Interest and Motivation in Informal Science Learning

K. Ann Renninger
Swarthmore College

In this paper, research on interest and motivation is revisited in the context of informal science learning (ISL) settings such as museums, out-of school or after-school clubs or groups, science camps, and enrichment programs[1]. The ISL context differs from traditional school "cookbook" science in a number of critical ways: rather than emphasizing science information, it is designed to engage participants in inquiry-informed and free-choice opportunities to work with authentic science[2]. Productive participation in the ISL setting should enable the development of scientific literacy and scientific thinking (Lehrer & Schauble, 2006), although tracking and documenting such development is not simple (Falk & Storksdieck, 2005).

ISL participation is easily discussed in terms of research on interest, where interest is conceptualized as both the state of heightened affect for science ***and*** the predisposition to re-engage science again (see Hidi & Renninger, 2006)[3]. Rather than simply a read on attraction, or positive feelings, interest includes the stored knowledge, stored value, and feelings that influence engagement, questioning, and activity of

[1] Falk, Dierking, and Storksdieck (2005) provide a useful reminder that learning in ISL settings may or may not be formal science content.
[2] This is not to suggest that school science is never exciting, meaningful, nor authentic, see for example, Metz (1995) or Springer (2006).
[3] Whereas motivation is used to describe the will-to-succeed across multiple contexts (see Eccles, Wigfield, & Schiefele, 1998), interest is not necessarily focused on achievement and is always linked to a particular class of objects, events, or ideas, such as science (Krapp, Hidi, & Renninger, 1992; Renninger & Wozniak, 1985). For the purposes of this paper, science will be used in a generic sense, although more specific interest for physics, chemistry, and so forth is likely to characterize participants over 10 years of age. Points made about interest for science, moreover, are likely both to apply to and draw on research of other disciplines or pursuits such as mathematics, writing, or soccer.

individuals (or groups of individuals). Other motivational variables (e.g., goal-setting, self-regulation, effort) have primarily been studied in contexts where expectations for learning are determined by the instructor/setting and assess the learners' will-to-succeed (see Eccles, Wigfield, & Schiefele, 1998; Wigfield, Eccles, Schiefele, Roeser, & Davis-Kean, 2006). In this paper, it is contended that in terms of its application to the ISL setting, research on both interest and motivation needs careful reconsideration. Research on each has the potential to add dimension to what is understood about the other, and to the design of and supports provided for learners.

In ISL settings, the participant often has choice and control over what is learned, when it is learned, and how it is engaged (Falk & Storksdieck, 2005); these contexts are designed to be safe and to allow exploration, free from the performance demands that often characterize schools (Nasir, Rosebery, Warren, & Lee, 2006). In order to participate productively in ISL settings, however, participants need to be able to attend and find meaning, set goals and have effective strategies for learning (NRC, 1996, 2006). These capacities are enhanced when the participant comes to the ISL setting with an interest for science (Renninger, 2000; see also Falk & Storksdieck, 2005).

Participants with little interest for science have less capacity to attend, find meaning, and identify their own questions (Renninger, Bachrach, & Posey, in press; Renninger, Ewen, & Lasher, 2002). With interest, participants begin to ask and seek answers to curiosity questions (e.g., Why do worms come out when it rains?) as they engage content (see Renninger, 2000). These may or may not be novel questions, and they may not be the questions held by others, the docent, camp leader, etc.

More developed interest has also been termed hobbies, personal excursions (Azevedo, 2006), islands of expertise (Crowley & Jacobs, 2002), or passions (Neumann, 2006). When participants have more developed interest for science, they pose curiosity questions and are also more inclined to learn and/or to use systematic approaches to seek answers (Engle & Conant, 2002; Kuhn & Franklin, 2006; Renninger, 2000). Participants who have an interest for science are also likely to be motivated learners in science; they are more likely to seek out challenge and difficulty, use effective learning strategies, and make use of feedback (Barron, 2006; Csikzentmihayli, Rathunde, & Whalen, 1993; Lipstein & Renninger, 2006; Renninger & Hidi, 2002).

Motivation to learn usually refers to the energy behind conscious decisions to achieve in school (measured by grades): to set goals, self-regulate, and exert effort (see Eccles, et. al., 1998; Murphy & Alexander, 2000; Wigfield, et. al., 2006). The types of goals that students adopt (e.g., mastery goals, performance-approach goals) influences their approach to learning, and these in turn influence the likelihood that they will self-regulate and exert needed effort in order to succeed. As Bandura (1986, 2005) has noted, students' perceptions of their abilities to succeed, or self-efficacy, affect the way in which they engage tasks. Students' goal-setting, self-regulation, and effort are the products of a choice or decision that is made by the student about whether success with tasks is possible (Dweck, 2002; Molden & Dweck, 2000).

Students calculate the worth of their effort, or "expectancy-value," based on previous success, perceptions of teachers' beliefs and practices (Eccles, et. al., 1983; see Eccles & Wigfield, 2002). Students are more likely to return to work on tasks over time and to expend effort to master them when they have self-efficacy and when they experience feelings of enjoyment and value for the tasks with which they are working (Linnenbrink & Pintrich, 2000; Wigfield & Eccles, 1992, 2000).

In contrast to school settings, participants are typically assumed to set their own goals in the ISL setting. The activity that follows is the basis for their enjoyment and learning. Participants may come to ISL with little to no interest for science, however. Such participants are not in a position to be setting and revising goals or exerting effort, since they know very little about their possibilities in given contexts (Renninger, Bachrach & Posey, in press). They are often only looking for an experience, rather than specific information or skills (Falk, 2005; Roggenbuck, Loomis, & Dagostino, 1990). Participants who come to ISL settings with developed interest, on the other hand, set more task-specific goals, self-regulate, and exert effort easily in the domain of their interest(s) and these behaviors can almost be considered to be habit (Lipstein & Renninger, 2006; Renninger & Hidi, 2002; Renninger, Sansone, & Smith, 2004). They, too, are looking for an experience but have more focused questions that inform their participation. They do not need the same type of support in order to set goals, self-regulate, or exert effort. Their interest can be said to provide this scaffold for them (Renninger, 1992).

Interest differs from other motivational variables in a number of ways. First, especially in early phases of its development, interest does not necessarily involve deliberate decision-making (e.g., about likely success and worth of self-regulation, etc.). Second, rather than being identified in the person, interest evolves in the interaction of the person with the environment and as a result can be supported to change. Third, interest is always identified with particular content (e.g. science) and is not a global construct. Fourth, the components of interest include stored value and stored knowledge, as well as feelings; thus, interest is both a cognitive and an affective variable. Finally, unlike other motivational variables that are impacted by culture, neuropsychology has identified “seeking behavior” (Panksepp, 1998) suggesting that all normatively functioning individuals can be expected to have interest (although the specific content of this interest may vary from science to video-games).

Importantly, interest always results in motivated behavior. Not all participants in ISL settings have a developed interest for science and are motivated to learn science, however. Although the ISL context provides ample opportunities for participants to pursue interest, those with little or no interest may need help to become productive participants. They are not likely to be ready to ask their own questions and seek answers to them, and may need support to develop the knowledge and skills that would allow them to begin such questioning and develop interest (Renninger, 2000). Those with developed interest are likely to need support that enables them to stretch their present understanding (Renninger, 2000). Thus, while the notion of facilitating learning (e.g. through exhibits, activities, interactions) in an inquiry-informed, free-choice setting could seem to be an oxymoron, participants are likely to benefit from support that allows them to optimize participation. Importantly, the literature on interest development suggests that interest for science can be supported to develop and deepen (Hidi & Renninger, 2006). This, in turn, should impact participant motivation (Lipstein & Renninger, 2006; Renninger & Hidi, 2002).

In order to consider the application of research on interest and motivation in ISL settings, XLAB, one type of ISL setting, and the experiences of two participants are described briefly. Following this, research on ISL settings and on interest and motivation are reviewed, and issues central to addressing interest and motivation in the free-choice environment of ISL discussed. Finally, open questions about the relation of interest and motivation in the development of productive participation will be identified.

XLAB, one type of ISL setting

> XLAB is an out-of-school laboratory housed on the campus of Georg-August University in Göttingen, Germany[4]. Its staff members have PhDs in anatomy, astrophysics, biology, physics, organic chemistry or neuroscience. Its equipment is state-of-the-art for research scientists. Participants wear lab coats, maintain lab books, and work in pairs with apparatus that may include electrical current, fire, and chemicals. They work alongside the staff to research live questions, and are provided with and expected to use information about appropriate safety measures and procedures. No one hovers to make sure that the participants are doing what they have been told to do.
>
> XLAB targets students who are in the last years of high school and want hands-on learning experiences in the sciences. Students drop-in after school, sign up for week-long work in one or another field, or they visit with their classmates during the school day when their teacher has scheduled them for the XLAB. Its programming may consist of either a single 3-hour lab or a sequence of 3-hour labs in one, or in different sciences, or a three-week intensive summer program.

[4] XLAB can be found online at: www.**XLAB-goettingen**.de (the English description of the XLAB international summer science camp also includes more general information about XLAB: http://www.XLAB-goettingen.de/staticsite/staticsite.php?menuid=1090&topmenu=460&keepmenu=inactive). The staff at XLAB also conduct workshops for teachers, so that they can refresh and update their knowledge in order to work more effectively with their students.

Imagine two 17-year olds, called I__ and NS__.[5] They differ in their interest and motivation to learn science. I__ has an interest for physics and returns frequently to XLAB because XLAB makes it possible to think with people who also like tinkering and want to do things like figure out how a CD-player works using a laser-diode. NS__, in contrast, has little interest for physics, or for sciences more generally. NS__ only goes to the XLAB because the biology teacher at school signed NS__'s class up to attend.

I__ and NS__ could be participants in the same lab. Their different interests and motivation for participation point to differing needs in program design and facilitation. In terms of the present case, two different lab contexts are presented in order to emphasize the distinction between "wanting" to go to XLAB and "having" to go (Sansone & Smith, 2000).

Present interests impact the likelihood that I__ and NS___ will return over time to XLAB, and/or to science more generally. Returning to XLAB is important. Repeat visits with opportunities for challenge allow participants to continue to develop and consolidate their skills and knowledge of science. Predictions might be that I__ will continue to return to XLAB because clear connections to the applications of the laser were made and the thinking that I__ is led to do is exciting. On the other hand, if I__ were to find that there were a limit to the possible applications of the technology, that the laser was not working and would not be fixed for some time, or that there were live discussions online about CD-player construction at the same time that the XLAB lab is scheduled, it is

[5] The experiences of I__ and NS__ draw on composite data from participant experiences (Renninger, Bachrach, & Posey, in press; Renninger & Hidi, 2002; Renninger, Lehman, Costello, Stevens, & Nekoba, 2007).

possible that I__'s interest in returning to the XLAB would fall off at least temporarily, even if I__ continued to have an interest in physics.

If NS__ were offered time to do something else that already was an interest, or if NS__'s partner in the lab had been as disgusted by the dissection of the heart that was the day's focus and had vowed not to return, it is unlikely that NS__ would return to XLAB. In fact, the likelihood that NS__ will return to the XLAB without being required to do so is small, unless the class visit triggered an as of yet untapped interest for biology. Perhaps putting on a lab coat and participating in labs with high-tech tools allows NS__ to identify with the role of scientist (Heath & Roach, 1999; Toth, Suthers, & Lesgold, 2002). These signs of participation in science may contribute to NS__'s feelings of possibilities in science (Markus & Nurius, 1987). Maybe the assigned lab partner was someone with whom NS__ could identify, thus helping NS__ to think that science is doable (Hannover, 1998; Renninger, in press). Maybe the lab expectations presented an optimal amount of personal challenge, enough to be exciting but not overwhelming (Renninger, 2000). Maybe the dissection of the pig's heart allowed NS__ to learn something more about what happens when a person has a heart attack, a personally relevant family problem, and the opportunity to explore the lung the next week is something that NS__ thinks might be worth doing (Hoffmann, 2002). It is possible that a number of these so-called triggers were in place, heightening the likelihood that NS___ will return another week, allowing consolidation of understanding.

The cases of I__ and NS__ illustrate just some of the issues of participant interest and motivation in ISL settings. Both I__ and NS__ could be productive participants in their XLAB labs. Their participation would differ, however. I__'s and NS__'s strengths, needs, and interests, together with the design and facilitation of their respective labs, would influence the nature of their participation.

Identifying the Issues: Interest and Motivation in the ISL Setting

XLAB is a particular type of ISL setting. It is an enrichment program that like other ISL settings is designed to provide a bridge between school science and authentic science—where authentic science refers to problem solving contexts in which the participant collaborates on decision-making and revision of questions being studied (Newmann & Wehlage, 1993; see examples in Engle & Conant, 2002; Rahm, 2002; see reviews by Buxton, 2006; Chin & Malhotra, 2002; Toth, Suthers, & Lesgold, 2002).[6] Unlike traditional school science that may gloss over opportunities to spark curiosity and help learners make connections to and consolidate their ideas about science, ISL settings assume participant interest and motivation. They are intended to respond to individual differences of experience and interest, and capitalize on these to promote learning. The ISL setting does not usually include goals set by the instructor; and they are flexible about the approach to the content, the content itself, and expected outcomes. They also are not graded.

Although all ISL settings provide complements to school learning, they typically differ from each other in terms of their structure. Each ISL setting is likely to have its own agenda, including the breadth and depth of content covered, the frequency or

[6] Authentic tasks are a form of free choice learning that are defined by decisions about engagement that participants make, and for which, as a result, they feel agency (Engle & Conant, 2002). The participants make connections to their own experience and are supported to link these to those of others.

regularity of “visits” (e.g., an hour a day for 5-weeks during the summer, an hour a week over the course of a school term or a year, one weekend morning each week), the heterogeneity (e.g., gender, race, SES, age) of participants, the ways in which the staff members regard and interact with participants, and the way in which activities and resources are designed. Such differences may impact the development of participants’ interest for science and also their motivation to learn.

The aims of ISL settings and/or individual staff members within the same setting (and parents, teachers, or others who encourage or require participants to attend settings that include ISL) can vary. Differences emerge based on the age-related developmental and/or experiential needs of participants, and participant interest and motivation. While all may champion inquiry-informed and free-choice learning of science, what these terms mean to individual staff members and/or the ways that they are implemented may vary (Renninger, 1998). Some may think that having fun, exploring, and making broad and/or personal connections to science is the purpose—meaning that building a pink fuzzy rocket may become a focus of several sessions originally intended to support thinking about momentum, even though color and texture may have little to do with momentum and were not on the agenda for the day (see relevant discussion on the importance of exploration in Flum & Kaplan, 2006). These same staff members, however, may or may not also recognize the inherent complication of encouraging a detour to make pink fuzzy rockets if a participant already understands momentum and is ready to think about it more seriously.

In contrast, staff members may perceive their role as one of providing information, modeling career options, and/or offering experiences that enable scientific thinking for participants. Such a perspective is likely to lead to demonstrations, mini-lectures or presentations, and rubrics for activities that assume levels of conceptual competence that may or may not be matched to participants' strengths and needs (Cox-Petersen, Marsh, Kisiel, & Melber, 2003; Meyers, 2005; Tal & Morag, 2007). In this case, the participant who needed the chance to experience the pink fuzzy rocket is overlooked.

Moreover, if staff members (parents, teachers, and so forth) assume interest and motivation are dichotomous you-have-them-or-you-do-not variables that are ***in*** the participant, then staff members may well think that there is not too much that they can do to facilitate the development of participant interest for science. They may prefer working with participants who have a well-developed individual interest for science, and may be most effective with these participants. Staff members' responses differ, if, on the other hand, they recognize that interest develops and deepens through participant experiences or interactions ***with*** others, exhibits, and/or objects. These staff members are likely to work well with all participants, those with well-developed ***and*** those with little to no interest for science (see Lipstein & Renninger, 2007). It is likely that their expectations and the kinds of interactions that they have with participants will enable interest to develop and/or deepen.

In short, staff members' aims and their understanding of participant interest are likely to influence the organization, facilitation, and/or participation in ISL settings. They are likely to influence the selection and focus of ISL content and activity types: novel or built on prior knowledge; within reach, within reach and challenging, and/or out-of-reach. They are also likely to impact the tone of interactions with participants, including receptivity of participants' ideas about next steps in the process, and the nature of feedback/scaffolding that is provided.

The nature of interactions with the characteristics of the ISL settings vary based on participant experience and interest (Falk & Dierking, 1992). If a participant has a well-developed individual interest for physics like I__, then encouragement to participate and scaffolding to help the participant make connections between prior experience and physics is not as essential as the quality of the information and whether the activities are authentic. Participants like I__ who have a developed interest for physics, also have some knowledge of physics. They may have grown up in families where science was an early interest (Gisbert, 1998; see Sonnert, 1995). They have experience with which to make connections to the science of the lab, allowing them to use the lab to build on what they already know. As a result, they value talking and thinking about science with staff members. In an XLAB-like setting they are doing authentic science, helping to identify questions, designing and refining experiments. This kind of context is one to which I__ is likely to return, and in which I__ is likely to seriously engage, whether wearing a lab coat or not.

Because there is interest, I__ is likely to attend to information-giving, demonstrations, read signage, and ask questions. It would be off- putting for I__ if labs consisted of sets of already-prepared procedures and did not involve participation in decision-making. Chances are that I__ would not chose to return to XLAB if I__ : does not have the opportunity to stretch personal knowledge, thinks staff members are being condescending by suggesting that I__ does not know or cannot understand, or thinks staff members do not know what they are talking about. However, because I__'s interest in physics is a well-developed individual interest, a disappointing experience in that setting would not alone dampen I__'s interest for physics.

On the other hand, if the participant is like NS__, with little or no interest for biology yet, support from others (staff members, parents, peers) that includes models of how to engage is likely to be critical. Participants like NS__, who have little to no interest for science also know very little about science. They may have grown up in a family and/or a school culture for whom science is "othered."[7] In order to engage ISL, they may need to be plunged into a setting that explicitly includes them in the role of being a scientist (Bonney, 2004; Lindemann-Matthies, 2005) and having fun in this role (Jarman, 2005; Stockmayer & Gilbert, 2002). Knowing that one is engaged in science is essential to possible identification with science. This realization can be encouraged through the seemingly simple act of providing a lab coat. Being introduced to experimentation in a way that involves NS__ in working to answer authentic questions may also enable NS__ to connect to the culture of science in ways that school does not (Metz, 1995, 2000; see also Heath & Roach, 1999). This may, in turn, provide NS__ with a language with which to engage science (Callanan & Jipson, 2001; Crowley, Callanan, Tenenbaum, & Allen, 2001; Heath, 1983) and the ability to begin developing a counternarrative[8] about the possibility of participating in science (Renninger, in press).

[7] "Othered" refers to seeing those who do pursue science as distinct from those in one's own family, neighborhood, etc. due to gender, race, ethnicity, or socio-economic status, etc. (see Weiss, 1980).

[8] The term counternarrative is used in critical race theory to refer to the need for a particular group to develop an alternative narrative about possibility (Perry, 2003). In the present use of this term, it refers to the need and potential of those who might not perceive the pursuit of science as a possibility to develop a different understanding of themselves in relation to science (see related discussion in Renninger, in press).

If science is unfamiliar or misconstrued, the participant may not know about what is expected in the setting (e.g. lab), what questions to ask, or what to attend to. For example, without knowledge of content or expectations for a task such as identification of an unknown compound, making choices about the tests to apply is very difficult. Help is needed to know what to attend to and what the results (e.g. color change) might mean. Support to make connections between the content and what the participant knows is critical (Mitchell, 1993; Renninger & Hidi, 2002; Renninger, Sansone, & Smith, 2004).

In contrast to I__, participants like NS__, with less interest for science, may need staff members to adjust the parameters of inquiry, by explaining procedures and providing some direction for experimentation (see Buxton, 2006). In this way, NS__ would be enabled to identify what the problem is and to begin serious work with it. These types of adjustments reorganize tasks so that they are authentic for the participant by making it possible for the participant to think about how to approach and work with them. In addition, staff member use of content-informed scaffolding can further facilitate participants' work with tasks (see Renninger, Ray, Luft, & Newton, 2005). This type of scaffolding provides participants with enough language and knowledge of science to begin thinking scientifically. Supports such as these could increase the possibility that NS__ wants to return, can set personal goals, and become an increasingly productive participant in the lab.

Enjoyment and Learning in ISL Settings

A common goal across ISL contexts is for participants to experience pleasure while working with tasks that allow exploration and do not overwhelm (e.g., Allen, 2004;

Martin, 2004). If there is participation, then learning is generally assumed to be occurring (see Lave, 1996). If there is enjoyment, then return to science and possible identification with science is anticipated. The objective is for participants to be having conversations, exploring, and having fun in and around solid science content. The focus is less on expert knowledge development and more on solid science as experience. The expectation is that science learning will follow and that participation in ISL contexts involves learning science.

To date, research on ISL participation is primarily descriptive work. It focuses on a particular context (e.g., a particular aquarium, a Cub Scout Troup, Citizen Scientists, one urban gardening program) and whether the context supports participant learning and enjoyment. Ethnographic methods coupled with science attitude surveys and/or interviews are often employed to assess changes in participation and learning. The questions of the surveys and interviews vary considerably but focus on enjoyment, fun, and whether learning occurred.

Enjoyment and interest (defined as liking in these studies) are typically used interchangeably to describe the outcomes of opportunities to explore science. Unlike the XLAB context that is designed to enable the deepening of knowledge that could be assessed using more traditional methods such as tests, most ISL settings focus do not have explicit aims for participant learning. Rather, they are designed to satisfy participants' aims to enjoy cultural, social, and/or educational experiences. For participants, with whom they go to the museum and what they had for lunch may be just as important as what they learn (Falk & Dierking, 1992).

Like the apparent detour from learning about momentum by making a pink fuzzy rocket, Falk and Dierking (1992) report that the entirety of the museum visit experience is basic to the possibility of returning to science and, like findings reported by Reveles, Cordova, and Kelly (2004), experience may be enough. Falk and Dierking (1992) also note that engagement in science can yield learning, even though the participant may not be aware that learning is occurring. As such, this learning may not be a fully developed conceptual understanding of science but instead can reflect more idiosyncratic connections to science as a field.

Because ISL is a relatively new field, and ISL settings are so seemingly varied, no single inductive model (hypothesized set of indicators) exists that can be used to predict participants' changed enjoyment and learning in the ISL context (see Babbie, 2007, for a discussion of inductive models; Falk, Dierking, and Storksdieck, 2005, have also pointed to the need for more systematic study of ISL contexts). A next step for ISL research is likely to include establishing underlying design principles that can be used to inform the study of enjoyment and learning, and consideration of differences among participants based on gender, socio-economic status, race, and/or ethnicity

In order to illustrate the kinds of insights about enjoyment and learning that have begun to surface in studies of ISL, findings from three settings are reviewed briefly. Points about how science is presented to participants, what is learned, and whether it is enjoyed are noted. Each setting provides participants with multiple opportunities to engage and reengage science content, and to work with some form of authentic task: Cub Scouts doing science activities; amateur bird watchers assisting scientists; and inner-city youths collaborating to run a community garden.

Jarman (2005) describes how in the Cub Scout troop that she studied, Scout leaders intentionally engaged the boys in group experiences that were fun and happened to be about science (e.g., mixing baking soda, red food coloring, and vinegar to make erupting volcanoes); they did not intend to impart important scientific ideas:

> There was… considerable consensus regarding the characteristics of a good Cub Scout science activity. Ideally, it should:
> • involve active participation, particularly in making things;
> • create expectation and excite wonder;
> • be different from school science, with a minimum of reading and writing;
> • be short, to allow for variety, and self-contained;
> • be easily resourced;
> • be, above all, 'fun".
> In addition… they should 'work'. They should be safe. (p. 434)

Of note is the role of the adults in structuring the Scouts' experience and the clear emphasis on fun activity that included solid but disembodied science. It might be expected that the Scouts' work with science would position them to take advantage of later opportunities to extend their basic knowledge. It is also likely that because the Scouts received a badge labeled "science activity," they not only had fun with science but knew that they were engaged in doing science. Wearing a badge that says "science" could signal that: "science is something that I can do; science is something that I have achieved."

The Scout experience has parallels with Cornell Laboratory of Ornithology's (CLO) Citizen Science projects (Bonney, 2004; Brossard, Lewenstein, & Bonney, 2005; Krasny & Bonney, 2004; Roth & Barton, 2004). Like the Scouts, Citizen Science participants enjoy working with science. Both groups are engaged in science without explicitly thinking about their activity as science. The Scout activities are self-contained tasks, however; and the CLO participants are engaged in an ongoing science investigation with “real” scientists. In the CLO, amateur birdwatchers are enlisted to follow a lab protocol that involves collecting data (e.g., helping with bird counts). The differences in the nature of the tasks in the two settings influences what the participants learn, or think that they learn.

Unlike the Scouts who can be expected to respond favorably to explosions but may or may not have an interest for volcanoes, Citizen Science participants have an interest for birds. As Krasny and Bonney (2004) report, they have curiosity questions, want to think about what they are doing and want feedback about the birds. While the intention of the Citizen Science projects is stated as involving “laypeople” or “amateurs” interested in birds in helping scientists, there is an additional expectation that through this experience participants could also learn about science[9].

The Citizen Scientist participants did not show gains in either their attitudes towards or conceptual understanding of science; they did, however, demonstrate “increased knowledge of the biology and habitat needs of cavity-nesting birds” (Krasny & Bonney, 2004; see also Brossard, Lewenstein, & Bonney, 2005). They also were able to use their knowledge about birds to revise the scientists’ lab protocol for data collection when it did not work (Bonney, 2004), making their participation more authentic than the

[9] It should noted that the CLO staff use the term “laypeople” to describe participants and have a focused interest in questions specific to birds. With the development of the program, education researchers have been included and these researchers have brought a complementary view of the Citizen Science participants to the project. They view them as emerging scientists and are interested in whether the participants are learning about birds as well as the process of scientific research (Brossard, Lewenstein, & Bonney, 2005).

typical assigned lab protocol would have allowed. This indicated that they understood the scientists' objectives and made the goals of the project their own. That the Citizen Scientists were able to figure out what to attend to and how to proceed given a failed protocol, suggests that they did have a solid conceptual understanding of the scientific process. The Citizen Scientists have interest for birds; they may not realize that having an interest for birds and asking questions about birds involves science. Whether the Citizen Scientists had had opportunities to link ornithology with science, and whether being labeled emerging scientists or science partners, rather than "laypeople" might have signaled to them that they were doing science remains an open question.

Like the Scouts, Rahm's (2002) 11-14 year-old inner-city youths are fully engaged in science-related activity as they grow and market crops. Like the Citizen Scientists, they are facilitated to ask questions about what they see and to think about science, but do not label their activity "science." Science formed a basis of interactions in the community of this urban gardening project. Rather than telling information or planning science lessons, staff members made use of "teachable moments." For example, Marc (a master gardener) focused his responses to Will's questions about the usefulness of flies on breaking down plant material, leading Will to wonder what flies are likely to eat. This, in turn, led Marc to introduce the concept of composting.

> Will: What are flies really good for?
>
> MARC: Flies? Well, they pollinate some flowers for us. They teach us patience….[giggle] What else can I think of?
>
> Will: They get on people's nerves!
>
> JRENE: They just test your nerves!

> MARC: Actually, they do play a good part in the ecology. They are food for other animals like birds and other insects. And they also help break down old plant material and things like that.
>
> Will: What do they eat?
>
> MARC: Flies themselves probably don't eat much of anything. But their larvae, the maggots, get into all kind of decaying material, and it will decay faster. You can find maggots in the compost piles.
>
> Will: Are we gonna make a compost?
>
> MARC: Yes, everybody is gonna take a part in it. (p. 172)

There is not a lot of information giving in this exchange. The fact that Will stays with the conversation and follows through to ask questions indicates that he is learning. As Rahm points out, the youths were both the creators and the consumers of the science curriculum.

It is not clear from Rahm's description whether the youths used the term science to refer to their work together in the garden. Referring to science might be important because it provides participants with a frame for understanding what they are doing and what science is, on which their understanding of science can be built (see Heath, 1983). As Eccles (2005) suggests, out-of-school learning can be a powerful opportunity for participants to try on identities (e.g., as scientist) and see that they fit—that is, if they have the language to label their engagement. If participants explore an identity domain, e.g. science, it can be expected that they might continue to participate and to consolidate parts of their identities that are associated with that activity if they are clear about what it involves (see Harter 2003, 2006). Such engagement should allow them to reorganize the feelings that they once had. If undertaken in light of individual interest and age-related identity development, it could also form the basis for developing a counternarrative that science is possible (Renninger, in press).

For some, distinguishing between school science and ISL may enhance positive feelings for science. Solomon (2005), for example, reports that 5- 10 year-old children enjoyed talking about science at home, but were reluctant to talk about experiences with school science when they were at home. As soon as parents in this study introduced or made connections to school science the children became tense and uneasy. Solomon suggests the promise of parents encouraging children to enjoy engaging and reengaging science at home. This point appears to be corroborated by Laukenmann (2003) who found that it was only high achieving students who felt joy (were having fun) pursuing science in school; low achieving students preferred pursuing science at home. The "fun" of the ISL context may provide its participants with opportunities to feel successful with science and to begin developing feelings of self-efficacy and/or identity with science.

Motivation and Interest

Not surprisingly, Laukenmann's (2003) study of 8th grade physics students' emotion diaries indicates that it is successful students who experience joy learning science in school. Students primarily associated their feelings of joy with successful learning, however, rather than with physics topics. Such students are motivated learners, but it might be questioned whether they are really engaging the content of science conceptually or developing an interest for physics (see Renninger, Ewen, & Lasher, 2002).

Motivation research links student achievement to goal setting, self-regulation, and effort. Student achievement is also linked to feelings of self-efficacy, the students' sense about whether achievement is possible (Bandura, 1986, 2005). In research on motivation, students typically complete a validated questionnaire such as the Motivated Strategies for Learning Questionnaire (MSLQ, Pintrich & deGroot, 1990) that asks them to complete a 7-point Likert scale with items such as: "I work hard to get a good grade even when I do not like a class;" "Even when study materials are dull and uninteresting, I keep working until I am finished;" and "I prefer class work that is challenging so that I can learn new things." Student responses are then analyzed in terms of particular clusters of items to provide information about goals, self-regulation, and effort. Probably because motivation in school is accepted as linked to success and measured by grades, case studies that address nuances of understanding related to student achievement are rare (for exceptions, see Lipstein & Renninger, 2006; Nolen, 2007; Pressik-Kilbourn & Walker, 2002; Renninger & Hidi, 2002). Instead, building on the understanding that grades and self-efficacy have a reciprocal influence, researchers of motivation seek to test hypotheses (e.g., Britner & Pajares, 2001: science self-efficacy beliefs will predict science achievement when motivational variables predicting achievement in other academic areas are controlled) based on previous findings (inductive models about the relation between motivational variables and achievement). In this work, they typically employ path analyses to model the relations among motivational variables and have demonstrated that the types of goals that students adopt influence their approach to learning.

Research on student motivation describes students as pursuing mastery goals when they want to develop competence by acquiring new knowledge and skills (Diener

& Dweck, 1978, 1980; see Molden & Dweck, 2000); they are described as pursuing performance-approach goals when they want to demonstrate their competence relative to others; they are described as pursuing performance-avoidance goals when they hope to avoid the demonstration of incompetence (Elliot & Church, 1997; Harackiewicz, Barron, & Elliot, 1998; Maehr, 1976; Middleton & Midgley, 1997), and they are described as adopting work avoidance goals when they seek to minimize effort (Brophy, 1983; Nicholls, 1989). The types of goals that students adopt are considered to reflect their feelings about their abilities and possibilities as learners (Bandura, 1986, 2005).

The types of goals students set for themselves influence the likelihood that they will self-regulate as learners, positioning themselves to meet their goals and experience success. Like goal-setting, self-regulation requires conscious decision making. It can modeled and supported by others, but it is the individual who self-regulates. They self-monitor, evaluating whether their goals have been met, and subsequently revise their behavior in order to meet or revise their goals (Zimmerman & Bandura, 1994).

In addition to setting goals and using self-regulatory strategies, effort contributes to students' success. In the school context, assessment of effort is based on teachers' perceptions of whether students try hard, ask for help, and participate in class (Brookhart, 1993). Teachers promote effort in the classroom by emphasizing participation, setting high expectations, and encouraging students to support each other as learners (Stipek, 2002). Studies of student effort generally suggest that the more difficult a task appears and the less likely that a student anticipates being able to complete it successfully, the less likely it is that a student will exert effort (Eccles & Wigfield, 1995; Pintrich, 1989, 1990; Salomon 1983, 1984; Smith, 1999). Setting goals, self-regulating, and exerting effort typically yield improved performance with challenging tasks that, in turn, increase participants' feelings of self-efficacy (Bandura, 1986, 2005).

While interest has been described as an outcome of motivated behavior because it develops and deepens with engagement, developmentally, interest is also a mediator of engagement (Hidi & Renninger, 2006). It is a mediator in the sense that interest positions the participant to attend, set goals, and make use of learning strategies that support self-regulation of behavior. Participant interest for science is also an outcome of motivated behavior because it develops and deepens as participants continue to re-engage science.

Research on interest has included both descriptive and quantitative methods. Findings from these studies indicate that there are four phases of interest development (Hidi & Renninger, 2006): a triggered situational interest, a maintained situational interest, an emerging individual interest, and a well-developed individual interest (Hidi & Renninger, 2006; see Figure 1). In its earliest phases, interest is described as being primarily triggered or maintained by the environment (others, tasks, etc.), and in later phases, interest is more likely to be self-regulated (Hidi & Ainley, in press; Sansone & Smith, 2000). In later phases of interest development, the participant is more likely to initiate engagement, and to generate and seek answers to curiosity questions about content (see discussion in Renninger, 2000). Of importance is the fact that interest is never entirely either extrinsically or intrinsically motivated (Hidi & Harackiewicz, 2000). Rather, in each phase of interest development, interest reflects what the participant brings to the task, what the environment (others, objects, etc.) affords, and the way in which the participant is able to work with the environment.

Like Jarman's (2005) description of the Cub Scouts, participants may experience a triggered, or possibly a maintained situational interest for science because they were able to explore (Flum & Kaplan, 2006; Mitchell, 1993). The Cub Scouts may bring little concrete information or interest for science to their activity, but are supported by the setting (the objects and the people) to have fun with science. While the Scouts' interest may have been triggered by positive experiences, the initial connections to science need not necessarily be positive (Hidi & Renninger, 2006).

For example, were NS__ to experience initial disgust during the dissection of the heart, this might have triggered a situational interest for continuing to work with the heart (Hostermann, 2007). Much like any of the "collative variables" (complexity, surprisingness, uncertainty, novelty, and incongruity) that Berlyne (1960) identified, disgust is likely to trigger attention because the affective response is unexpected. In the case of the participant like NS__ with little to no knowledge, any change in affect could trigger interest. Triggering of interest can occur in all phases of interest and probably contributes to the development and deepening of interest (Renninger & Hidi, 2002). For a participant with more developed interest, such triggering calls attention to additional aspects of the task (e.g, I__ may not have had prior interest in sound but on learning how the cd player works, became interested in balance and sound). The number of triggers and specifics about support that needs to be in place to yield developed interest are not known, although it appears likely that changes in a participant's phase of interest requires multiple triggers (see Renninger & Hidi, 2002).

In early phases of interest for science, interest can be conflated with the context generally— the trip leader, the topic, the other people in the group (Renninger, Lehman, Costello, Stevens, & Nekoba, 2007). While a participant's interest can be triggered and even sustained by something(s) or some person(s) in the environment, a triggered situational interest is not necessarily a reflective or deliberate process of engaging with content. Moreover, younger participants with only a triggered interest are not always able to purposefully identify goals for learning or decide to self-regulate in order to better understand (Renninger, Sansone, & Smith, 2004). Self-regulation for tasks that are not of interest is more likely among older students and adults (e.g., Sansone & Smith, 2000; Sansone, Weir, Harpster, & Morgan, 1992).

The development and/or deepening of participants' interest requires that participants acquire enough knowledge about the setting (e.g., the organization and purpose of a lab; how to learn from an exhibit) and background knowledge in order to begin asking questions (Renninger, 2000; see Renninger, Bachrach, & Posey, in press). Having questions to which they want to find answers can lead them to want to determine the next steps of the lab protocol, or to make a choice about whether to take notes on their observations (Lipstein & Renninger, 2006). They need to be positioned to ask, and also to find answers. Often support for articulating and generating questions is present in the form of another person. For example, Marc's responses to Will's questions about the flies enabled Will to begin thinking about the role of compost in gardening. Support can also be provided in the organization of tasks so that NS__ and the other lab participants are supported through the way that the lab is structured to begin setting goals and assuming roles in decision-making, or developing self-regulation. Participating in such a lab would also presumably provide experiences that could help those like NS__ to develop an understanding of themselves as possible scientists.

In more developed phases of interest, participants can seek answers on their own and pursue work with science themselves. They are able to set their own goals and self-regulate as necessary in order to achieve them (Lipstein & Renninger, 2006). With more developed knowledge and stored valuing, they are likely to exert effort and persevere to work with challenge and/or the frustration that can accompany the failed experiment, broken apparatus, and so forth. Like the Citizen Scientists, they are also able to use their understanding to revise plans and to rethink strategies (Izard & Ackerman, 2000). In these more developed phases of individual interest, participants can focus on deepening conceptual understanding (Renninger, Ewen, & Lasher, 2002). This is also a process of developing understanding about what science participation is and figuring out the match between it and their own sense of possibility (Marcus & Nurius, 1987).

Open Questions about Interest and Motivation in ISL

In ISL settings, participants are provided with opportunities to engage with serious science content. The settings may vary in their structure, but all typically focus on providing participants with experiences (Falk & Dierking, 1992). They involve exploration and allow participants to derive their own meaning and understanding. As such, ISL settings contrast with school science that often skips participant-initiated exploration in order to focus on content that needs to be covered. Responding to student interest in the school classrooms is difficult when teacher planning is constrained by the demands of state and local curricular frameworks (Blumenfeld, Marx, & Harris, 2006). The ISL setting may be particularly important to learning science because it allows participants to make connections by providing opportunities to explore and work with science. ISL appears to be playing a critical role in enabling the development of scientific thinking and science literacy. Fadigan and Hammrich (2004) suggest that those who continue to pursue science in school are those who have had experience in out-of-school science learning.

As presently conceptualized, participants benefit from ISL settings; however, the impact of ISL could be limited by its ready acceptance of its participants. Unfortunately, because school socialization tends to reward memorization, science activities can be perceived as too much fun to be considered real science by the better students (Carlone, 2004). Such perceptions could limit the impact of ISL; as could the population of visitors who tend to be white, middle-class, and educated (Botelho & Morais, 2006; Falk & Dierking, 1992).

It is not surprising that studies of ISL may not typically demonstrate gains in knowledge or interest, given the short duration of an interaction with an exhibit, lack of scaffolding to stretch thinking, and the emphasis on fun. Instead of simply supporting fun and participation in science, it is also possible that these settings might also be designed to enhance productive participation by addressing participant interest and knowledge. Depending on the goals of the ISL setting and its staff members (or the others who bring or encourage their children, students, etc. to participate), participants could be supported to develop their interest. As Crowley and Jacobs (2002) suggest, conversations around objects in museums can be powerful referents for later discussions among family members about “islands of expertise”—however, the family members need to consciously seize and make use of this opportunity. Participants’ prior knowledge can also be used to optimize engagement by matching competence and challenge (Azevedo, 2006).

Exploration and conversation about science does enable the development of important and meaningful connections to science, one form of science literacy. Return engagement that allows interest and experiences to build might provide for deeper understanding, e.g. Scout experiences that make links to broader science concepts like chemical reactions or energy transformations, instead of simply presenting disembodied activities. With experience exploring, a developed language for talking about science, and clarity about scientific concepts, ISL settings could also support the development of scientific thinking. Thus, a participant like NS__ could begin to think about and discuss the dissection of the heart (and subsequent work with the lung) in terms of relations among body systems.

Even though differences among phases of interest are documented, not a lot is known about the conditions that can support interest to shift from one to another phase (Hidi & Baird, 1986; Hidi & Anderson, 1992; Schraw & Lehman, 2001). Each phase of interest development has been found to be characterized by a distinct pattern of motivational variables (Lipstein & Renninger, 2006), suggesting that the development of interest is accompanied by shifts in the relation of motivational variables such as goal-setting, self-regulation, and effort. Findings from Nolen's (2006, 2007) detailed study of two elementary classrooms points to the importance of the structure of the environment in promoting interest development. These findings are further complicated, however, by those indicating that shifts between phases of interest may also be linked to participants' perceptions of opportunity, not simply to particular participant structures or activity

(Renninger & Lipstein, 2006). Thus, while group work may generally be expected to support learner interest (Mitchell, 1993), it may or may not contribute to whether a particular learner's interest will continue to develop and/or deepen, or falls off.

In order to better understand participants' perceptions of opportunity and how transitions to deeper forms of knowledge and enjoyment can be supported, it would be useful to reconsider the relation among interest and other motivational variables in a context that is not constrained by the need to succeed in terms of grades. The inquiry-oriented, free-choice ISL setting offers the possibility of reexamining what has been understood about these variables and their relation to learning.

Initial questions might address the role of interest and motivated behavior in productive participation: What does the shift from exploration of science content to science literacy look like? What are the similarities and differences in this shift across ISL settings, and between ISL settings and more formal learning settings such as traditional school science?

What characterizes interest for science and does this differ among disciplines, e.g., biological sciences, chemistry, engineering? Are the indicators of interest for science at one age (e.g., preschoolers) the same over the lifespan? Do the collative variables that contribute to the triggering of interest for science differ in predictable ways based on age or experience of participant? What are the interests (not necessarily science-related) that participants bring to engagement in ISL settings and how do these meld with and/or find support from the topics, focus, and facilitation of the ISL setting?

What conditions support participants to shift from exploring science content to posing questions that characterize science literacy? What features of the exhibits or tasks with which they engage promote enjoyment, reflection, and/or revision of strategies? When and how might scaffolding of participation, including science information, be optimally provided for participants in different phases of interest? How can participants be supported to reorganize what they understand science to include so that they embrace science out-of-school? How do participants perceive the support of the ISL group that they are in, their family, and/or ISL support staff? What might it take for them to ask questions of these individuals and be resourceful about finding answers to these themselves?

How does a participant feel successful in the ISL setting, given that they may not have much understanding of science, or any goals for learning it? How can participants' feelings that it is possible to do science, their feelings of self-efficacy, be optimally supported in the early phases of triggered interest for science?

What are participants' prototypes about pursuing science generally, and pursuing science in ISL more specifically? What types of counternarratives need to be developed in order to enable participants to seriously engage science?

What types of goals, self-regulation, and effort characterize productive participation in ISL, and how do these characterizations vary from those held in more formal learning settings like traditional schooling? What is the relation of interest to goals, self-regulation, and effort in ISL settings—is it a mediator and/or an outcome of their development?

Falk and Storksdieck (2005) suggest the importance of tracking the trajectories of participant learning beyond the ISL setting in order to understand the impact of a short visit with a given exhibit; they also decry the complications inherent in research that is conducted in different settings with different measures and the lack of coherence in questions. One issue, of course, is that ISL research is not only research on interest and motivation in ISL, but also needs to be use-informed (Stokes, 1997). Findings from research that is undertaken need to provide information to those who will use it to inform practice. To this end, as Sigel (2006) suggests, this research needs to be undertaken as a collaboration among practitioners and researchers. The first question for discussion might concern perceptions of the goals and possibilities for productive participation in the research setting(s).

Ideally, data collection would include combined methods (e.g., ethnography and participant observation, in-depth structured interviews, and collection of artifacts). The indicators studied and the measures used would extend existing research by building on well-established measures and they would also allow identification of emergent findings (Gee, 1999). Sampling would account for ISL type (museum, enrichment program) and also allow for analysis of difference among cohorts of participants in relation to gender, socio-economic status, race, and ethnicity, as this is possible. Such data would allow tracking and documenting of the development of productive participation for purposes of use, and would provide a rich set of data with which to reconsider models and understanding of interest and motivation.

References

Allen, S. (2004). Designs for learning: Studying science museum exhibits that do more than entertain. *Science Education, 88* (Suppl. 10), S17-S33.

Azevedo, F. S. (2006). Personal excursions: Investigating the dynamics of student engagement. *International Journal of Computers for Mathematical Learning, 11*, 57-98.

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, NJ: Prentice-Hall.

Bandura, A. (2005). Adolescent development from an agentic perspective. In F. Pajares & T. Urdan (Eds.), *Self-efficacy beliefs of adolescents* (Chapter 1, pp. 1-43). Greenwich, CT: Information Age Publishing.

Barron, B. (in press). Interest and self-sustained learning as catalysts of development: A learning ecologies perspective. *Human Development*.

Berlyne, D. E. (1960). *Conflict, arousal and curiosity*. New York: Grove Press.

Blumenfeld, P. C., Marx, R. W., & Harris, C. J. (2006). Learning environments. In K. A. Renninger & I. E. Sigel (2006), *Handbook of Child Psychology, Vol. 4, 6th Edition* (pp. 297-341). Hoboken, NJ: John Wiley & Sons.

Bonney, R. (2004). Understanding the process of research. In D. Chittenden, G. Farmelo, & B. Lewenstein (Eds.), *Creating connections: Museums and the public understanding of current research* (pp.199-210). Walnut Creek, CA: Altamira Press.

Botelho, A., & Morais, A. M. (2006). Students-exhibits interaction at a science center. *Journal of Research in Science Teaching, 43*(10), 987-1018.

Britner, S. L., & Pajares, F. (2001). Self-efficacy beliefs, motivation, race, and gender in middle school science. *Journal of Women and Minorities in Science and Engineering, 7*, 271-285.

Brookhart, S. (1993). Teachers' grading practices: Meaning and values. *Journal of Educational Measurement, 30*(2), 123-142.

Brophy, J. E. (1983). Research on the self-fulfilling prophecy and teacher expectations. *Journal of Educational Psychology, 75*, 631-661.

Brossard, D., Lewenstein, B., & Bonney, R. (2005). Scientific knowledge and attitude change: The impact of a citizen science project. *International Journal of Science Education, 27*(9), 1099-1121.

Buxton, C. A. (2006). Creating contextually authentic science in a "low-performing" urban elementary school. *Journal of Research in Science Teaching, 43*(7), 695-721.

Callanan, M. A., & Jipson, J. L. (2001). Explanatory conversations and young children's developing scientific literacy. In K. Crowley, C. D. Schunn, & T. Okada (Eds.), Designing for science: Implications from everyday, classroom, and professional science (pp. 21 - 49). Mahwah, NJ: Lawrence Erlbaum Associates.

Carlone, H. B. (2004). The cultural production of science in reform-based physics: Girls' access, participation, and resistance. *Journal of Research in Science Teaching, 41*(4), 392-414.

Chin, C. A., & Malhotra, B. A. (2002). Epistemologically authentic inquiry in schools: A theoretical framework for evaluating in inquiry tasks. *Science Education, 86*, 175-218.

Cox-Petersen, A. M., Marsh, D. D., Kisiel, J., & Melber, L. M. (2003). Investigation of guided school tours, student learning, and science reform recommendations at a museum of natural history. *Journal of Research in Science Teaching, 40*(2), pp. 200-218.

Crowley, K., Callanan, M. A., Tenenbaum, H. R., & Allen, E. (2001). Parents explain more often to boys than to girls during shared scientific thinking. *Psychological Science, 12*(3), 258-261.

Crowley, K., & Jacobs, M. (2002). Islands of expertise and the development of family scientific literacy. In G. Leinhardt, K. Crowley, & K. Knutson (Eds.), *Learning conversations in museums*. Mahwah, NJ: Lawrence Erlbaum.

Csikszentmihali, M., Rathunde, K & Whalen, S. (1993). *Talented teenagers: The roots of success and failure*. New York: Cambridge University Press.

Diener, C. I., & Dweck, C.S. (1978). An analysis of learned helplessness: Continuous change in performance and strategy and achievement conditions following failure. *Journal of Personality and Social Psychology, 36*, 451-462.

Diener, C.I. & Dweck, C. S. (1980). An analysis of learned helplessness II: The processing of success. *Journal of Personality and Social Psychology, 39*, 940-952.

Dweck, C. S. (2002). The development of ability conceptions. In A. Wigfield & J. S. Eccles (Eds.), *Development of achievement motivation* (pp. 57-88). San Diego, CA: Academic Press.

Eccles, J. S. (2005). The present and future of research on activity settings as developmental contexts. In L. Mahoney, R. W. Larson, & J. S. Eccles, (Eds.), *Organized activities as contexts of development: Extracurricular activities, after-school and community programs* (Chapter 16, pp. 353-371). Mahwah, NJ: Lawrence Erlbaum Associates.

Eccles, J. S., & Midgely, C. (1989). Stage/environment fit: Developmentally appropriate classrooms for early adolescents. In R. Ames & C. Ames (Eds.), *Research on motivation in education* (Vol. 3, pp. 139-181). New York: Academic Press.

Eccles, J. S., & Wigfield, A. (1995). In the mind of the actor: The structure of adolescents' achievement task values and expectancy-related beliefs. *Personality and Social Psychology Bulletin, 21*(3), 215-225.

Eccles, J. S., Wigfield, A., Schiefele, U. (1998). Motivation to Succeed. In N. Eisenberg (Ed.), *Handbook of child psychology: Social, emotional, and personality development* (5th ed., Vol. 3, pp. 1017-1095). New York.

Eccles-Parsons, J., Adler, T. F., Futterman, R., Goff, S. B., Kaczala, C. M., Meece, J. L., & Midgley, C. (1983). Expectancies, values, and academic behaviors. In J. T. Spence (Ed.), *Achievement and achievement motivation* (pp. 75-146). San Francisco: Freeman.

Elliot, E. S., & Church, M. A. (1997). A hierarchal model of approach and avoidance achievement motivation. *Journal of Personality and Social Psychology, 72*, 218-232.

Engle, R. A., & Conant, F. R. (2002). Guiding principles for fostering productive disciplinary engagement: Explaining an emergent argument in a community of learners classroom. *Cognition and Instruction, 20*(4), 399-483.

Fadigan, K. A., & Hammrich, P. L. (2004). A longitudinal study of the educational and career trajectories of female participants of an urban informal science education program. *Journal of Research in Science Teaching, 41*, 835-860.

Falk, J. H., & Adelman, L. M. (2003). Investigating the impact of prior knowledge and interest on aquarium visitor learning. *Journal of Research in Science Teaching, 40*(2), 163-176.

Falk, J. H., & Dierking, L. D. (1992). *The museum experience*. Howells House, Washington, D.C.

Falk, J. H., Dierking, L. D., & Storksdieck, M. (2005). A review of research on lifelong science learning. In J. Moon (Ed.), *Informal Science Research*. Washington DC: Board on Science Education, National Academy of Science.

Falk, J. H. & Storksdieck, M. (2005). Using the contextual model of learning to understand visitor learning from a science center exhibition. *Science Education, 89*(5), 744-778.

Flum, H. & Kaplan, A. (2006). Exploratory orientation as an educational goal. *Educational Psychologist, 41* (2), 99-110.

Gee, J. P. (1999). *An introduction to discourse analysis: Theory and method.* London: Routledge.

Gisbert, K. (1998). Individual interest in mathematics and female gender identity: Biographical case studies. In L. Hoffmann, A. Krapp, K. A. Renninger, J. Baumert (Eds.), *Interest and learning: Proceedings of the Seeon conference on interest and gender* (pp. 387-401). Kiel, Germany: IPN.

Hannover, B. (1998). The development of self-concept and interests. In L. Hoffmann, A. Krapp, K. A. Renninger, & J. Baumert (Eds.), *Interest and learning: Proceedings of the Seeon conference on interest and gender* (pp. 105–125). Kiel, Germany: IPN.

Harakiewicz, J. M., Barron, K. E., & Elliot, A. J. (1998). Rethinking achievement goals: When are they adaptive for college students and why? *Educational Psychologist, 33*, 1-21.

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

Harter, S. (2006). The self. In W. Damon & R. M. Lerner (Series Eds.) & N. Eisenberg (Vol. Ed.), *Handbook of child psychology: Social, emotional, and personality development* (Vol. 3, pp. 505-570). New York: Wiley.

Heath, S. B. (1983). *Ways with words: Language, life, and work in communities and classrooms.* New York: Cambridge University Press.

Hidi, S. & Ainley, M. (in press). Interest and self-regulation: Relationships between two variables that influence learning. In D. H. Schunk & B.J. Zimmerman (Eds.), *Motivation and self-regulated learning: Theory, research, and applications*. Mahwah, NJ: Lawrence Erlbaum Associates.

Hidi, S., & Anderson, V. (1992). Situational interest and its impact on reading and expository writing. In K. A. Renninger, S. Hidi, & A. Krapp (Eds.), *The role of interest in learning and development* (pp. 215-238). Hillsdale, NJ: Lawrence Erlbaum.

Hidi, S. & Baird, W. (1986). Interestingness – A neglected variable in discourse processing. *Cognitive Science, 10*(2), 179-194.

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

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

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

Holstermann, N. (2007). Präparieren im Biologieunterricht. Dissertation (unveröffentlicht).

Izard, C. E. & Ackerman, B. P. (2000). Motivational, organizational, and regulatory functions of discrete emotions. In M. Lewis & J. M. Haviland-Jones (Eds.), *Handbook of emotions* (2nd Ed., pp. 253-264). New York: Guilford Press.

Jarman, R. (2005). Science learning through Scouting: An understudied context for informal science education. *International Journal of Science Education, 27*(4), 427-450.

Kisiel, J. F. (2003). Teachers, museums, and worksheets: A closer look at a learning experience. *Journal of Science Teacher Education, 14*(1), 3-21.

Krapp, A., Renninger, K. A., & Hidi, S. (1992). Interest, learning and development. In K. A. Renninger, S. Hidi, & A. Krapp (Eds.), *The role of interest in learning and development* (pp. 3-25). Hillsdale, NJ: Lawrence Erlbaum.

Krasny, M. & Bonney, R. (2004). Environmental education through citizen science and participatory action research. In E. A. Johnson & M. J. Mappin (Eds.), *Environmental education or advocacy: Perspectives of ecology & education in environmental education* (pp. 177-196). New York/Cambridge: Cambridge University Press.

Kuhn, D., & Franklin, S. (2006). The second decade: What develops (and how)? In W. Damon & R. Lerner (Series Eds.) & D. Kuhn & R. Siegler (Vol. Eds.), *Handbook of child psychology: Vol. 2. Cognition, perception, and language* (6th ed., pp. 953-993). Hoboken, NJ: Wiley.

Laukenmann, M. An investigation of the influence of emotional factors on learning in physics instruction. *International Journal of Science Education, 25*(4), 489-507.

Lave, J. (1996). Teaching, as learning, in practice. *Mind, Culture, and Activity, 3*(3), 149-164.

Lehrer, R., & Schauble, L. (2006). Cultivating model-based reasoning in science eduation. In K. Sawyer (Ed.), *Cambridge handbook of the learning sciences* (pp. 371-388). New York: Cambridge University Press.

Lindemann-Matthies, P. (2005). ‘Loveable’ mammals and ‘lifeless’ plants: How children’s interest in common local organisms can be enhanced through observation of nature. *International Journal of Science Education, 6*(16), 655-677.

Linnenbrink, E., & Pintrich, P. R. (2000). Multiple pathways to learning and achievement: The role of goal orientation in fostering adaptive motivation, affect, and cognition. In C. Sansone & J. Harackiewicz (Eds.), *Intrinsic and extrinsic* *motivation: The search for optimal motivation and performance* (pp. 195-227). San Diego, CA: Academic Press.

Lipstein, R. & Renninger, K. A. (2006). "Putting things into words": The development of 12-15-year-old students' interest for writing. In Boscolo, P. & Hidi, S. (Eds.), *Motivation and writing: Research and School Practice* (pp. 113- 140). New York: Kluwer Academic/Plenum.

Lipstein, R. & Renninger, K. A. (2007). Interest for writing: How teachers can make a difference. *English Journal*. Reston, VA: NCTE.

Maehr, M. L. (1976). Continuing motivation: An analysis of a seldom considered educational outcome. *Review of Educational Research, 46*, 443-462.

Markus, H., & Nurius, P. (1986). Possible selves. *American Psychologist, 4*, 954–969.

Martin, L. M. (2004). An emerging research framework for studying informal learning and schools. *Science Education, 88* (Suppl. 1), S71-S82.

Metz, K. E. (1995). Re-assessment of developmental assumptions in children's science instruction. *Review of Educational Research, 65*(2), 93-127.

Metz, K. E. (2000). Young children's inquiry of biology: Building the knowledge bases to empower independent inquiry. In J. Minstrell & E. H. van Zee (Eds.), *Inquiry into inquiry learning and teaching in science* (pp. 371-404). Washington, D.C.: Americcan Association for the Advancement of Science.

Meyers, R. B. (2005). A pragmatic epistemology for free-choice learning. *Environmental Education Research, 11*(3), 309-320.

Middleton, M., & Midgley, C. (1997). Avoiding the demonstration of lack of ability: An under-explored aspect of goal theory. *Journal of Educational Psychology, 89*, 710-718.

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

Molden, D.C. & Dweck, C.S. (2000). Meaning and motivation. . In C. Sansone and J. M. Harackiewicz (Eds.) *Intrinsic motivation: Controversies and new directions* (pp. 131-159). San Diego, CA: Academic Press.

Murphy, P. K., & Alexander, P. A. (2000). A motivated look at motivational terminology. [Special Issue]. *Contemporary Educational Psychology, 25*, 3□53.

Nasir, N. S., Rosebery, A. S., Warren B., & Lee, C. D. (2006). Learning as a cultural process: Achieving equity through diversity. In *The Cambridge Handbook of the Learning Sciences*, Chapter 29 (pp.489-504). Cambridge: Cambridge University Press.

National Research Council (NRC). (1996). *National science education standards.* National Committee on Science Education Standards and Assessment. Washington, DC: National Academy Press.

National Research Council (NRC). (2006). *Taking Science to School: Learning and Teaching Science in Grades K-8*. Washington, D.C.: National Academics Press.

Neumann, A. (2006). Professing passion: Emotion in the scholarship of professors in research universities. *American Educational Research Journal, 43*, 381-424.

Newmann, F. M., & Wehlage, G. G. (1993). Five standards of authentic instruction. *Authentic Learning, 50*(7), 8-12.

Nicholls, J. G. (1989). *The competitive ethos and democratic education*. Cambridge, MA: Harvard University Press.

Nolen, S. B. (2006). The role of literate communities in the development of children's interest in writing. In Boscolo, P. & Hidi, S. (Eds.), *Motivation and writing: Research and School Practice* (pp. 241-256). New York: Kluwer Academic/Plenum.

Nolen, S. B. (2007). Young children's motivation to read and write: Development in social contexts. *Cognition and Instruction, 25* (2).

Panksepp, J. (1998). *Affective neuroscience: The foundations of human and animal emotions*. Oxford: Oxford University Press.

Perry, T. (2003). Up from the parched earth: Toward a theory of African-American achievement. In Perry, T., Steele, C., & Hilliard, A. (Eds.). *Young, gifted, and black: Promoting high achievement among African-American students* (pp. 1-51). Boston: Beacon press.

Pintrich, P. R. (1989). The dynamic interplay of student motivation and cognition in the college classroom. In C. Ames & M. Maehr (Eds.), *Advances in motivation and achievement: Motivation enhancing environments, Volume 6* (pp. 117-160). Greenwich, CT: JAI Press.

Pintrich, P. R. (1990). Implications of psychological research on student learning and college teaching for teacher education. In W. R. Houston, M. Haberman, & J. Sikula (Eds.), *Handbook of research on teacher education* (pp. 826-857). New York: MacMillan.

Pintrich, P. R., & deGroot, E. V. (1990). Motivational and self-regulated learning components of classroom academic performance. *Journal of Educational Psychology, 82,* 33-40.

Pressik-Kilbourn, K., & Walker, R. (2002). The social construction of interest in a learning community. In D. McInerney & S.Van Etten (Eds.), *Research on socio-cultural influences on motivation and learning: Vol. 2* (pp.153-182). Greenwich, CT: Information Age Publishing.

Rahm, J. (2002). Emergent learning opportunities in an inner-city youth gardening program. *Journal of Research in Science Teaching, 39*(2), 164-184.

Renninger, K. A. (1992). Individual interest and development: Implications for theory and practice. In K. A. Renninger, S. Hidi, & A. Krapp (Eds.), *The role of interest in learning and development* (pp. 361-376). Hillsdale, NJ: Lawrence Erlbaum Associates.

Renninger, K. A. (1998). Developmental psychology and instruction: Issues from and for practice. In W. Damon (Gen. Ed.) & I. E. Sigel & K. A. Renninger (Vol. Eds.), *Handbook of child psychology: Vol. 4. Child psychology in practice* (5th ed., pp. 211-274). New York: John Wiley and Sons.

Renninger, K. A. (2000). Individual interest and its implications for understanding intrinsic motivation. In C. Sansone and J. M. Harackiewicz (Eds.) *Intrinsic motivation: Controversies and new directions* (pp. 373-404). San Diego, CA: Academic Press.

Renninger, K. A. (in press). Learner interest and identity: An inductive model. *Educational Psychologist.*

Renninger, K. A., Bachrach, J., & Posey, S. (in press). Interest, self-efficacy, and the learning environment: Studies of out-of-school choral training and science. In Maehr, M.L., Karabenick, S., & Urdan, T. (Eds.). *Social psychological perspective on motivation and achievement: Vol. 15, Advances in Motivation and Achievement.* New York: Elsevier.

Renninger, K. A., Ewen, E., & Lasher, A. K. (2002). Individual interest as context in expository text and mathematical word problems. *Learning and Instruction, 12,* 467-491.

Renninger, K. A., & Hidi, S. (2002). Interest and achievement: Developmental issues raised by a case study. In A. Wigfield & J. Eccles (Eds.), *Development of achievement motivation* (pp. 173-195). New York: Academic Press.

Renninger, K. A., Lehman, D., Stevens, S. J., Costello, C., & Nekoba, W. S. (March, 2007). *Student perceptions, motivation, and learning in the science classroom: A short-longitudinal, cross-sectional study*. Paper presented at the Meetings of the Society for Research in Child Development, Boston, MA.

Renninger, K. A. & Lipstein, R. (2006). Come si sviluppa l'interesse per la scrittura; Cosa volgliono gli studenti e di cosa hannobisogno? [Developing interest for writing: What do students want and what do students need?] *Età Evolutiva*, 84, 65-83.

Renninger, K. A., Ray, L. S., Luft, I., & Newton, E. L. (2005). Coding online content-informed scaffolding of mathematical thinking. *New Ideas in Psychology*, 23, pp. 152-165.

Renninger, K. A., Sansone, C., & Smith, J. L. (2004). Love of learning. In C. Peterson & M. E. P. Seligman (Eds.), *Character strengths and virtues: A handbook and classification* (pp. 161-179). New York: Oxford University Press.

Renninger, K. A., & Wozniak, R. H. (1985). Effect of interests on attentional shift, recognition, and recall in young children. *Developmental Psychology, 21*(4), 624-631.

Reveles, J. M., Cordova, R., & Kelly, G. J. (2004). Science literacy and academic identity formulation. *Journal of Research in Science Teaching, 41*(10), 1111-1144.

Roggenbuck, J., Loomis, R. J., & Dagostino, J. D. (1990). The learning benefits of leisure. *Journal of Leisure Research, 22*, 112-124.

Roth, W. & Barton, A. C. (2004). *Rethinking scientific literacy*. New York: Routledge-Falmer.

Salomon, G. (1983). The differential investment of mental effort in learning from different sources. *Educational Psychologist, 18*(1), 42-50.

Salomon, G. (1984). Television is "easy" and print is "tough": The differential investment of mental effort in learning as a function of perceptions and attributions. *Journal of Educational Psychology, 76*(4), 647-658.

Sansone, C., & Harackiewicz, J. M. (1996). "I don't feel like it": The function of interest in self-regulation. In L. Martin & A. Tesser (Eds.), *Striving and feeling: Interactions between goals and affect.* Hillsdale, N.J.: Erlbaum.

Sansone, C., & Smith, J.L. (2000). Interest and self-regulation: The relation between having to and wanting to. In C. Sansone & J.M. Harackiewicz (Eds.). *Intrinsic and Extrinsic Motivation: The Search for Optimal Motivation and Performance*. San Diego, CA: Academic Press.

Sansone, C., Weir, C., Harpster, L., & Morgan, C. (1992). Once a boring task always a boring task? Interest as a self-regulatory mechanism. *Journal of Personality and Social Psychology, 63*, 379-390.

Schraw, G., & Lehman, S. (2001). Situational interest: A review of the literature and directions for future research. *Educational Psychology Review, 13*, 23-52.

Sigel, I. E. (2006). Research to practice redefined. In K. A. Renninger & I. E. Sigel (Eds.), *Handbook of child psychology: Vol. 4. Child psychology in practice, 6th Edition* (pp. 1017-1023). Hoboken, NJ: John Wiley and Sons.

Solomon, J. (2005). Home-school learning of science: The culture of homes, and pupils' difficult border crossing. *Journal of Research in Science Teaching 40*(2), 219-233.

Sonnert, G. (1995). *Who succeeds in science? The gender dimension*. New Brunswick, NJ: Rutgers University Press.

Stipek, D. (2002). *Motivation to learn: Integrating theory and practice*. Boston: Allyn-Bacon.

Stocklmayer, S., & Gilbert, J. K. (2002). New experiences and old knowledge: Towards a model for the personal awareness of science and technology. *International Journal of Science Education, 24*(8), 835-858.

Stokes, D. E. (1997). *Pasteur's quadrant: Basic science and technological innovation.* Washington, DC: The Brookings Institution.

Tal, T., & Morag, O. (2007). School visits to natural history museums: Teaching or enriching? *Journal of Research in Science Teaching, 44*(1): 1-23.

Travers, R. M. W. (1978). *Children's interests*. Kalamazoo, MI: Michigan State University, College of Education.

Toth, E., Suthers, D., & Lesgold, A. (2002). Mapping to know: The effects of evidence maps and reflective assessment on scientific inquiry skills. *Science Education, 86*(2), 264-286.

Wigfield, A., & Eccles, J. S. (1992). The development of achievement task values: A theoretical analysis. *Developmental Review, 12*, 265-310.

Wigfield, A., & Eccles, J. S. (2000). Expectancy-value theory of achievement motivation. *Contemporary Educational Psychology, 25*, 68-81.

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

Zimmerman, B., & Bandura, A. (1994). Impact of self-regulatory influences on writing course attainment. *American Education Research Journal, 31*, 845-862.

Figure 1: Four-phases of interest development, an overview[10]

Phase 1: Triggered situational interest

Triggered situational interest refers to a psychological state of interest that results from short-term changes in affective and cognitive processing. A triggered situational interest:

(a) can be sparked by environmental, text, or activity features such as incongruous, surprising information; character identification or personal relevance; and intensity.
(b) is typically, but not exclusively, externally supported.
(c) can be introduced through learning environments that include group work, puzzles, computers.
(d) may be a precursor to the predisposition to reengage particular content over time, as in more developed phases of interest.

Phase 2: Maintained situational interest

Maintained situational interest refers to a psychological state of interest that is subsequent to a triggered state, involves focused attention and persistence over an extended episode in time, or that re-occurs and again persists. A maintained situational interest:

(a) is sustained through the meaningfulness of tasks and personal involvement.
(b) is typically, but not exclusively, externally supported.
(c) can be introduced through learning environments that provide meaningful and personally involving activities, such as project-based learning, cooperative group work, or one-on-one tutoring.
(d) may or may not be a precursor to the development of a predisposition to reengage particular content over time, as in more developed forms of interest.

Phase 3: Emerging Individual Interest

Emerging individual interest refers to a psychological state of interest as well as to the beginning phases of a relatively enduring predisposition to seek repeated reengagement

---

[10] Characterizations of each phase of interest are based on empirical findings, see Hidi and Renninger (2006).

with particular classes of content over time. An emerging individual interest:

(a) is characterized by positive feelings, stored knowledge and stored value.

(b) is typically but not exclusively self-generated.

(c) can be supported by features of the learning environment

(d) may or may not lead to well-developed individual interest.

Phase 4: Well-developed individual interest

Well-developed individual interest refers to the psychological state of interest as well as to a relatively enduring predisposition to reengage with particular classes of content over time. A well-developed individual interest:

(a) is characterized by positive feelings, and more stored knowledge and more stored value for particular content than for other activity including emerging individual interest.

(b) is typically but not exclusively self-generated.

(c) will enable a participant to persevere to work, or address a question, even in the face of frustration.

(d) can be facilitated to deepen and develop through interaction and challenge that leads to knowledge-building.