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Triggering and maintaining interest in early phases of interest development☆

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ABSTRACT

This article reports on the complexities of triggering and maintaining interest, a process that is initiated when something catches the attention of a learner. Triggering interest (the initiation of the psychological state of interest) can occur in both earlier and later phases of interest development. However, in this study we focus on this process in earlier phases of interest development. Findings from a study of the activity of eight, Black, inner-city, middle school-age participants in an out-of-school biology workshop are described. We address the identification and generalizability of potential triggers for interest across activities and explore the relationship between triggers for interest and learner characteristics. Taken together, findings from the study suggest that learners do not perceive and respond identically to potential triggers for interest; and that the triggering process is nuanced by particular activity, and the readiness of the learner to respond.

The present study is an in-depth consideration of potential triggers for interest and their relation to learner characteristics. It was undertaken using field notes from an entry level biology workshop that is offered yearly, in response to workshop instructors' questions about how to support youth with no formal training to engage and develop an interest in science. The instructors have backgrounds in science, and worked with an educator to develop the curriculum for urban, middle school age youth considered to be at-risk because of economic and social challenges. Following the workshop's implementation, the instructors wanted to know if some features of the environment were more effective supports for the youth than others.

Even though it has been widely demonstrated that regardless of age or learning context the development of interest benefits learning (e.g., Crouch, Wisittanawat, Cai, & Renninger, 2018; Harackiewicz, Durik, Barron, Linnenbrink-Garcia, & Tauer, 2008; Jansen, Lüdtke, & Schroeders, 2016; Nolen, 2007; Palmer, Dixon, & Archer, 2017; see Hidi & Renninger, 2019), relatively little is understood about the process that results in triggering and then maintaining the development of interest. Here, we report on findings based on analysis of a detailed corpus of field notes. We consider the identification and generalizability of potential triggers for interest across workshop activities, and explore the relation between triggers for interest and learner characteristics.

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1. Background, the development of interest

Interest is universal; all persons are hardwired to develop interest (Panksepp, 1998; Hidi & Renninger, 2006; see Renninger & Hidi, 2016). Even when people have only some interest in a particular content such as science, they are likely to search for relevant information, continue to seek deeper understanding and persevere (e.g., Azevedo, 2013; Renninger & Hidi, 2019). They also are likely to be engaged in meaningful learning and are motivated: they are attentive, effortful, pursue and realize goals, and they develop and effectively use strategies (e.g., Sansone, Thoman, & Fraughton, 2015).

In the Four-Phase Model of Interest Development, Hidi and Renninger (2006; see also Renninger and Hidi, 2011, 2016) describe a person's interest as developing through four phases (not stages[1]): triggered situational, maintained situational, emerging individual, and well-developed individual interest. Interest described as a variable that develops has dual meaning. It refers to individuals' psychological state during engagement with some content, as well as to their motivation to reengage with that content (see extended discussion in Renninger & Hidi, 2016). We also note that interest is distinct from, and also coordinated in its development with, goal setting, self-efficacy, self-regulation, and identity (Renninger & Hidi, 2016).

The development of a new interest is initiated when something catches the attention of a learner, a process called triggering (Dewey, 1913; Hidi & Baird, 1986). Triggering establishes engagement (Bohnert, Fredricks, & Randall, 2010; Fredricks, Blumenfeld, & Paris, 2004). It may be fleeting, but there is also the possibility that it will lead to maintained interest (e.g., Guthrie et al., 2006; Harackiewicz et al., 2008; Palmer, 2004; Rotgans & Schmidt, 2011a, 2011b), and that it will allow interest to develop from an earlier phase to a later and more well-developed phase. Triggering that occurs in later phases of interest may be self-generated and is related to the existing knowledge of the person. Hedges and Cooper (2016) have demonstrated that even children's questions are a fundamental source of their interest, questions that come from already acquired knowledge about their world. Although the triggering of interest occurs repeatedly in every phase of interest and enables the development and deepening of interest, this article focuses on the early phases of interest development: triggered situational interest and maintained situational interest.

Earlier phases of interest development are characterized by heightened affect and dependence on the triggering of interest that is provided by others (e.g., teachers, parents, peers; see Bergin, 2016; DiGiacomo, van Horne, van Steenis, & Penuel, 2018; Harackiewicz et al., 2008; Pressick-Kilborn, 2015) and/or on the design of activities or instructional practices (e.g., group work, introduction of novelty; see Dohn & Dohn, 2017; Mayer, Griffith, Jurkowitz, & Rothman, 2008; Mitchell, 1993; Palmer, 2004, 2009) that help learners engage. Triggered situational interest can support learners to seriously engage with disciplinary content and improve performance (e.g., Crouch et al., 2018; Renninger et al., 2014).

The first studies to address the process of triggering interest focused on conditions that elicited and maintained interest in texts. Text-based studies demonstrated that readers were interested in texts that included unusual, incongruent, surprising, or novel ideas, and/or content that described actions and feelings that they found important and could identify with (e.g., Anderson, Mason, & Shirey, 1984; Hidi & Baird, 1986, 1988). This work was later expanded to the classroom and out-of-school contexts, following a study by Mitchell (1993), who reported both that group work, puzzles, and computers triggered situational interest in a high school classroom, and that meaningfulness could promote longer lasting, or maintained, situational interest. Studies of the generation or sources of interest have since pointed to a wide range of potential triggers for interest (e.g., affect, autonomy, challenge, and so forth; see Table 1).

In general, the literature on interest points to the potential of triggers without clarifying their nature. Thus, for example, researchers may assume that if an activity is meaningful, it is a trigger for interest, even though the experimenter is not necessarily in a position to know what is “meaningful.” Meaningfulness needs to be both defined and subsequently identified (operationalized). Researchers (and practitioners) also often expect that triggers for interest are generalizable to all persons. If educators use group work assuming that sociability will trigger interest (Bergin, 2016, they also need to consider that not all students are sociable (Renninger, 2009). In other words, learners may not respond to intended triggers if the triggers do not provide them with the possibility of making the kinds of connections to content that they need (Renninger & Hidi, 2016, 2019).

Studies have shown that triggers may or may not work, meaning that they may or may not maintain interest (e.g., Harackiewicz, Barron, Tauer, & Elliot, 2002; Palmer, Dixon, & Archer, 2016; see Renninger & Su, 2012/2019). In their work, some researchers have adopted Dewey's (1913) phrases of “catching” and “holding” interest (e.g., Mitchell, 1993). However, catch and trigger are not synonymous verbs (Hidi, 2000). Triggering describes the initiation of the psychological state of interest by increased attention generated in possibly disengaged individuals, whereas catching interest implies that the interest of already engaged individuals is redirected towards a new situation.

1.1. Triggers for situational interest

There is a growing literature on triggers for generating interest. It spans learning in and out of school, including do-it-yourself (DIY) projects (e.g., B. Barron, Gomez, Pinkard, & Martin, 2014), classroom simulations (e.g., Knogler, Harackiewicz, Gegenfurtner, & Lewalter, 2015; Lo & Tierney, 2017; Rotgans & Schmidt, 2017); and science demonstrations and projects (e.g. Palmer, 2004, 2009; Palmer et al., 2016; Pressick-Kilborn, 2015). Common to each is a focus on identifying features of the rich, problem-based environment that can capture and then sustain learners' attention.

[1] To note, the Four-Phase Model describes phases rather than stages in the development of interest because if there is not enough opportunity and/or support in place for interest to develop, interest may stagnate, fall off, or disappear altogether.

Table 1
Working definitions for potential triggers for interest in the biology workshop.

Potential trigger	Working definition	Example from observation notes	Related constructs	Seminal references
Affect	Heightened emotion that emerges during activity or some aspect of an activity.	They are very excited about digging for worms. … N holds up a big, cool worm. G gets a big smile on her face. … A holds a big worm up in front of her, and she gets a big smile on her face. … (Notes, *Worm collection*)	- Activity level - Entertaining style - Fun - Games - Intensity/intense description - Liking - Playful exploration	- Anderson et al. (1984) - Hidi and Baird (1986)
Autonomy	Learner-directed activity, often involving answering a personal question.	L wanted to know if there were baby plants inside all of the seeds. She wasn't convinced that there were. All on her own, she came up with the idea of soaking more different kinds of seeds, and looking inside them tomorrow. (Notes, *observing seeds*) They independently check on their seeds throughout the course of the summer. (Notes, *Growing Seeds Part II*)	- Autonomy support - Choice - Control - Flexibility - Rewards, motivation - Self-determination theory - Time	- Azevedo (2006) - Williams and Deci (1996)
Challenge	Content, skills, or anything else that is difficult for the learner.	Understanding the logic of isolating variables during the seed experiment was difficult and many of the children were visibly frustrated. (Notes, *Growing Seeds Part II*) L gets the right answer when student assistant 2 asks her what she can learn from a particular set of seed germination bags, and she is so excited. They do a high-five, and L is glowing. G comes over to see what's going on, and L tells her to, "go away so that she can remember." (Notes, *Growing Seeds Part II*)	- Coherence - Competence - Effectance motivation - Hardiness - Puzzles - Scaffolding - Self-determination theory - Zone of proximal development	- Berlyne (1960) - Chen, Darst, and Pangrazi (2001)
Character identification	Seeing oneself as a scientist (or other relevant character).	Student Assistant 1 says, "Sounds like you discovered lots of things." G responds, "So, does that make us scientists?" A says "I want to be a scientist so I can learn about things I don't know about." (Notes, *What is Science?*)	- Fantasy - Identity - Modeling	- Hidi and Baird (1988) - Malone and Lepper (1987)
Computers, technology	Work with computers or another form of technology.	He is interested in the gypsy moths that are mentioned in the article. I ask him what he is so excited about, but before he tells me, he makes me wait because he wants to click on the link to find out what it looks like first. Then he tells me about them. (Notes, *Computer Research*)		- Malone and Lepper (1987) - Mitchell (1993)
Group work	Work with others, where others are peers and not the instructor.	"There's the little leaf, and there's the little root." They had a lot of fun showing it to me. And they showed the morning glory seed to each other. (Notes, *Observing Seeds*)	- Belongingness - Parallel play - Sociability - Social interaction - Social involvement - Social stimulation - Social support - Social-emotional goals - Working together	- Herrenkohl and Guerra (1998) - Mitchell (1993)
Hands-on activity	An activity (or component of an activity) that is interactive or involves the use of one's hands.	She can show me which experiment shows that seeds need water. There is a seed that was given water that did not sprout yet, and she knows that it should have grown. She opens this seed up to look for the little	- Activity level - Involvement - Physical activity	- Mastropieri, Scruggs, and Magnusen (1999) - Mitchell (1993)

(*continued on next page*)

Table 1 (*continued*)

Potential trigger	Working definition	Example from observation notes	Related constructs	Seminal references
		plant. She says, "I want to see that it started to grow inside even though it didn't come out." This is what she finds. (Notes, *Growing Seeds Part II*)		
Instructional conversation	A conversation that engages content and enables a learner to reach a new understanding.	How are we going to set it up? L: "I think we should put five on one side and five on the other side, and we'll count tomorrow. Student assistant 1 asks L why we need the same number on each side. … "So it can be even." Simone explains to her how they are keeping everything the same except for the light, like they did for the seed experiment. … They know that they need the same number of worms in each side. N says that he's keeping track. Student Assistant 2 asks how we should have one side be light and one side be dark. (Notes, *Worm Experiment I*)	- Complexity - Comprehension - External support - Performance feedback - Rationale - Scaffolding - Zone of proximal development	- Schraw (1997) - van Dijk and Kintsch (1983)
Novelty	Anything that is new, including new insight about something that is familiar.	"I didn't know we had that kind of bones" (Notes, *Skulls and Skeletons*)	- Coherence - Discrepancy - Hole in the schema - Surprise - Unexpectedness - Variety - Visual stimuli	- Berlyne (1960) - Hidi and Baird (1986)
Ownership	A learner's feeling that some aspect of an activity is "his" or "hers" or belongs to him or her.	"I can't wait to go in the woods and see mine!" A was especially excited about her earthworms. She claimed them as hers, because they were the thing that she had researched. (Notes, *Walk in the Woods*)		- Pierce, Kostova, and Dirks (2003) - Renninger (2000)
Personal relevance	A connection between an activity (or aspect of an activity) and a learner's past experience.	Crabs are something that these kids are familiar with. They have been to the ocean, and they have eaten crabs. (Notes, *Models*)	- Importance - Life themes - Meaningful context - Meaningfulness - Personalization - Prior knowledge	- Hidi and Baird (1988) - Schank (1979)

Although the use of terminology differ, authors whose work has focused on the generation of interest point to a range of possible triggers that include novelty, challenge, meaningfulness, hands-on activity, group work, variety, games, and visual stimulation. Certain topics, such as death and romance, are also assumed to trigger interest for everybody, and to be rendered more or less interesting based on their unexpectedness and personal relevance (Schank, 1979). Triggers that distract the learner from important content have been described as seductive details (see Garner, Gillingham, & White, 1989; Magner, Schwanke, Aleven, Popescu, & Renkl, 2014; Mayer et al., 2008). Along the same lines, Magner et al. (2014) reported that decorative illustrations (seductive details) triggered situational interest for learners, but did not maintain it, and derailed learning for those with less developed interest.

Studies of triggers for interest have tended to be experimental and focused on one or another feature of an activity or text as a trigger for interest (e.g., autonomy, character identification). Researchers have now begun to consider whether potential triggers work the same way for all learners, and if they occur independently, or if they might be more appropriately described as co-occurring. For example, in a series of studies on situational interest and science teaching, Palmer (2004) identified novelty, meaningfulness, involvement, group work, and personal anecdotes as sources of situational interest. Whereas he (Palmer, 2009) observed that novelty was primary, he also included autonomy and social involvement as triggers for situational interest. He reported that the students' skills affected their engagement. He also found that the impact of triggers varied with different parts of the lesson (e.g., demonstration, experimentation, copying notes; see related findings in Knogler et al., 2015; Rotgans & Schmidt, 2011a, 2011b). He noted that additional sources of interest could be studied across activity types, and suggested that responses of the group as a whole are needed. Most recently, Palmer and his colleagues (Palmer et al., 2016) identified increases in situational interest when individuals experienced success learning novel information that was personally meaningful.

Studies addressing the triggering and maintaining of situational interest are consistent in pointing to an essential relation between the learner and the environment. As Renninger and Hidi (2016) point out, the potential for developing interest is in the learner, but it is in the relation of the individual and the environment that interest may be supported to develop. However, even though a study of triggered situational interest may, for example, point to the potential of jigsaw[2] learning to trigger situational interest (e.g., Hidi, Weiss, Berndorff, & Nolen, 1998), studies have not focused on the source of participants' increased engagement. Questions important to educators' understanding and ability to make use of the research on triggering could have included: Were the role assignments in the jigsaw novel for the students? Were they meaningful? Did they involve choice, physical activity, social involvement, fun, challenge, or ownership? Did they involve all of these? If we are to explain when and why and for whom potential triggers for situational interest are effective, more differentiated information is needed about potential triggers. Such information could position educators to better understand how learners' interest might be supported to develop.

1.2. Interest and learner characteristics

Although the role of the self in the development of interest is readily acknowledged by interest theorists (e.g., Hidi, Renninger, & Northoff, 2018, 2019; Hofer, 2010; Krapp, 2007; Schiefele, 2009), other learner characteristics (e.g., whether they are conscientious, open, sociable) have not been a focus of research on earlier phases of interest development (possibly because of the expectation that learners in earlier phases of interest will respond to potential triggers similarly). Instead, research on triggering situational interest has addressed what the environment (other people, the design of tasks and activities) can do to trigger interest.

Unlike research on interest, research on learner characteristics tends to be domain general, meaning that the characteristics of individuals are considered to be trait-like and are not expected to vary by content area (see McAdams, Shiner, & Tackett, 2018). Moreover, as Shiner (1998) pointed out, the work on learner characteristics is largely undertaken with a focus on pathology and behaviors of clinical relevance, and much of the research has been undertaken with infants, with the possible exception of research on the Big 5 personality characteristics (extraversion, agreeableness, openness, conscientiousness, and neuroticism; McCrae & John, 1992).

A few studies have been conducted on the association of learner characteristics and interest in particular content. These investigations suggest that learner characteristics may influence and be influenced by the learners' state of interest (e.g., Ainley, 2007, 2010; Reeve, Lee, & Won, 2015). They also imply that interest, considered as both a state and a predisposition to re-engage, has a consistent relation to learner characteristics (Renninger & Leckrone, 1991; Sansone, Wiebe, & Morgan, 1999; Trautwein et al., 2015).

For example, Trautwein et al. (2015) examined the relation between interest and conscientiousness in academic effort. They found what they describe as a compensatory interaction between these variables such that having an interest in subjects to be learned was especially beneficial to students who were not conscientious. As Sansone et al. (2015) have also pointed out, the ability to self-regulate (an ability that is likely to be related to conscientiousness) is only a problem when a person lacks interest. These findings suggest that the maintenance of interest may be influenced by learner characteristics, and that the relation between the triggering of interest and learner characteristics warrants serious consideration.

2. The present study

Informed by grounded theory, the systematic consideration of qualitative data (Strauss & Corbin, 1998), we conducted a two-part study of the triggering and maintaining of interest in an out-of-school science workshop. The first part of the study addresses the

[2] Aronson et al. (1978) developed the jigsaw classroom as a method for supporting learning in desegregated classrooms. The method involves participants in a sequence of collaborative groupings that address a broad topic area, in which each serves as an expert in turn.

identification and generalizability of potential triggers across activities, including the occurrence, co-occurrence, and effectiveness of potential triggers for interest. The second part of the study explores the relation between potential triggers for interest and learner characteristics.

Two research questions are considered:

1. Given available data, what can be said about when triggers for interest are and are not maintained?
2. Given available data, what can be said about the relation between triggers for interest that are maintained and learner characteristics?

3. Methods

3.1. Participants

Study participants included all of the eight youths (3 males, 5 females) enrolled in an out-of school biology workshop. The workshop was part of a summer program that accompanied their membership in a rigorous choral training program that they joined two or three years earlier—participation in the workshop was not voluntary for the members. Consistent with Institutional Review Board regulations, all individuals agreed to participate in the study. The youth were Black, economically challenged, inner city youth who range in age from 9 to 12 years; mean age was 10.5 years. They knew each other from the choral training program; they did not attend the same schools, however they all attended schools in the same school district. None of these schools provided their students with formal science instruction. For another unrelated study, all study participants had been identified as having only a triggered interest for science.[3]

3.2. Learning environment

Workshop sessions were held an hour a day, four days a week, for five weeks. The sessions were developed and facilitated by instructors (a tenured biology professor and two college student research assistants) in a newly constructed and fully equipped college biology laboratory.

Four topics were addressed over the course of the workshop: Plants, Seeds and Growing, Local Forest Ecosystem, Worms, and Bodies (see Supplementary Appendix A for session descriptions). Workshop sessions were inquiry-oriented[4] and included direct experience, cognitive challenge, and social interaction. They included direct observation of phenomena (e.g., plants, seeds, bugs, the forest) and supported the development of science skills, strategies, and thought processes (e.g., measuring, looking through a microscope, writing in a science notebook, setting up an experiment, isolating variables). There was always a planned instructional objective; however, the plans were adapted regularly to account for opportunities in the environment and the participants' questions (see Supplementary Appendix B for examples).

A typical session began with questions to think about (e.g., What did you have for lunch and where did it come from?) or something to look at (e.g., What can you say about the seeds on the table? Are they alive?) The questions of the day were often written on the board and/or relevant specimens were placed on the lab benches before the start of the workshop session. The participants were involved in discussion or writing about these, and in this way were introduced to the focus of the day's session. They were then engaged in project-based work designed to encourage them to explore the topic and continue practicing skills (e.g., conducting a collaborative experiment). Follow-on discussions were based on what the youth were observing, and were intended to support focused, in-depth consideration of session topics.

3.3. Data sources

Field notes, or running observational records (c.f. Carini, 1975), are the primary data source for this study. They chronicled the professor, student assistants, and participants' observable behaviors and conversations, and were collected each day of the workshop by one researcher who was blind to study questions. Following each workshop session, the professor, the student assistants, and the researcher met to review the observational records. This allowed the researcher to confirm and add additional information to her record.

[3] The participants' phase of interest in science was identified using interview data from the participants and their parents or guardians, in combination with observation records. Following Renninger and Wozniak (1985; see Renninger & Hidi, 2016) each participant's phase of science interest was assessed based on four behavioral indicators: voluntary engagement in science content, its frequency and depth relative to other activities, and their ability to engage science independently. Sample questions included: Would you say you know more about science than other things? [probes: art, math, basketball] What about liking? Do you think you like science more than other things? [probes: art, math, basketball] If they like it: What do you like about science? If they don't: What don't you like about science? What TV shows do you watch? Do any of them have science in them? Inter-rater reliability was 100%.

[4] Workshop design was informed by the work of White and Frederiksen (1998); Marx, Blumenfeld, Krajcik, and Soloway (1997); Metz (1995, 2000); Michaels, Shouse, and Schweingruber (2008); and Yamauchi, Wyatt, and Carroll (2005), as well as the Benchmarks for Science Literacy (American Association for the Advancement of Science, 1993) and Project 2061 (Baker & MacVicar, 1989).

Table 2
Working definitions for learner characteristics in the biology workshop.

Learner characteristic	Working definition	Example from observation notes	Related constructs	Seminal references
Activity level	Need to be able to move around, ability to sit still for long periods of time, amount of energy	T came alive in the woods in a way that I hadn't seen from him much in lab. He was very excited and he seemed to have more to say. All of the boys, actually, were very into running ahead and looking at things. (Notes, *Walk in the Woods*)	Activity Biological rhythmicity Energy Fantasy Gross motor activity Tempo Vigor	Buss and Plomin (1984) Thomas and Chess (1977)
Awareness	Amount of relevant past experience or stored information; ability to draw on past experiences and make connections	We were looking at some pollinators. He asked about what pollination was, and we clicked on the link that defined it for us. … he said that he knew about pollen from "Honey I Shrunk the Kids" (Notes, computer research)	Background experience Prior knowledge	Alexander and Murphy (1998) Renninger (1990)
Emotionality	Ability to become immersed in activity; excitability, willingness to "get into it"	The kids were really into finding their things. I heard a lot of exclamations about stuff that they had found. They wanted other people to come see what they saw, and there was lots of pointing, and they were very into it. (Notes, *Walk in the Woods*)	- Affect - Agreeableness - Arousal - Intensity of reaction - Negative emotionality - Threshold of responsiveness	- Buss and Plomin (1984) - Thomas and Chess (1977)
Independence	Ability to self-regulate and function independently; self-sufficiency; initiative	Student assistant 2 asks, "Do you want to try and find the answers to the questions you had?" Y replies, "I want to try it myself. I don't want to read it in a book." (Notes, *Worms II and Dissection*)	- Attention span - Conscientiousness - Dependence - Discipline - Impulsivity - Mental reflection - Planfulness - Self-regulation - Will to achieve	- Buss and Plomin (1984) - Thomas and Chess (1977)
Mood	A way of feeling at a particular time; disposition; outlook, current affect	N is sad because of something that happened outside of the room. Student assistant 1 takes him to look at turtles in student assistant 2's lab (instead of looking at crabs). (Notes, *Models*)	- Agreeableness - Emotion - Temperament - Well-being	- Ainley (2007) - Thomas and Chess (1977)
Openness	Desire to learn, inquisitiveness, sense of wonder; willingness to try new things; open to the world	T is looking at his worm. At first he is scared, but he does the dissection anyway because he is so curious. (Notes, *Worms II and Dissection*)	Approach or withdrawal Cognitive exploration Cognitive flexibility Curiosity Intellect	Costa Jr. and McCrae (2001) Thomas and Chess (1977)
Reactivity	Flexibility; persistence; ability to focus/reorganize despite distraction or when things are difficult; ability to deal with frustrating experiences and other challenges, including having ideas challenged	L asks a question that G just asked. G gets very defensive about L asking her question. (Notes, *Worm Experiment I*)	- Adaptability - Distractibility - Hardiness - Persistence	- Rothbart and Derryberry (1981) - Thomas and Chess (1977)
Sociability	Ability to get along or collaborate with others, tendency to seek out social interactions; sense of self in relation to others; extroversion	Student assistant 1 and student assistant 2 worked with G, L, and DY on a poster about what seeds need to grow. This was challenging, because of group dynamics. If Y was wrong about something or if something wasn't going right, she would stop interacting, and it would be very difficult to get her to open up again. (Notes, *Making Posters*)	Agreeableness Empathy Extraversion/introversion Sensitivity Shyness	- Buss and Plomin (1984) - Rothbart (1989)

3.4. Analysis strategy

For each part of the study, associated working examples and definitions were developed for the purpose of identifying the potential triggers for interest and the learner characteristics that could be studied in the workshop context. Eleven potential triggers for interest were identified for study: affect, autonomy, challenge, character identification, computers/technology, group work, hands-on activity, instructional conversation, novelty, ownership, and personal relevance (Table 1, see also Supplementary Appendix C), and seven learner characteristics were identified: activity level, awareness, emotionality, independence, mood, openness,

Table 3
The potential triggers by topics of workshop sessions.

Workshop session	Affect	Autonomy	Challenge	Character identification	Computers/ technology	Group work	Hands-on activity	Instructional conversation	Novelty	Ownership	Personal relevance
Oobleck	X	X		X			X	O	X		
What is science?				X		O		X			
Observing plants	X			X			X	O		X	X
Observing seeds	X	X		X	X	X	X	X	X		X
Food chains	X, O	O	O		O	O		O	X, O		X
Growing seeds part I		O	X	O		O	O	X, O	O		
Growing seeds part II		X	O	X		O	X	X	X, O		X
Computer research	O	X, O	X, O	X	X			X		X	X
Walk in the woods	X		X				X	X	X	X	
Worm collection	X	X	X			X	X	O		X	
Worm experiment I	X	X, O	X			X, O	X	X	X		X
Worms II and dissection	X	X	X	X		X	X		X	X	X
Models	O		O			O	O	O			X
Dissecting crabs	X	X, O				X	X	X, O			X
Skulls and skeletons	X		O			O	O		X		X
Making posters			O	X	X	X, O		X		X	
Presenting posters			X, O	X, O		O				X	

Note: Triggers that were maintained are indicated by an "X" and triggers that were not maintained are indicated by an "O." A blank space indicates that the given trigger was not present in that session. "X,O" is listed when at the same time, some participants had an interest and some did not.

reactivity, and sociability (Table 2, see also Supplementary Appendix D).

Following Stake (2005), analyses of participant observation records were conducted at the level of the group. Categorical directed content analysis (e.g., Hickey & Kipping, 1996; Hsieh & Shannon, 2005; Potter & Levine-Donnerstein, 1999) was used to establish procedures for coding. This analysis strategy involved using existing research and theory to inform data reduction and also allowed identification of emergent categories for coding.

In Part 1 of the study, the field notes were read and coded session by session and trigger by trigger. Following training, a research assistant who was also blind to study questions and unfamiliar with the related research literature, independently assessed the presence of triggers for interest in 22% of the notes. Inter-rater reliability was very high (93%).

In Part 2 of the study, the analysis strategy included reading the field notes, noting each recorded instance of each trigger in each session, and determining its relation, if any, to each of the learner characteristics (see Supplementary Appendix E). Reliability for this analysis was conducted using an adaptation of Amabile's (1996) consensual assessment technique. Two persons blind to study questions and the previous analyses reviewed and coded the notes separately for each learner characteristic. The two sets of analyses were then compared, and differences were resolved through re-review of relevant data.

4. Results

4.1. Part 1: Triggers for interest that are and are not maintained

Part 1 of this study was designed to address what the field notes could tell us about when triggers for interest are maintained and when they are not. As depicted in Table 3, triggers for interest can be identified in multiple workshop sessions, and occur with different frequencies, possibly due to the curricular structure or implementation of the workshop session (e.g., the day that there was a walk in the woods, there was no use of computers). Importantly, none of the triggers seem to occur in isolation. Instead, between 3 and 9 triggers could be identified in a given workshop session, and some of these triggers worked, in that they were maintained, and some did not.

Table 4 describes the characteristics of workshop sessions in which potential triggers for interest were and were not maintained. Triggers were maintained in sessions that included sustained individual activity, spontaneity, and use of science tools (which are novel for these youth); whereas in sessions that lacked individual attention, and involved mismatched abilities in group work assignments, conceptual difficulty, and/or insufficient time, interest was not maintained.

A synopsis of findings from analyses of each of the potential triggers studied is presented in Table 5. They confirm previously described characteristics of each of the triggers (e.g., that affect as a trigger for interest may be positive or negative, see Hidi, 2000; Iran-Nejad, 1987). They show that triggers for interest may be promoted in some, but not in all sessions (e.g. affect was a trigger for interest when activities were hands-on). They also suggest that there is a relation between whether a trigger is maintained and learner characteristics (e.g., affect is a trigger for interest when a participant is rated high on openness, defined as responsiveness to experience).

In summary, findings from Part 1 of this study suggest that the triggering of interest is a nuanced process that involves multiple triggers rather than a single trigger. The results suggest that triggers may or may not be recognized by the participant. Moreover, potential triggers such as group work or hands-on activity are planned by others, whereas other triggers such as ownership and

Table 4
Relation among session characteristics, relative number of identified triggers, and whether triggering is maintained.

	Characteristics of sessions with triggers that are and are not maintained	
	Triggers maintained	Triggers not maintained
Many triggers	- Sustained individual activity - Spontaneity - Use of science tools	- Lack of individual attention - Mismatched abilities in group work - Conceptual difficulty - Lack of time
Few triggers	- Whole-class discussion - Presentation to others - Dense content	- Open-ended activity without specification for mastery - Multiple potential triggers that worked - Few potential triggers overall

Note: This table summarizes data presented in Table 3 and Supplementary Appendix A, (1) Sessions with many (7-9) triggers that work include: *Observing Seeds, Computer Research, Worm Experiment I, Worms II and Dissection*. (2) Sessions with many (6-7) triggers that do not work include: *Food Chains, Growing Seeds Part I*. (3) Sessions with few (1-3) triggers that work include: *What is Science? Food Chains, Growing Seeds Part I, Models, Skulls and Skeletons, Presenting Posters*. (4) Sessions with few (0-1) triggers that do not work include: *Oobleck, What is Science? Observing Plants, Observing Seeds, Walk in the Woods, Worm Collection, Worms II and Dissection.*

personal relevance are potentially always present but may not be recognized. Finally, some potential triggers also appear to be more likely to be maintained if they are accompanied by another trigger, for example, hands-on activity appears to be more likely to trigger interest when accompanied by heightened affect. Emergent data from the analyses further suggest that the participants' responsiveness to potential triggers may be affected by their characteristics as learners, providing support for the focus of the second part of this study.

4.2. Part 2: Triggers for interest and learner characteristics

Part 2 of this study was designed to address what the field notes could tell us about the relation between triggers for interest that are maintained and learner characteristics. Table 6 reports relevant learner characteristics for each potential trigger by workshop session, and Table 7 reports the frequency with which each learner characteristic is linked to each potential trigger. These results provide further evidence for the suggestion made in Part 1, that there is a relation between potential triggers for interest and learner characteristics. They further suggest that whether a potential trigger for interest is maintained is related to learner characteristics of the participants and not just the presence of the potential trigger. Finally, it also appears that it is the potential trigger in addition to the characteristics of the learner that explains whether a potential trigger for interest is recognized and responded to.

A number of previously unreported relations among potential triggers and learner characteristics surfaced. In particular, some learner characteristics were found to be more relevant to some triggers than others. For example: activity level (ability to remain seated) appears most likely to influence whether affect and hands-on activity work as triggers for interest, in that triggering is maintained. Awareness (ability to make use of prior experience or knowledge) appears most likely to influence whether personal relevance, novelty, and challenge work as triggers for interest that are maintained. Emotionality (ability to become immersed in activity) appears most likely to influence whether affect, character identification, and ownership work as triggers and maintain interest. Independence (conscientiousness, planfulness) appears most likely to influence whether autonomy and challenge trigger and maintain interest. Mood (feelings in the moment) appears most likely to influence whether affect, challenge, and group trigger and maintain interest. Openness (intellect and responsiveness to experience) appears most likely to influence whether affect, autonomy, computers/technology trigger and maintain interest. Reactivity (adaptability) appears most likely to influence whether challenge triggers and maintains interest. Finally, sociability (approach to and desire to be with other people) appears most likely to influence whether group work triggers and maintains interest.

The success of some potential triggers also was found to always be tied to particular learner characteristics. For example, autonomy was always affected by independence and openness. Group work was always affected by sociability. Ownership was always affected by emotionality. And, personal relevance was always affected by awareness. In addition, potential triggers were found to be affected by different numbers of learner characteristics. Affect, challenge, and group work were affected by all of the 8 identified learner characteristics. Computers/technology, hands-on activity, instructional conversation, and novelty were each affected by 7 of the 8 identified learner characteristics. Autonomy, character identification, ownership, and personal relevance were each affected by 5 of the 8 identified learner characteristics. Furthermore, the findings from the analyses suggest that both high and low ends of the spectrum for each learner characteristic may be relevant—for example too much independence and not enough independence may both interfere with the triggering process.

In summary, findings from Part 2 of this study suggest that at least in these data learner characteristics affect when and how potential triggers may be maintained. Moreover, although all potential triggers for interest were affected by the participants' learner characteristics, they were not all affected by the same learner characteristics, nor were they affected to the same extent.

5. Discussion

We designed the present study to explore the triggering and maintaining of interest in the early phases of its development. Learner

Table 5
Summary findings for each potential trigger.

Trigger	Summary findings
Affect	Participants' interest was triggered by heightened affect when they were having fun or when they experienced an intense situation. Participants were most likely to have fun during activities that either had a hands-on component or did not have a specific educational goal. Heightened affect appeared to trigger interest when participants were handling Oobleck,[a] observing natural objects (seeds, plants, worms, crabs, and skulls), and performing dissections. Heightened affect did not need to be positive in order to trigger interest. For example, even though many of the participants appeared to be afraid or disgusted during the session titled *Walk in the Woods* and while confronting death during sessions on *Worms II and Dissection*, the intensity of these activities triggered interest. Heightened affect tended to co-occur with other triggers that worked, and the most successful sessions tended to include heightened affect. Heightened affect was not likely to occur during sessions with activities that involved sitting, listening, and talking. The process of analyzing affect as a potential trigger revealed that it is not always easy to predict how a participant will experience an activity. The environment can be designed with the intention of supporting a learner to experience heightened affect, but affect cannot be planned into a session as a potential trigger in the same way that hands-on activities, for example, can be. The affective response comes from the individual.
Autonomy	Participants were likely to have their interest triggered by autonomy when they perceived the opportunity to direct an aspect of the activity. Participants were most likely to have their interest triggered by autonomy when they felt free to explore, as they were with the activities in sessions involving worms, as well as those with Oobleck, seeds, and crabs. During these activities, there were no "rules" to follow (excepting those relevant to safety concerns). A participant who ran back into the lab, scooped up the worms one last time, and announced that she wanted to see them mate under the microscope had her autonomy supported by the open-workshop policy that allowed worms to sit out and microscopes to be available. Participants tended to stay focused and engaged while they observed their specimens and pursued their own questions. Participants were less likely to have their interest triggered by autonomy when their instructors had a goal in mind and led them through an activity in a particular sequence. Time limitations and other constraints could also sometimes interfere with the possibility of triggering interest with autonomy, e.g., the possibility for a participant to pursue his or her own questions. During the seed experiment, for example, it was not possible for the participants to test variables other than those for which materials were present, even if they expressed an interest in doing so. The process of analyzing autonomy as a potential trigger for interest suggests that although opportunities for autonomy can be planned into an activity, an individual may also independently demonstrate autonomy. In each case, prior experience appears to determine whether interest will be triggered by autonomy, suggesting the possibility of a reciprocal relation between autonomy and interest (Hidi & Renninger, 2006).
Challenge	Participants were likely to have their interest triggered when they overcame a challenge and experienced success. The primary challenges the participants faced were personal, dealing with unfamiliar situations or fear (e.g., during sessions such as *Worm Collection* and *Worms II and Dissection*), and in some cases challenging their sense of themselves (e.g., touching a worm for the first time). Other challenges included struggling through difficult content or focusing on an activity for an extended period. The process of analyzing challenge as a potential trigger for interest revealed that when the challenge was too easy or too hard, or too similar to a previous activity, it was unlikely to trigger interest. It seems that experiencing a sense of accomplishment is critical for challenge to trigger interest. Thus, even if an instructor observed a participant being successful with a difficult activity, interest may not have been triggered unless the participant recognized the accomplishment.
Character identification	Participants were likely to have their interest triggered by character identification when they were able to see themselves as scientists, something that could happen in more than one way. During earlier workshop sessions, lab coats and lab notebooks triggered participants' interest through character identification. Participants' interest was also triggered through character identification when they connected their own activity to their understanding of what a scientist does, such as looking inside a worm. The process of analyzing character identification as a potential trigger for interest suggested that workshop elements such as lab coats became less effective as triggers for interest in later sessions of the workshop, possibly because the lab coats became more superficial as the participants found ways to identify with the science content.
Computers/technology	Participants' interest was triggered by the use of computers and other "fancy" technology (such as powerful microscopes) when they worked with these tools. They were most likely to have their interest triggered by computers and technology when they also received appropriate scaffolding (e.g., sessions on *Computer Research*, *Making Posters*) or when the technology could be used to produce something that looked professional (e.g., session on *Making Posters*). They were less likely to have their interest triggered by technology when they did not receive one-on-one support (e.g., session on *Food Chains*); at these times they played on the computers, looking at sites that were not science-related, and thus their interest for science content was not triggered. The process of analyzing technology as a potential trigger for interest indicated that its presence in a session needed to be planned and structured. Furthermore, because the technology is not always available, the opportunity for participants' interest to be triggered by computers or other technology is not always possible. In this way, in this workshop, technology differed from other potential triggers for interest such as affect or challenge.
Group work	Participants were likely to have their interest triggered by group work such as a jigsaw when they had an experience that they wanted to share with others, and/or they were paired with people whom they liked. Group work was less likely to trigger interest when participants were paired with other participants with whom they did not get along. The process of analyzing group work as a potential trigger for interest indicated that group work could range from collaboration and/or cooperation to side-by-side participation. In addition, sometimes participants independently chose to involve their peers in what they were doing, meaning that group work sometimes occurred when it was not planned into the workshop session. However, group work may or may not function as a trigger for interest in science because even if participants are enjoying working in a group, they may not be associating what they are doing with science. They may simply be enjoying spending time with their friends. They may also be distracting each other. It also appears that group work may not trigger interest for participants who are middle-school aged, a time when peer interactions are complicated because they are concerned about how they present themselves to others (see Harter, 2006).

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Table 5 (*continued*)

Trigger	Summary findings
Hands-on activity	Participants were likely to have their interest triggered by hands-on activity when the activity allowed or led them to see phenomena clearly and concretely. In the workshops, hands-on activities were used to demonstrate the dynamic nature of living things. Hands-on activities appeared less likely to trigger interest if the participants did not want to engage in the hands-on component (e.g., handling skulls), or if there was not enough time to complete the activity. The process of analyzing hands-on activity as a potential trigger for interest further suggests that hands-on activity can refer to the manipulation of an object either as an essential or as a tangential component of a session. Whether hands-on activities trigger interest for the content of science is related to whether science content is integral to the activity or whether the hands-on activity was incorporated "just for fun." If hands-on activities are simply included to make the activity more fun, they may distract the participant from the science content. While autonomy or group work was sometimes spontaneously generated by participants, hands-on activity was not.
Instructional conversation	Participants were likely to have their interest triggered by instructional conversation when instructors guided them to new understanding. We observed participants being proud of themselves during such conversations when they realized that they understood a difficult concept. Participants were less likely to have their interest triggered by instructional conversation when they became bored or frustrated by the difficulty of the content. The process of analyzing instructional conversation as a potential trigger for interest further indicated that participants were often bored by activities that involved sitting and talking, making instructional conversation difficult to implement successfully. Furthermore, the effectiveness of instructional conversation as a potential trigger for interest appears to rely heavily on quality of the scaffolding provided by the instructor, the time that serious consideration of an idea involves, and the possibilities for instructors working with participants on a one-on-one or small group basis.
Novelty	Participants' interest was triggered by novelty when something new or strange about an activity caught their attention. There were many ways in which something could be novel-for example, participating in a new experience, seeing something familiar in a new way, or something behaving unexpectedly. The process of analyzing novelty as a potential trigger for interest indicated that all participants were likely to have their interest triggered by novelty; however, what was novel to one participant was not necessarily novel to the next participant.
Ownership	Participants' interest was triggered by ownership when participants were able to claim something of an activity as "theirs" or as belonging to them, and/or when participants discovered something by themselves. In this workshop, participants also experienced ownership when they were provided with something that became their own—a plant or an animal to research. The process of analyzing ownership as a potential trigger for interest revealed that the potential for ownership to trigger interest is always present, although participants may or may not respond to it. It appears that participants had to recognize and personally seize the opportunity to claim ownership, if their interest was to be triggered by ownership. No instances in which ownership was recognized failed to trigger interest.
Personal relevance	Participants' interest was triggered by personal relevance when participants made connections between some aspect of workshop activities and their own prior experience. For example, activities that addressed topics such as living, growing, and eating included potential triggers for personal relevance. The process of analyzing personal relevance as a potential trigger for interest suggested that when the participants did not recognize connection(s) between the activity's content and their own experiences, there was no personal relevance, and interest was not triggered.

[a] Oobleck is a green gooey substance referenced in Dr. Seuss' *Bartholomew and the Oobleck*. It is frequently used in elementary school science to explore properties of matter, and can be made by combining cornstarch, water, and green food coloring.

engagement with potential triggers for interest in activities is detailed, as are the relations that could be observed among these triggers and particular learner characteristics. Understanding which triggers work, when, and for whom are essential questions for educators. This type of information can inform instructional methods and enable educators to support those with little prior knowledge and to help motivate the unmotivated.

Methodologically, the study differs from laboratory-based studies of triggers for interest in that it focused on a naturally occurring workshop environment over an extended period of time. Study findings indicate that triggers for interest that have been examined in experimental studies can be reliably defined and operationalized for study in the naturally occurring workshop setting. They confirm that when triggers work, attention is captured, and the triggering that enables engagement is often the result of interactions with other people in the environment, the design of activities, or serendipity such as when a participant walks into a spider's web.

The findings also reveal that the triggering of interest may be more complex than researchers and educators realize. Triggers do not appear to exist in isolation, as they are often investigated and employed. Moreover, simply inserting potential triggers for interest into the learning environment may not yield uniform and predictable results for participants.

Even though the process of triggering and maintaining interest is complicated, study findings can be helpful to the workshop instructors, and teachers more generally. The characteristics of sessions in which triggered interest was maintained varied, indicating that triggering and maintaining of interest can occur in a wide range of contexts, including: sustained individual activity, spontaneous activity, use of science tools, whole class discussion, presentations to others, and/or work with dense content. Moreover, it appears that triggers related to the self, such as personal relevance, ownership, and character identification, may be more universal than other triggers for interest; this finding is consistent with findings from neuroscientific research (see Hidi et al., 2018, 2019).

Study findings also point to likely relations between some triggers for interest that are maintained and learner characteristics. They suggest that affect and hands-on activities trigger interest that is maintained when learners' activity level (ability to remain seated) is high; personal relevance, novelty, and challenge trigger interest that is maintained when learners' awareness (ability to make use of prior experience or knowledge) is high; affect, character identification, and ownership trigger interest that is maintained

Table 6
Learner characteristics and potential triggers, by topics of workshop session.

Workshop session	Affect	Autonomy	Challenge	Character identification	Computers/technology	Group work
Oobleck	Emotionality Mood Openness Sociability	Independence Openness		Awareness		
What is science?				Awareness Emotionality Openness		Activity Level Mood Reactivity Sociability
Observing plants	Emotionality Mood Openness			Emotionality		
Observing seeds	Awareness Emotionality Mood Openness Reactivity	Awareness Independence Openness		Awareness Openness	Openness	Emotionality Independence Openness Sociability
Food chains	Activity Level Awareness Emotionality Independence Mood Openness Reactivity	Awareness Independence Openness	Awareness Emotionality Independence Mood Reactivity		Activity Level Awareness Emotionality Independence Openness	Activity Level Emotionality Independence Reactivity Sociability
Growing seeds part I		Awareness Independence Openness	Awareness Emotionality Mood Reactivity	Emotionality		Awareness Independence Openness Reactivity Sociability
Growing seeds part II		Emotionality Independence Openness	Activity Level Awareness Independence Reactivity	Emotionality Independence		Independence Mood Reactivity Sociability
Computer research	Activity Level Awareness Emotionality Mood Openness	Awareness Independence Openness	Awareness Independence Mood Openness Reactivity	Emotionality Sociability	Activity Level Awareness Emotionality Independence Openness	
Walk in the woods	Activity Level Awareness Emotionality Openness Reactivity Sociability		Activity Level Awareness Emotionality Reactivity			

Workshop session	Hands-on activity	Instructional conversation	Novelty	Ownership	Personal relevance
Oobleck	Activity level Emotionality Openness	Awareness Openness	Emotionality Independence		
What is science?		Activity level Awareness Openness Reactivity Sociability			
Observing plants	Emotionality Independence Openness	Reactivity Sociability		Emotionality Sociability	Independence
Observing seeds	Openness Emotionality Independence	Activity Level Sociability	Awareness Emotionality		Awareness Reactivity

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Table 6 (*continued*)

Workshop session	Hands-on activity	Instructional conversation	Novelty	Ownership	Personal relevance
Food chains		Openness Reactivity	Awareness Emotionality Mood Openness Reactivity		Awareness Emotionality Openness
Growing seeds part I	Activity level Awareness Independence Reactivity Sociability	Awareness Independence Reactivity	Awareness Independence Openness		
Growing seeds part II	Awareness Independence Openness	Awareness	Awareness Emotionality Mood Openness		Awareness
Computer research		Independence Openness		Emotionality Openness	Awareness
Walk in the woods	Activity level Emotionality Openness	Emotionality Openness	Activity level Awareness Mood Reactivity	Activity level Emotionality Independence Openness Sociability	

Workshop session	Affect	Autonomy	Challenge	Character identification	Computers/technology	Group work
Worm collection	Activity Level Emotionality Mood	Emotionality Independence Openness	Activity Level Emotionality Independence Mood Openness Reactivity			Activity Level Emotionality Independence Openness Sociability
Worm experiment I	Awareness Independence Openness	Awareness Independence Openness Sociability	Awareness Emotionality Independence Openness Reactivity			Awareness Emotionality Mood Reactivity Sociability
Worms II and dissection	Awareness Emotionality Independence Openness Reactivity	Independence Openness	Awareness Emotionality Independence Openness Reactivity	Emotionality Openness		Emotionality Independence Sociability
Models	Activity Level Independence Reactivity Sociability		Awareness Independence Reactivity			Activity Level Emotionality Mood Reactivity Sociability
Dissecting crabs	Emotionality Independence Openness	Independence Openness				Emotionality Independence Mood Openness Reactivity Sociability
Skulls and skeletons	Emotionality Mood Openness		Awareness Mood Openness Reactivity Sociability			Awareness Independence Mood Reactivity Sociability
Making posters			Independence	Emotionality	Emotionality Sociability	Reactivity Sociability
Presenting posters			Independence Mood Sociability	Emotionality Sociability		Independence Sociability

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Table 6 (*continued*)

Workshop session	Hands-on activity	Instructional conversation	Novelty	Ownership	Personal relevance
Worm collection Worm Experiment I	Activity level Emotionality	Activity level Emotionality Independence Openness		Emotionality	
Worms II and dissection	Emotionality Independence Reactivity	Awareness Sociability	Awareness Independence Openness		Awareness
Models	Openness Reactivity		Emotionality Reactivity	Emotionality	Awareness Emotionality
Dissecting crabs	Activity level Independence Openness Sociability	Activity level Mood Reactivity			Awareness
Skulls and skeletons	Emotionality Independence Openness	Awareness Emotionality Openness			Awareness
Making posters	Emotionality Openness Reactivity		Awareness		Awareness
Presenting posters Worm collection		Sociability		Emotionality Emotionality	

Table 7
Learner characteristics by potential trigger, reported in percentages.

Potential trigger	Activity level	Awareness	Emotionality	Independence	Mood	Openness	Reactivity	Sociability
Affect (12)	42	50	***83***	42	58	***83***	42	25
Autonomy (10)		50	20	***100***		***100***		10
Challenge (12)	25	***75***	50	***75***	50	50	***83***	17
Character identification (10)		20	***80***	10		30		20
Computers; technology (4)	10	25	50	50		***75***	10	25
Group work (13)	31	23	54	*69*	46	31	*69*	***100***
Hands-on activity (12)	42	17	*67*	58		*67*	33	36
Instructional conversation (14)	29	43	21	21		43	36	36
Novelty (10)	10	***70***	50	30	30	40	30	
Ownership (7)			***100***	14	14	29		29
Personal relevance (9)		***100***	22	11		11	11	

Note: Values represent the percentage of the time each learner characteristic affected whether a potential trigger was maintained. Percentages were obtained by dividing the number of times a learner characteristic had an impact on the trigger by the total number of recorded instances of the trigger. Numbers in parentheses indicate number of recorded instances. For ease of viewing patterns in the data, percentages have been typeset as follows: numbers that are underlined are between 50% and 59%; numbers that are *underlined and italicized* are *between 60 and 69%*; and numbers that are ***underlined, bold, and italicized*** are ***at least 70%***. No value is reported if a learner characteristic was not recorded as occurring with a trigger.

when learners' emotionality (ability to become immersed in activity) is high; autonomy and challenge trigger interest that is maintained when learners' independence (conscientiousness, planfulness) is high; affect, challenge, and group work trigger interest that is maintained when learners' mood (feelings in the moment) is high; affect, autonomy, computers/technology trigger interest that is maintained when learners' openness (intellect and responsiveness to experience) is high; challenge is a trigger for interest that is maintained when learners' reactivity (adaptability) is high, and group work triggers interest that is maintained when learners' sociability (approach to and desire to be with other people) is high.

The strength and the weakness of this study is that it focuses on the triggering and maintaining of interest and leaner characteristics of all participants in a single biology workshop, which consisted of a relatively small group of youth with no prior formal training in science. Analyzed at the level of the group, study findings provide a set of systematically derived insights that have not been available previously. They also hold recommendations for subsequent study. It is essential for both interest theory and practice that research address how and whether potential triggers for interest among participants who are in the earliest phase of interest development generalize to learners in other phases of interest development. Present findings also point to the importance of studying triggers for interest in relation to learner characteristics. In addition, they underscore a need to clarify which learner characteristics are relevant to the possibilities for maintaining and further developing interest in different phases of interest development.

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Conflicts of interest

None.

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