learning unit are included in Pressick-Kilborn and Walker (2002), Walker et al. (2004, 2010), and MacCallum and Pressick-Kilborn (2011).

Michaela (evidence of early phase of interest development), Eleni, and Philippa (both later phase)—is highlighted, with consideration of participant observations and students' self-reports of interest to inform discussion of perceived connectedness to the task and topic and to their peers and teacher, Ms. Wheeldon. The students selected are at different phases of development of interest in the topic, which enables a focus on how individual learners create meaning related to particular triggers and how reasons may differ for the experience of interest in the same activity.

Focusing on Lesson 3: Dissecting a Chicken's Egg

In this 70-minute lesson, excitement among the students was generated from the outset as Ms. Wheeldon introduced the investigatory task of dissecting a chicken's egg as the focus. Following this brief introduction, the students watched a 10-minute informative documentary video about eggs. This had a clear purpose, as the students were aware that they would be using this knowledge in the focus activity for the lesson. Ms. Wheeldon then drew on the knowledge that the students had developed through the video to direct a class discussion about "parts of an egg to look out for." She recorded the parts that the students identified, writing these on a board at the front of the classroom so that all students could make reference to these during the dissection activity. Although this part of the lesson was quite strongly teacher directed, the students were able to contribute their ideas about the features of an egg, providing opportunity for student input.

The main stage of the lesson was student-directed, with opportunities for creating multiple pathways along which the activity could develop. Each student was given her own raw chicken's egg to crack open and dissect. There was a general sense of excited anticipation in the classroom as students each gathered an egg on a plastic plate. Although this was an individual task, the girls were clustered in groups, so that they discussed their progress with peers. Within these groups, various discoveries were made at different times and loudly and excitedly shared with others in the group. Students were using specific terms that had been recorded on the blackboard, such as *chalaza* and *membrane*. There was much laughter and squealing as well! The teacher and researcher were frequently called over to groups, often with urgency evident in the students' desire to share what was of interest at that moment. The students had ample time to engage in this highly tactile activity, including time for playful exploration once they had identified key features of their egg. When it came time to pack away, some students developed a side investigation at the garbage bin. They each held the yolk by its membrane over the bin and then waited to see how long it would take to break. As Anna walked back to her desk, she exclaimed, "That was the best thing ever!"

To conclude the lesson, Ms. Wheeldon directed a class discussion about the functions of the parts of an egg the students had located. Drawing on their firsthand experience, the students then were given the task of sketching a labeled diagram of a cross-section of an egg in their science workbooks.

Focusing on Michaela, Eleni, and Philippa During Lesson 3

The description of the structure of the lesson recounted in the previous section indicates certain possibilities for student involvement and opportunities for interest to develop along particular pathways or channels, because of the materials available, the task attributes, and the overall structure of the lesson as designed by the teacher. The documentary video and teacher explanation and elicitation contributed to clarity of expectations for the dissection task. The purpose of watching the video was clear to the students, who appeared to understand that viewing it would help them complete the dissection task. The dissection was an individual activity; however, there was an explicit expectation from the teacher that students would provide collaborative support for one another. Students could work at their own pace, with teacher support for autonomy. By focusing now more specifically on Michaela, Eleni, and Philippa, insights can be gained into how the individual students' own actions and interests directed their involvement and possibilities for creating and pursuing particular pathways.

Michaela. Michaela was observed to be at an earlier phase of interest development in relation to the eggs topic, with greater fluctuations and shifts in her interest both observed and retrospectively self-reported by Michaela during the different stages of this lesson. During the video, Michaela was attentive. She had no off-task "side conversations" with peers, as had been observed in previous lessons. She rated herself as experiencing a high level of interest, and later wrote in her reflection that she felt "very interested because you learnt a lot from a video and you usually don't." Novelty was a trigger for Michaela's interest at this initial stage in the lesson. Michaela was actively involved in the class discussions. She raised her hand and volunteered one of the parts of an egg during the brainstorming. It was evident that Michaela wanted to be a part of the dissection activity and engaged in identifying specific parts of the egg. She located the membrane inside the shell and showed it to peers in her group. Michaela initiated conversation in the class discussion at the end of the lesson, when Ms. Wheeldon asked "Is there anything else?" in relation to recording parts and functions of a chicken's egg. Later, Michaela accurately recalled specific features and reflected that "It was terrific and I saw the chalaza, air sack, germinal spot, and albumen." For the dissection task, Michaela's interest trajectory peaked and she reported herself as feeling very interested. The task of labeling an egg, however, was rated by Michaela as her feeling lower than not interested at all, indicating extreme fluctuation in her interest between the second and third tasks in this lesson. Michaela experienced considerable fluctuation in her interest during this lesson, with evidence of greater dependence on contextual, task-related triggers.

Eleni. From the outset of this lesson, Eleni's engagement was evident. Her face lit up in visible excitement as Ms. Wheeldon introduced the egg dissection task. I was sitting close to Eleni during the lesson introduction, and she commented to me as an aside that she would definitely tell her younger brother about this, as he would want to do it at home. During the video, Eleni looked over to the class notice board, where the students' questions about eggs, posed in Lesson 1, were displayed. Later in her reflection, it became evident that her attention to the notice board at this time was related to her realization that the video had answered her question. At the end of the video, Eleni told her peers nearby that she found out things she did not know, and she rated herself as feeling very interested when she later completed her trajectory graph. Eleni was initially reluctant to use her fingers during the dissection task, and took up Philippa's suggestion to “use a paper clip as a prodder.” Despite this initial reluctance, Eleni held the yolk in her hands at the end of the dissection and saved half of the shell to take home, carefully wrapping it in a tissue. She actively volunteered during the class discussions in the first and final stages of the lesson. Eleni’s ratings of her interest for the dissection and labeling tasks extend beyond her feeling “very interested.”

Philippa. Philippa was highly attentive during the video, volunteering during the class discussion that followed. Although she found the video interesting, it was the dissection task in which she experienced a very high level of interest. Philippa’s facial expressions revealed her delight in using her hands to carefully identify the parts of the egg and she delicately separated the membrane from the shell and saved it. Novelty within this lesson was a strong aspect of Philippa’s reflection on her interest experienced during the different activities. “I really enjoyed the video because it taught me many things that I never knew before.” The egg dissection was also a new experience for Philippa, “just so intriguing because it was the first time I got to touch the insides of a raw egg.”

To contextualize the tasks within this lesson in relation to students’ trajectories across tasks in other lessons in the unit, Eleni experienced consistently high levels of interest in the egg-laying animals topic that the class was studying (valuing of the *topic* evident). Philippa’s experiences of interest, however, fluctuated across different tasks but were relatively positive overall (valuing of the *domain* of science and technology evident), and Michaela experienced extreme highs and lows in relation to her interest in tasks, sometimes within the same lesson (valuing of *tasks* evident), as was the case in the snapshot shared here.

This case snapshot has revealed the variation in individual students' experiences of interest within the same classroom community. The tasks within the lesson designed by Ms. Wheeldon had characteristics that included potential interest triggers, with the purposeful inclusion of a video that afforded knowledge acquisition, a hands-on and novel dissection task that related to knowledge developed through watching the video and that promoted social involvement and autonomy, and a concluding task that fostered reflection on the content of what had been learned (Dohn, 2013; Renninger & Su, 2012). Yet for each of the three students, the lesson was experienced differently in terms of the ways in which the tasks and context contributed to canalizing their interest and promoting connectedness.

Implications for Research

There is a need for studies of interest in authentic classroom settings over time, so that initial interest triggers as well as triggers for development at different points—from one phase of interest to the next—can be investigated. As Valsiner (1992) and others have observed, a challenge in studying interest is that we often do not recognize interest until it has emerged. Empirical studies, therefore, need to be designed in such a way that the developmental processes leading up to the emergence of recognizable interest becoming the focus of the research. Such an approach to research design should enable further study of triggers for interest development, in the context of dynamic and authentic interactions between individuals and situations for learning science.

The potential of sociocultural and situative theories (Nolen & Ward, 2008) in explaining interest development is yet to be widely investigated. Valsiner (1992) explicitly framed a theoretical discussion of interest from a sociocultural perspective, and Renninger (2000) drew on aspects of sociocultural theory in a review of research. With the exception of Lightfoot (1988), it is not until more recently that empirical studies framing interest from these perspectives have been reported (Dohn, 2011, 2013; Nolen, 2007; Pressick-Kilborn & Walker, 2002; Walker et al., 2010). Particular strengths of such perspectives appear to be the conceptualization of the individual and context as inclusively separate and dynamically interdependent. Continued studies in science education contexts, which draw on key notions from these perspectives, are needed to establish the usefulness of sociocultural and situative theories in interpreting research data gathered in authentic classrooms, and for understanding the interest construct and explaining how interest develops. For example, the salience of different sources that trigger interest may change depending on a student's phase of interest development, and research that focuses on students' participation in ongoing science activities is needed for such questions to be answered. The recent research of Renninger and her colleagues (Renninger & Riley, 2013; Renninger & Su, 2012) takes this approach.

Implications for Practice

The main implication for classroom practice is the vital role elementary science teachers play. First, teachers must plan and program science-based learning experiences that are personally meaningful and relevant to students, yet also provide elements that are surprising, novel, wonderful, and complex. The decisions a teacher makes about the content focus, the sequence and types of tasks, the grouping structures and provision for individual work, the physical and human resources, the use of display boards in the classroom, and the allocation of time all create opportunities for and limitations on the development of interest. Tasks that allow students to pursue lines of inquiry guided by curiosity questions can support the triggering of interest, through providing opportunities for students to deepen their knowledge about aspects of a topic that have personal meaning or that provide a stimulus for wonder. Teachers need to be aware of the ways in which their pedagogical decision making contributes to creating affordances and constraints on children's development of interest. Hands-on activities, such as investigation through fair testing and design-and-make tasks, provide opportunities for students to develop, apply, evaluate, and reflect on their understanding. Such activities may trigger interest development by raising new questions for students, highlighting another aspect of a particular topic that they have yet to understand or a skill that they need to develop. The very nature of hands-on activities also seems to promote interest in learning science. Furthermore, opportunities for students to encounter "the real thing" through excursions and field trips appear key to creating potential triggers for students' interest development in science. Explicit connections made between students' school-based learning and their experiences outside of school, in their families and other community groups, should also be included in the design of classroom-based programs.

Emphasizing relationships across the communities in which students participate is likely to promote triggering at various points in the development of interest, through enhancing connectedness by supporting the personal relevance and meaning of science-based tasks and topics.

Second, teachers are potential models of interested learners, with whom elementary students often experience a sense of connection. This is an area for which there are few empirical investigations (Long & Hoy, 2006), although Renninger and colleagues (Lipstein & Renninger, 2007; Renninger & Riley, 2013) have acknowledged the role of the teacher in the triggering process. It seems that when students perceive their teachers as interested and responsive to their own learning, as well as interested in the tasks and topics of the science program, there is the potential for a sense of connectedness to develop between students and their teachers, and for interest to be triggered. Such connectedness enhances the potential for shared meaning and focus to develop in the classroom. "When students see their teacher's wonder, they recognize that wonder is what they too are experiencing. When they see their teacher's excitement about learning, they recognize their own excitement" (Metcalfe & Game, 2006, p. 103). Students need to see their teachers' interest and actions within learning contexts, in order for them to develop interest themselves (Dewey, 1913). Nonverbal cues, such as facial expressions and the use of gestures, as well as articulations by the teacher related to interest, provide students with a basis for their impressions of a teacher's interest in learning.

Finally, it is important to return to the unique nature of interest as a motivational variable that combines cognition and affect. Although teachers play a critical role as models for students' valuing of and enjoyment in learning science, they also are vital to helping students to connect with key science concepts, so that deep and broad knowledge and understanding develop. As part of the triggering process, students need to experience interest in scientific knowledge (Krapp & Prenzel, 2011) and a sense of personal connectedness to that knowledge. Elementary teachers need to have sound conceptual understanding of a range of science topics, and preservice and in-service professional learning should focus on ensuring that teachers' own knowledge does not limit the potential for students to engage with expert knowledge in the domain.

Concluding Thoughts

The broad question that focuses this research is how teachers' pedagogical decision making can support elementary students' development of interest in science. A specific contribution of this work is the framing of interest from a sociocultural perspective. As highlighted in this chapter, sociocultural and situative perspectives have only relatively recently been used to study interest in classroom-based learning environments, and further research is needed to continue to develop such theories. The utility of notions drawn from sociocultural theories, such as canalization and connectedness, needs further investigation.

Discussion of the implications for research and practice points to the continued need to conduct interest research in authentic classroom settings over time. The focus of such research should be to better understand and explain how contextual and individual aspects of interest interact as interest develops. Such an understanding will support teachers in designing and implementing classroom-based science programs that trigger, deepen, and expand students' interest in the discipline, at all phases of interest development. Descriptions and analyses of such classroom-based elementary science programs have the potential to make important and insightful contributions to the research and professional literatures.

Conducting research in complex settings, such as classrooms, presents particular challenges for both studying and conceptualizing interest. A challenge for future interest research is the further development of methodologies and research designs that contribute to both advancement of theory and applications in science teaching practice. Studies that have the input of researchers and classroom practitioners in their design and interpretation should ensure the robustness and relevance of theories of interest for classroom practice, as researchers and teachers collaborate to gain understanding and new insights into how best to support students in meaningful, engaging, and enjoyable science learning.

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References

Ainley, M. (2001). Interest in learning and classroom interactions. In D. Clarke (Ed.), *Perspectives on practices and meaning in mathematics and science classrooms* (pp. 105–130). Dordrecht, The Netherlands: Kluwer Academic.

Bergin, D. A. (1999). Influences on classroom interest. *Educational Psychologist*, *34*, 87–98.

Brown, A. L. (1992). Design experiments: Theoretical and methodological challenges in creating complex interventions in classroom settings. *Journal of the Learning Sciences*, *2*, 141–178.

Brown, A. L. (1997). Transforming schools into communities of thinking and learning about serious matters. *American Psychologist*, *52*, 399–413.

Cole, M. (1996). *Cultural psychology: A once and future discipline*. Cambridge, MA: Belknap.

Dewey, J. (1913). *Interest and effort in education*. Cambridge, MA: Riverside.

Dohn, N. B. (2011). Situational interest of high school students who visit an aquarium. *Science Education*, *95*, 337–357.

Dohn, N. B. (2013). Situational interest in engineering design activities. *International Journal of Science Education*, *35*, 2057–2078. doi:10.1080/09500693.2012.757670

Faire, J., & Cosgrove, M. (1988). *Teaching primary science*. Hamilton, New Zealand: Waikato Education Centre.

Gallimore, R., & Tharp, R. (1990). Teaching mind in society: Teaching, schooling and literate discourse. In L. C. Moll (Ed.), *Vygotsky and education: Instructional implications and applications of sociohistorical psychology* (pp. 175–205). Cambridge UK: Cambridge University Press.

Griffin, J. (1998). *School-museum interactive learning experiences in science*. Unpublished doctoral dissertation, University of Technology, Sydney, Australia.

Guthrie, J. T., & Alao, S. (1997). Designing contexts to increase motivations for reading. *Educational Psychologist*, *32*, 95–105.

Hidi, S., & Renninger, K. A. (2006). The Four-Phase Model of Interest Development. *Educational Psychologist*, *41*, 111–127.

Hidi, S., Renninger, K. A., & Krapp, A. (2004). Interest, a motivational variable that combines affective and cognitive functioning. In D. Y. Dai & R. J. Sternberg (Eds.), *Motivation, emotion and cognition: Integrative perspectives on intellectual functioning and development* (pp. 89–115). Mahwah, NJ: Lawrence Erlbaum.

Hoffmann, L. (2000). *The effect of students' interest in science on their achievement.* Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans.

Hoffmann, L. (2002). Promoting girls' interest and achievement in physics classes for beginners. *Learning and Instruction, 12*(4), 447-465.

Krapp, A., & Prenzel, M. (2011). Research on interest in science: Theories, methods and findings. *International Journal of Science Education*, *33*, 27–50.

Lightfoot, C. (1988). The social construction of cognitive conflict: A place for affect. In J. Valsiner (Ed.), *Child development within culturally structured environments: Social co-construction and environmental guidance in development* (Vol. 2, pp. 28–65). Norwood, NJ: Ablex.

Lipstein, R., & Renninger, K. A. (2007). “Putting things into words”: 12-15 year old students’ interest for writing. In P. Boscolo & S. Hidi (Eds.), *Motivation and writing: Research and school practice* (pp. 113–140). New York: Kluwer Academic/Plenum.

Long, J. F., & Hoy, A. W. (2006). Interested instructors: A composite portrait of individual differences and effectiveness. *Teaching and Teacher Education*, *22*, 303–314.

MacCallum, J., & Pressick-Kilborn, K. (2011). Examining change in motivation: The potential of sociocultural theory. In D. M. McInerney, R. A. Walker, & G.A.D. Liem (Eds.), *Sociocultural theories of learning and motivation: Looking back, looking forward* (pp. 163–187). Charlotte, NC: Information Age.

Metcalfe, A., & Game, A. (2006). The teacher's enthusiasm. *Australian Educational Researcher*, *33*, 91–106.

Meyer, D. K., & Turner, J. C. (2002). Discovering emotion in classroom motivation research. *Educational Psychologist*, *37*, 107–114.

Mitchell, M. (1993). Situational interest: Its multifaceted structure in the secondary school mathematics classroom. *Journal of Educational Psychology*, *85*, 424–436.

Nolen, S. B. (2007). Young children's motivation to read and write: Development in social contexts. *Cognition and Instruction*, *25*, 219–270.

Nolen, S. B., & Ward, C. J. (2008). Sociocultural and situative research on motivation. In M. Maehr, S. Karabenick, & T. C. Urdan (Eds.), *Social psychological perspectives on motivation and achievement: Advances in motivation and achievement* (Vol. 15, pp. 428–460). London: Emerald.

Palmer, D. (2004). Situational interest and the attitudes towards science of primary teacher education students. *International Journal of Science Education, 26,* 895–908.

Palmer, D. (2009). Student interest generated during an inquiry skills lesson. *Journal of Research in Science Teaching, 46,* 147–165.

Pressick-Kilborn, K., & Walker, R. A. (2002). The social construction of interest in a learning community. In D. M. McInerney & S. Van Etten (Eds.), *Sociocultural influences on motivation and learning* (Vol. 2, pp. 153–182). Greenwich, CT: Information Age.

Reimann, P. (2011). Design-based research. In L. Markauskaite, P. Freebody, & J. Irwin, (Eds.), *Methodological choice and design: Scholarship, policy and practice in social and educational research* (pp. 37–50). New York: Springer.

Renninger, K. A. (2000). Individual interest and its implications for understanding intrinsic motivation. In C. Sansone & J. M. Harackiewicz (Eds.), *Intrinsic and extrinsic motivation: The search for optimal motivation and performance* (pp. 373–404). San Diego, CA: Academic Press.

Renninger, K. A. (2010). Working with and cultivating interest, self-efficacy and self-regulation. In D. Preiss & R. Sternberg (Eds.), *Innovations in educational psychology: Perspectives on learning, teaching and human development* (pp. 107–138). New York: Springer.

Renninger, K. A., & Riley, K. (2013). Interest, cognition and the case of L__ and science. In S. Kreitler (Ed.), *Cognition and motivation: Forging an interdisciplinary perspective* (pp. 352–382). Cambridge, UK: Cambridge University Press.

Renninger, K. A., & Su, S. (2012). Interest and its development. In R. Ryan (Ed.), *Oxford handbook of human motivation* (pp. 167–187). New York: Oxford University Press.

Rogoff, B. (1990). *Apprenticeship in thinking: Cognitive development in social context*. New York: Oxford University Press.

Rogoff, B. (1998). Cognition as a collaborative process. In W. Damon, D. Kuhn, & R. Siegler (Eds.), *Handbook of child psychology* (5th ed., Vol. 2, pp. 679–744). New York: John Wiley.

Rogoff, B. (2003). *The cultural nature of human development*. New York: Oxford University Press.

Roth, W.-M., & Lee, Y.-J. (2006). Contradictions in theorizing and implementing communities in education. *Educational Research Review*, *1*, 27–40.

Turner, J. C., & Patrick, H. (2009). The cultural situatedness of motivation. In A. Kaplan, S. Karabenick, & E. De Groot (Eds.), *Culture, self and motivation: Essays in honor of Martin L. Maehr* (pp. 243–265). Charlotte, NC: Information Age.

Valsiner, J. (1992). Interest: A metatheoretical perspective. In K. A. Renninger, S. Hidi, & A. Krapp (Eds.), *The role of interest in learning and instruction* (pp. 27–41). Hillsdale, NJ: Lawrence Erlbaum.

Valsiner, J. (1997). *Culture and the development of children's action: A theory of human development* (2nd ed.). New York: John Wiley.

Valsiner, J. (1998). Dualisms displaced: From crusades to analytic distinctions. *Human Development*, *41*, 350–354.

Valsiner, J., & Lawrence, J. A. (1997). Human development in culture across the lifespan. In J. W. Berry, P. R. Dasen, & T. S. Saraswathi (Eds.), *Handbook of cross-cultural psychology, Vol. 2: Basic processes and human development* (2nd ed., pp. 69–106). Boston: Allyn & Bacon.

Vygotsky, L. S. (1978). *Mind in society*. Cambridge, MA: Harvard University Press.

Walker, R. A. (2010). Sociocultural issues in motivation. In P. Peterson, E. Baker, & B. McGaw (Eds.), *International encyclopedia of education* (3rd ed., Vol. 6, pp. 712–717). Oxford, UK: Elsevier.

Walker, R. A., Pressick-Kilborn, K., Arnold, L., & Sainsbury, E. J. (2004). Investigating motivation in context: Multiple dimensions, domains and assessments. *European Psychologist*, *9*, 245–256.

Walker, R. A., Pressick-Kilborn, K., Sainsbury, E., & MacCallum, J. (2010). A sociocultural approach to motivation: A long time coming but here at last. In S. Karabenick & T. C. Urdan (Eds.), *Advances in motivation and achievement* (Vol. 16B, pp. 1–42). Bingley, UK: Emerald.