Interpersonal Relationships and the Development of Student Interest in Science

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Abstract

This study explored how interpersonal relationships may affect the development of interest in science from college students' perspectives. Semi-structured interviews with 24 college students were conducted and analyzed. The findings indicated that interpersonal relationships could start and sustain students' interest in science; negative interpersonal relationships could cause students to lose interest in science. Four qualities were often associated with the interest-raising relationships: (1) The influential figure was perceived as having a positive relation with science. (2) The influential figure actively mediated the relation between the student and science. (3) The influential figure conveyed as well as created positive emotions about science when he or she did science with the student. (4) The influential figure and the student had a personal relationship characterized by caring, sharing, and/or launching. Interest-lowering relationships lacked these qualities. Implications for education and future research were discussed.

Key words: interest, science, interpersonal relationships, development, college students

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Introduction

A common goal shared by many science educators is to help students develop a genuine and long-lasting interest in science because interest has the potential to enhance the quality of learning (Ainley, Hidi, & Berndorff, 2002; Hidi, Renninger, & Krapp, 2004) and increase the likelihood that students will continue learning outside the classroom. Yet it is clear that many students are not interested in science and many who are interested in science lose their interest over time (Barmby, Kind, & Jones, 2008; Krapp & Prenzel, 2011). In order to foster and maintain student interest in science, how people's interest in science starts and develops needs to be understood. However, research on interest development is still "in its infancy" (Renninger & Su, 2012, p. 183). As Brophy (1999, 2004) pointed out, it is known that preexisting interest in a topic can lead to higher quality learning about the topic, but little is known about how to induce and nurture such interest if it is not already present (cf. Swarat, 2008).

Several scholars have suggested that an individual's interest in a particular domain could be affected by interactions with others who are interested in that domain (e.g., Csikszentmihalyi, 1988). Some empirical evidence also indicates that children's development of value/interest and career-related choices could be affected by the value/interest of others influential in their lives (Dabney, Chakraverty, & Tai, 2013; Eccles-Parsons, Adler, & Kaczala, 1982; Ferry, Fouad, & Smith, 2000; Jacobs & Bleeker, 2004). Bandura (1986) has proposed in his social cognitive theory that virtually all learning phenomena, resulting from direct experience, can occur vicariously by observing other people's behavior and its consequences for them. Therefore, it might be possible that a child could observe how others do science and acquire positive experiences in science and hence learn to like science. In other words, Csikszentmihalyi, Bandura, and empirical evidence all suggest that it is reasonable to hypothesize that through interaction with others who are interested in science, a child might internalize that interest and make it his or her own.

The above described hypothesis, however, does not explain one phenomenon. Every individual encounters many people with their own interests. An individual does not develop shared interests with all the people with whom he or she has interacted. This hypothesis does not explain the reasons that cause one's interests to be influenced by some people but not by others.

Deci and Ryan's self-determination theory carries the potential to explain why an individual does or does not develop an interest similar to another person's interest. The self-determination theory proposes that three basic psychological needs are intrinsic to the self --- the needs for competence, autonomy, and relatedness (Deci, 1992; Deci, Vallerand, Pelletier, & Ryan, 1991). It is hypothesized that social contexts that allow the satisfaction of these three basic needs will promote intrinsic motivation, internalization, and interest (Ryan & Deci, 2000; Ryan & Powelson, 1991; Ryan & Stiller, 1991). Since an individual forms different relationships with different people, it is possible that the qualities of these relationships mediate the extent to which the individual develops interests similar to other people's interests. Numerous studies have shown that competence-promoting information enhances interest, whereas competence-diminishing information undermines interest (e.g., Elliot et al., 2000; Harackiewicz, Abrahams, & Wageman, 1987). Empirical work has also shown that autonomy-supportive contexts tend to enhance interest, whereas controlling contexts tend to diminish interest (e.g., Black & Deci, 2000; Guay, Boggiano, & Vallerand, 2001).

Regarding relatedness, many studies have explored how various qualities of relatedness students experienced with respect to parents, teachers, and/or peers are associated with their school-related functioning, motivation, and affect (e.g., Decker, Dona, & Christenson, 2007; Furrer & Skinner, 2003; Hamre & Pianta, 2001; Harter, 1996; Johnson & Johnson, 2009; Murray & Greenberg, 2000; Riese, Samara, & Lillejord, 2012; Ryan & Patrick, 2001; Ryan, Stiller, & Lynch, 1994; Wentzel, 1997, Wentzel, Barry, & Caldwell, 2004). However, these studies mainly assessed general school-related constructs (e.g., school adjustment, academic motivation or engagement, achievement, self-esteem, school-related affect) rather than domain-specific interests. Although several studies have examined qualities of teacher-student relationships and domain-specific motivation and/or performance in a relatively short period of time (e.g., Bouchey & Harter, 2005; Goodenow, 1993; Lapointe, Legault, & Batiste, 2005), little research has directly addressed the relationship between "relatedness" and the development of relatively stable and enduring domain-specific interest in science. The present study was an empirical effort to explore the role of "relatedness" in mediating the development of domain-specific interest in science based on college students' perspectives. Specifically it addressed the following research questions using data from interviews conducted with 24 college students.

- From college students' perspectives, is the development of their interest (or lack of interest) in science affected by other people?
- What qualities of interpersonal relationships with the influential figures facilitate or hinder the development of their interest in science?

College students were chosen as the participants of this study because they were likely to have formed a relatively stable and enduring interest or lack of interest in science and have the ability to reflect on their experiences in thoughtful ways. Their reflections were also likely to reveal factors, possibly interpersonal relationships, in their experiences that had affected the development of their interest in science. The findings of this study should help science educators at all levels develop insights about ways to conceptualize and facilitate the development of student interest in science.

Conceptual Framework

Conceptualization of Science

In this study learning science was conceptualized as mastery of *a canon of knowledge* and *norms for participation* (Anderson, 1992). Mastering the canon of knowledge involves developing conceptual understanding of the accumulated knowledge in scientific communities; mastering the norms for participation involves learning ways that scientists use to generate knowledge, both individually and as social groups (Anderson, 1992).

A distinction was also made between science in school and science outside of school. Some students might not be very attentive during their science lessons or feel enthused about the science experiments they conduct in school, but they might read science books for their own interest or do experiments to figure out answers to their own questions outside of school.

Based on the distinctions discussed above, four aspects of student interest in science were explored in this study: (1) interest in learning science facts and concepts in school (e.g., listening to lectures or reading textbooks about various science topics), (2) interest in learning science facts and concepts outside of school (e.g., reading science magazines or watching TV programs about cancer, polymers, outer space, animals and plants), (3) interest in trying to figure out scientific knowledge in school (e.g., doing experiments, having discussions in school about science topics) and (4) interest in trying to figure out scientific knowledge outside of school (e.g., trying to understand the process of baking by varying temperature or ingredients and analyzing the results, trying to understand the function of a car, a watch, or a sewing machine by manipulating it in various ways, participating in discussion about science topics with friends or family members).

Conceptualization of Interest

Although most investigators acknowledge that interest occurs in a person-activity interaction, researchers often focus on one of the two components. One body of research concentrates more on the characteristics of learning activities that capture the interest of many individuals (*situational interest*); the other body of research emphasizes variations in *individual interest* (people's relatively enduring preference for certain topics or activities) (Hidi, 2006; Hidi & Harackiewicz, 2000; Palmer, 2009). For the purpose of this study, the development of individual interest in science was chosen as the central focus, because individual interest in science is the aim to be fostered in our students for their life-long science learning. Individual interest in science was conceptualized as a relatively stable and enduring preference toward learning science either for an intrinsic reason (i.e., enjoying the activity itself) (Csikszentmihalyi, 1990; Lepper & Hodell, 1989) or for a self-determined instrumental reason (i.e., the activity leading to something the person truly values, rather than being coerced to value) (Deci & Ryan, 1991, 2000).

It is important to point out that in this conceptual framework, interest is not necessarily manifested through a career choice. Although important work has been done to study reasons that cause students to switch from science-related majors to non-science-related majors (Seymour, 1992, 1995; Seymour & Hewitt, 1997; Tobias, 1990), it is not clear whether the reasons that account for switching majors do influence students' interest in science as conceptualized in this study. A non-science major can still be very interested in science and use leisure time to read science magazines, watch the Discovery Channel, or figure out how a toaster works. Since a common goal among science educators is to help all students, not merely science majors, to develop their interest in science so they will continue learning science outside of academic settings and become scientifically literate citizens, this study did not directly build on the research that investigated issues related to the loss of science majors; instead it strove to understand factors, particularly interpersonal relationships, to which college students attributed their interest or lack of interest in science irrespective of their career choices.

Conceptualization of Interpersonal Relationships

Most research on personal relationships is directed at one of three levels of analysis: individual, dyadic and systemic (Sarason, Sarason, & Pierce, 1995). At an individual level of analysis, a personal relationship can be defined in terms of a participant's perception of his or her relationship with another person. At a dyadic level of analysis, relationships are conceptualized primarily in terms of the social bond shared by two participants. A systemic level of analysis seeks to account for the links, not only between the two participants in a personal relationship, but also with others in the social network who influence and are influenced by members of the target dyad. The three levels can be viewed as mutually complementary rather than mutually exclusive. This study took an individual level of analysis based on the assumption that whether or how a certain relationship affects an individual's development of interest in science mainly depends on how this individual makes sense of that relationship and comes to shape his or her interest in the context of that relationship (Maehr, 1991).

The conceptualization of this perception of interpersonal relationship was mainly developed from Bowlby's attachment theory (Bowlby, 1973, 1980) and Baldwin's idea of relational schemas (Baldwin, 1992). In Bowlby's attachment theory, it is assumed that people actively organize and internalize their interactions with significant others. The mental representations of the organized and internalized interactions with significant others become the individuals' internal working models of their relationships. The internal working models of relationships shape an individual's sense of self and experience of subsequent interactions with the same significant others as well as with other people. In Baldwin's idea of relational schemas, these cognitive structures are hypothesized to include images of self and other, along with a script for an expected pattern of interaction. It is important to note that in this conceptualization, the images of self and other are images of *self and other in relation,* rather than *self and other in isolation*. The definition of the "self-with-other" construct proposed by Ogilvie and Ashmore (1991) illustrates the idea of *self and other in relation*. Ogilvie and Ashmore defined the "self-with-other" construct as a mental representation that includes the set of personal qualities (traits, feelings, and the like) that an individual believes characterizes his or her self when with a particular other person. In a similar way, one can define "other-with-self" as a mental representation that includes the set of personal qualities (traits, feelings, and the like) that an individual believes characterizes the other person when that other person is with this individual.

It seems reasonable to assume that students' interest in science should be shaped by their experiences of engagement with science activities. During these engagements, there are often other people (e.g., parents, science teachers, peers) involved. It was assumed that students form relational schemas with these people. Since relational schemas can shape one's sense of self (possibly including one's self-perception related to science) and subsequent interactions with other people (possibly including other people in science), it is worth examining whether a student's relational schemas affect development of interest in science, and if they do, how.

Methods

Participants and Recruitment

Twenty-four college students were recruited from a few undergraduate psychology courses through the subject pool established in a Midwestern university. All the research projects which were recruiting participants from the subject pool were posted for the students to volunteer. Students in the subject pool were encouraged to sign up for the research projects based on the project titles, restrictions for certain characteristics of the participants, the lengths of time required, and the schedules. The title of this project was posted as "understanding the development of student interest or lack of interest in science." The amount of time required for this project was one and a half hours. Various time slots were offered for potential participants to sign up. Each potential participant was also offered the opportunity to set a time with the author that would work. Students were given some extra credits in their psychology courses for their participation in these research projects. In general, two to five hours of participation in these research projects constituted about 5% of the final grade.

The participants were grouped based on self-reported interest in science. The author intended to recruit 12 participants (six male, six female) who identified themselves as interested in science and 12 (six male, six female) who identified themselves as uninterested in science. Once six participants were recruited for one of the four groups needed (male interested, male uninterested, female interested, female uninterested) the recruitment for that group was stopped. The recruitment continued until the intended four groups were filled. Science majors were not differentiated from non-science majors because it was assumed that interest in science explored in this study was not necessarily manifested through career choice. Thus the distinction was not important for the purpose of this study.

Interviews

A semi-structured interview protocol was developed for the study. Each interview started with several open-ended questions that asked the participant to talk about his or her view of science, major experiences in science, and the development of interest or lack of interest in science. These interview questions are described in detail in another article (Yang, 2010). Then the questions listed below were asked to further explore the origin and development of the participant's interest or lack of interest in science and the qualities of influential interpersonal relationships. It should be pointed out that the interview questions that directly asked the participants about people who have affected their interest in science were asked after the participants had been given opportunities to talk about any experience that had affected their interest in science. In this way the interview would not lead them only to talking about interpersonal relationships and ignoring other factors that might have affected the development of their interest in science.

- How did your interest in science start? (or Why did you never develop an interest in science? Or How did your "non-interest" start?)
- If you draw a curve to represent the development of your interest in science with time/age as the horizontal axis and the interest level in science as the vertical axis, what would your curve look like? Can you talk about the curve?
- Is there anything in your life that has affected your interest in science?
- How did that something affect you?
- Is there any person in your life who has affected your interest in science?
- Can you tell me a little more about the change of your interest in science as a result of interacting with that person?
- What did that person do to make you interested in science (or to lower your interest in science)? Can you give me an example?
- How would you describe your interaction with that person? Can you give me an example?
- How would you describe your relationship with that person?
- Can you come up with some adjectives to describe your relationship with that person?
- Do you think that your relationship with that person has anything to do with your interest in science? If yes, how?

During the interviews, probing questions were used to clarify the points the interviewees attempted to make. All the interviews were conducted in a quiet room, and were audio-recorded with the permission of the interviewees.

Data Analysis

Based on Glaser and Strauss' (1967) constant comparative method, three stages of qualitative analysis were conducted by the author.

(1) Formulating categories and comparing incidents applicable to each category

At this stage, all the transcripts were read and re-read thoroughly. Anything that was noticed as potentially interesting to follow up was recorded as a tentative category in a matrix. The matrix was formatted so that a row represented a single participant, and a column represents each tentative category. After all tentative categories were recorded in the matrix, each transcript was read once more to code evidence in this matrix. While coding an incident for a category, it was compared with the previous incidents in the same and different categories.

(2) Integrating categories and their properties
As coding proceeded, this constant comparison of the incidents generated theoretical properties of the category. As the coding continued, the constant comparative units changed from comparison of incident with incident to comparison of incident with properties of the category. Revisions of categories were made when two or more tentative categories could be combined into one integrated category that was conceptually more meaningful in terms of making contrasts among participants.

(3) Developing claims with relevant evidence organized around the claims
At the third stage, comparisons were made to examine whether any differential pattern existed between the interested group and the uninterested group, as well as between the interest-raising relationships and the interest-lowering relationships.

Results

The analysis of the findings followed the tradition of grounded theory to identify patterns that emerged from the data (Glaser & Strauss, 1967). Therefore, the findings reported might not correspond perfectly to the conceptual framework used for the design of the study. This choice was made consciously because the purpose of this study was to develop a deeper understanding of students' experiences and perceptions related to the research questions, not to impose the researcher's thinking on the participants.

The findings related to the nature of the participants' interest or lack of interest in science are discussed in another paper (Yang, 2010). The focus of this paper will be on the findings related to the interpersonal relationships that facilitated or hindered the development of student interest in science. All reported students' names are pseudonyms.

The Development of Interest in Science as Affected by Other People

All 12 participants in the interested group and seven participants in the uninterested group mentioned interest-raising influential figures in their interviews. The influential figures mentioned were science teachers (by 10 students in the interested group and three students in the uninterested group), parents or grandparents (by four students in the interested group and three students in the uninterested group), and siblings/cousins (by two students in the interested group and two students in the uninterested group). The influential figures were often described by the students as being interested in science, as practicing in a science-related field, as someone with a scientist's habit of mind, or someone who demonstrated that science could be useful or relevant to life.

Fourteen of the 19 interest-raising influential figures mentioned by the students in the interested group and seven of the eight mentioned by the students in the uninterested group were also described as having a good relationship with the student. Andrea's comments provided an example of a good relationship between the student and the influential figure.

Interviewer: Is there anything in your life that has affected your interest in science?

Andrea: That one genetics class I took in high school…I really liked the teacher....He was really interested in what we were doing, in our success and failure with fruit flies…He always asked us about them. He helped us with them. If we were frustrated, he reassured us.

Interviewer: How would you describe your relationship with this teacher?

Andrea: Really good and personal, because we went on the wilderness trip. He was with us…We were addressing him on a first name basis. We were like friends…because we had spent a lot of time together…

Three students (one male, two female) in the uninterested group mentioned interest-lowering experiences that involved negative relationships with science teachers. Since some students in the uninterested group also reported interest-raising relationships, the data suggested that it was not that the students in the uninterested group completely lacked interest-raising experience in their lives; it was quite possible that their interest-lowering experiences outweighed their interest-raising experiences. Edna's experiences illustrated how some of her teachers lowered her interest in science through relationships that Edna described as "bitter."

Interviewer: Is there any person in your life who has affected your interest in science negatively?

Edna: Just teachers. The way they teach it… Basically it's like they are told what they have to teach for this class, and they go over that. There is no like, "Well, I know this is interesting," like interesting facts at the beginning of the class, like "Do you know what's happening outside?" It's just like, "We are here. We are going to do our job, and we are going home."

Interviewer: How would you describe your interactions with those teachers?

Edna: Bitter, very bitter.

Interviewer: Why?

Edna: …They know it's boring because half of the class was asleep, talking, or distracted, but they just keep on going. Listen or not, I just want to hurry up. They just got the attitude that I want to finish this hour of class and just go home.

Qualities Associated with Interest-Raising Relationships and Interest-Lowering Relationships

During the interviews, 19 students (six male interested, six female interested, three male uninterested, four female uninterested) of a total of 24 mentioned one or a few interest-raising experience(s) in which at least one heavily involved person(s) could be identified. Four students (one male interested, one male uninterested, two female uninterested) mentioned interest-lowering experiences which involved (an) influential figure(s). The total number of interest-raising relationships mentioned was 27. The total number of interest-lowering relationships mentioned was four. The analysis of all the interest-raising and interest-lowering relationships revealed that four kinds of information about these relationships were mentioned by the participants: (a) how the participants perceived the relation between this influential figure and science, (b) how they perceived the ways the influential figure mediated the relation between science and themselves, (c) what emotions/motivations were conveyed and/or created between the influential figure and the participants while they were engaged in science-related activities, and (d) how they perceived the personal aspect of the relationship between the influential figure and themselves.

The reason why the four kinds of information were treated as information about a relationship came from Baldwin's idea of relational schema (1992). As discussed earlier, according to Baldwin, a student's perception of his or her relationship with an influential figure should contain three components: how the student perceives the influential figure (other-with-self), how the student perceives the ways the influential figure perceives the student (self-with-other), how the student perceives the pattern of interaction between the influential figure and the student. The first kind of information described in the previous paragraph would be important when we try to understand how the student perceived the influential figure. The second and third kinds of information described in the previous paragraph were primarily about patterns of interaction. The fourth kind of information was about certain patterns of interaction with strong implications about how the influential figure perceived the student. The meaning of each kind of information will be further revealed as the findings with regard to each category are discussed.

Relation between the influential figure and science. In interest-raising relationships, the influential figures were often perceived by the students as having a positive relation with science. They were described as being engaged in science at the behavioral level, the cognitive level, and/or the motivational level (cf. Fredricks, Blumenfeld, & Paris, 2004).

The most commonly mentioned behavioral engagement with science of the influential figure was practicing or learning in a science-related field. Twenty-two of the 27 interest-raising figures were described as practicing in a science-related field. Seven interest-raising figures were described as knowledgeable or smart in science. This description reflected the student's perception of the influential figure's cognitive engagement with science. Five interest-raising figures were described as interested in or curious about science. This description reflected the motivational engagement with science of this person.

A different pattern existed in the four interest-lowering relationships with regard to the relation between the influential figure and science. Although the four interest-lowering influential figures all practiced in a science-related field, no participant mentioned their positive cognitive or motivational engagement in science. In fact, some negative sides of cognitive and motivational aspects were mentioned about one interest-lowering influential figure. When Mark talked about why he was not interested in science before he came to the university, he mentioned that his high school teachers were not knowledgeable about science, did not seem to care about science, and how that lowered his interest in science.

How the influential figure mediated a relation between science and the student. Twenty-one of the 27 interest-raising influential figures were described as having done something to mediate the relation between science and the student. The things done by the influential figures to promote a relation between science and the student were categorized into three categories: (a) pointing out how science can be meaningful and/or interesting to the student, (b) helping the student experience science through first-hand experiences, and (c) helpfully responding to the student's desire of wanting to know more (Table 1).

Table 1. How the influential figure mediated the relation between the student and science.

Name	Gender/ Interest	Influential figure	Pointed out how science could be meaningful and interesting to me	Helped me experience science through seeing, touching, etc.	Responded to my desire of wanting to know in helpful ways
Adam	MI	Father		x	x
		Grandfather	x	x	
		Sci. T		x	x
Charles	MI	HS Physics T			
		Sister	x		
Mark	MI	College Prof	x		
Richard	MI	Father			
Simon	MI	HS biology T.		x	x
Tom	MI	Father	x	x	x
		MS& HS T		x	x
Amelia	FI	HS biology T		x	x
		Mother			
Andrea	FI	HS genetics T	x	x	x
Linda	FI	HS biology T	x	x	x
Melissa	FI	Surgeon			
Rebecca	FI	ES Sci T	x		
		Brother	x		
Sarah	FI	MS Sci T		x	
		HS Sci T	x	x	x
Brice	MU				
Bert	MU				
Derek	MU	Mother		x	x
David	MU				
John	MU	Father			
Martin	MU	Sci T		x	x
Anna	FU	Brother	x		x
Angela	FU				
Edna	FU	Cousin	x	x	x
		HS astronomy T	x	x	
Elza	FU	HS physics T	x	x	
Julie	FU	Mother			
Theresa	FU				

Note. MI = male interested; MU = male uninterested; FI = female interested; FU = female uninterested; HS = High School; MS = Middle School; ES = Elementary School; Sci = Science; T = Teacher(s); Prof = Professor(s).

Pointing out how science can be meaningful and/or interesting to the student. Thirteen interest-raising influential figures were mentioned as either pointing out or helping the students to experience how science could be meaningful or interesting to them. Mark's experience with his psychology professor provided an example.

Interviewer: Is there any person who has affected your interest in science?
Mark: My psychology professor right now…He makes everything easier to learn. He uses a lot of examples that apply to my daily life...He just talked about the effects of alcohol the other day. It just relates to me because my friends really like alcohol. It makes me think about it all the time.

Helping the student experience science through first-hand experience. Sixteen interest-raising influential figures were described by the students as having done something to help the student obtain first-hand experiences in science. Simon's experience with his high school biology teacher provided an example.

Interviewer: Is there any person in you life who has affected your interest in science?
Simon: …my high school freshman biology teacher…We did dissections. She helped us to work with frogs and lab hearts...We measured openings of skulls. She gets you involved…

Helpfully responding to the student's desire of wanting to know more. Thirteen interest-raising influential figures were mentioned as responding helpfully to the student's desire of wanting to know more. Derek's description of his mother provided an example.

Interviewer: Is there any person in your life who has affected your interest in science?
Derek: Probably my mom…just by taking me to places, like museums, science centers. I guess I go to her first to ask her. I probably know more science than she does, but I wouldn't be afraid of asking her: "How does this work?" "How does that work?" "How does the radio work?" "Help me collect some leaves." "Show me what poison ivy is."

Later on during the interview…

Derek: Whatever book I wanted she would be willing to get for me. She would be willing to answer the questions. She would be patient with me. She stayed up late to watch whatever is on NOVA, Mr. Wizard.

No one mentioned in the four interest-lowering relationships any of these three positive aspects. Opposite to interest-raising relationships, two figures were described as "not providing help when the students needed it."

Emotions/Motivations conveyed and/or created between the influential figure and the student. The only frequently mentioned emotion conveyed by the interest-raising influential figures while doing science together with the students was the feeling of enthusiasm for helping the student learn and/or appreciate science. The most frequently mentioned emotion that was created in the student was the sense of wonder or amazement about science. The most important motivation conveyed or created between the interest-raising influential figure and the student was the motivation to reach a higher standard, to figure out, and to know more.

Ten of the 27 interest-raising influential figures were felt by the students as “wanting the student to learn” due to the various ways they helped the students. Charles emphasized how his physics teacher wanted them to truly understand what they were learning, and be able to apply what they learned to their lives.

Interviewer: Can you tell me some of your major experiences with science?

Charles: …My physics class in high school. I liked it. It was challenging. I went to a Catholic school. An old priest was our teacher. He wanted you to learn from the course. It’s not only memorizing theories, but being able to apply them to things in your life, like how sound waves travel in the air so we hear things the way we do.

The sense of amazement or wonder was mentioned in episodes with five interest-raising influential figures. Edna’s feeling towards astronomy provided one example.

Interviewer: Can you tell me something that interests you a lot?

Edna: Astronomy.

Interviewer: Why is that interesting?

Edna: It’s just something that no matter how hard they are trying to rub their brains to find out what’s really going on, we just don’t know. We are always wondering… “Is there life on Mars.”…It’s just so mysterious…I had a really good astronomy teacher. I think that’s what really made me get into it…He was just like “You know, it’s just so interesting. There is so much stuff that we don’t know. The moon, the volcanoes, how do they get there, …” Just stuff like that. It was just really interesting.

Five students mentioned how the interest-raising influential figure challenged him or her to reach a higher standard, to figure out and to learn more. Richard’s interactions with his father provided an example. Richard described how his father’s questioning attitude affected his own thinking, so it developed toward being more like a scientist’s thinking.

Richard: I think another reason why I see my life as being so highly believing in science is because when I was a kid I used to say things that I heard, like “Dad, I heard that this and this happened.” My dad would say, “How do you know that happened for sure?” He would just ask me that question. I would say, “That’s what somebody said.” He would say, “How do you know if that person was true with you? How do you know what you read is true? You can’t believe everything you read or you hear or you see.”…I think because of him saying that to me, it more and more made me progress toward being a little bit more concise in stating the things I believe and the things I actually take to be true.

According to Richard, although his father’s questioning attitude had frustrated him for several years, it also helped him to mature in his scientific thinking. One could tell this constituted an important part of his life from his other comments such as “My girlfriend tells me that I treat everything in my life like a scientific project.” “A lot of time I am just very inquisitive. I will try things and see what happens.”

Once again, no one mentioned any positive aspects regarding emotions and motivations in the four interest-lowering relationships. The descriptions of two interest-lowering figures were strongly characterized by a lack of enthusiasm.

Personal aspects of interpersonal relationships between the influential figures and the students. The analysis revealed that many relationships between the interest-raising influential figure and the student had all or part of the following three qualities: (a) caring, (b) sharing, and (c) launching (Table 2). A caring relationship is a relationship in which the influential figure makes the student receive the message “This person cares about me. Therefore, I am important.” A sharing relationship is a relationship in which the influential figure and the student likes to do things together, and to reveal themselves to each other. A launching relationship is a relationship in which the student receives a message “This person sees my potential. Therefore, I can do better than I am doing.”

The quality of caring. Twenty of the total 27 episodes with interest-raising influential figures were identified as possessing the quality of a caring relationship. One student did describe his interest-lowering teachers as “not enthusiastic” and “boring,” but “cared and provided support when the students had questions.” The other three interest-lowering relationships lacked a caring quality. Linda’s description of her high school biology teacher offered an example of a caring relationship.

Linda: My freshman year in high school, I had biology…I had a great teacher…We had a lot of opportunities to have our questions answered. If we were confused, he would give reviews…If you had any questions, you could always ask him…He went out of his way to make sure we understand everything.

Interviewer: Went out of his way?

Linda: Like the review sessions. We had some for the final. We had reviews at 8:00 in the morning. I am sure he had better things to do that day.

The quality of sharing. Sixteen of the total 27 episodes with interest-raising influential figures possessed an element of sharing; none of the interest-lowering relationships possessed this quality. Some of the shared experiences were about science, while many others were about various aspects of their lives. Sarah talked about how the influential biology teacher shared certain experiences with her outside of biology, and how she knew that this teacher wanted to do fun things with the students.

Interviewer: Can you tell me a little bit more about your interaction with this teacher?

Sarah: She was the mentor for this RC club. I was the president of that club, so I talked to her more. It was a club for students who played RC sports, like soccer or football. They come together and do fun things. She liked doing that. That was fun, being able to talk to her other than science….I know she liked her students…I know she wanted to do fun things with us.

The quality of launching. In seven of the total 27 interest-raising relationships, the influential figure conveyed a message to the student about the potential of the student - a potential that pointed to a higher level, which the influential figure believed the student could reach, although the student had not reached that level yet. None of the interest-lowering relationships contained this component. Simon talked about how his high school biology teacher helped him see how he could be a better student, and out of that experience, he became a better student and more interested in science.

Interviewer: Can you come up with some adjectives to describe your high school biology teacher?

Simon: Challenging. She makes you work…She has high expectations. You will have to meet them. If you don't meet them, switch out or fail.

Interviewer: Can you describe your relationship with her?

Simon: Interesting. I am one of those people who don't like to do homework. She explained to me that I couldn't do that and pass the class. She helped me to raise my conscience as a student…

Interviewer: Do you think your relationship with this teacher influenced your interest in science?

Simon: I think so. I was interested before. After her class, I learned a lot more about biology. I became a better student. I learned that I had to do certain homework to be able to be accomplished in any field, and that class definitely helped me be interested in science…

Table 2. Personal aspects of interest-raising relationships.

Name	Gender/ Interest	Influential figure	Caring	Sharing	Launching
Adam	MI	Father	x	x	
		Grandfather		x	
		Sci T	x	x	
Charles	MI	HS Physics T			x
		Sister	x	x	
Mark	MI	College Prof			
Richard	MI	Father			x
Simon	MI	HS biology T	x		x
Tom	MI	Father	x	x	
		MS & HS T	x		
Amelia	FI	HS biology T	x		
		Mother		x	
Andrea	FI	HS genetics T	x	x	x
Linda	FI	HS biology T	x	x	
Melissa	FI	Surgeon	x		
Rebecca	FI	Elem Sci T			
		Brother	x	x	
Sarah	FI	MS Sci T	x	x	x
		HS Sci T	x	x	
Brice	MU				

Bert	MU				
Derek	MU	Mother	x	x	
David	MU				
John	MU	Father	x	x	x
Martin	MU	Sci. T	x		
Anna	FU	Brother	x	x	
Angela	FU				
Edna	FU	Cousin	x	x	
		HS astronomy T	x		
Elza	FU	HS physics T			
Julie	FU	Mother	x	x	x
Theresa	FU				

Note. MI = male interested; MU = male uninterested; FI = female interested; FU = female uninterested; HS = High School; MS = Middle School; ES = Elementary School; Sci = Science; T = Teacher(s).

Discussion

The findings of this study indicated that from many college students' perspectives, influential figures affected the development of their interest in science. The findings also revealed characteristics associated with interest-raising and interest-lowering relationships. These characteristics of interest-raising relationships were fairly consistent with the characteristics of caring science teachers found by Sickle and Spector (1996) and the engaging pedagogy described by students (Darby, 2005), although Sickle and Spector's and Darby's studies did not directly address the effect of the caring and engaging science teachers on the development of their students' interest in science.

Several previous studies found an association between interpersonal relationships and student interest in a related domain within a relatively short period of time. For example, Midgley and her colleagues found that when students moved from elementary teachers they perceived to be low in support to junior high teachers they perceived to be high in support, the intrinsic value of math was enhanced, while students who moved from teachers they perceived to be high in support to teachers they perceived to be low in support experienced a sharp decline in both the intrinsic value and perceived usefulness and importance of math (Midgley, Feldlaufer, & Eccles, 1989). Goodenow (1993) reported that early adolescent student-perceived teacher support explained over one third of students' assessment of the interest, importance, and value of the academic work of that class. Basu and Calabrese Barton (2007) found that when the science learning environments were shaped by how students value relationships, youth developed a sustained interest in science. Patrick, Mantzicopoulos, Samarapungavan, and French (2008) found that kindergarten students' motivation in science was positively related to children's reports of qualities of their relationship with their teacher. The present study, taking a retrospective approach, further strengthened the assertion that from the students' perspectives, interpersonal relationships could constitute an influential factor for the development of relatively long-term domain-specific interest in science.

The findings of this study also provided empirical evidence to support Goodenow (1993) and Wentzel's (1997) argument that models of motivation based on psychological or instructional variables should be extended to include the students' perceptions of relationships with others. This insight is particularly important in the effort of addressing gender and racial/ethnic science achievement gaps, promoting equal participation in science, technology, engineering, and math (STEM) fields, and providing sufficient qualified science teachers for secondary school students. Findings from nationally representative data in the United States indicated that the African American-Caucasian science achievement gap, approximately -1.07 SD, did not change from Grade 3 to Grade 8, and the female-male gap, approximately -0.23 SD, only narrowed slightly by eighth grade (Quinn & Cooc, 2015). Less than 50% of the students who entered college with the aspiration to earn a Bachelor's degree in STEM obtained the degree within six years, and the percentages were alarmingly low among Latino, African American, and Native American aspirants (Hurtado, 2015). The United States also faces the challenge of supplying sufficient qualified science teachers for secondary school students (Ingersoll & Perda, 2010; U.S. Department of Education Office of Postsecondary Education, 2013). Many factors are involved in these challenges; student interest in science is an important one among them. Teacher education programs for pre-service science teachers and professional development workshops for in-service science teachers and higher education science faculty should raise educators' attention to the effects of teacher-student relationships on students' interest in science and in becoming science teachers.

Given the assertion that positive interpersonal relationships facilitate the development of student interest in science, one observation in this study remained puzzling: many students who had some interest-raising experiences/relationships in science still identified themselves as being "uninterested in science." Two issues related to this puzzle are worth a closer look. First, the dualistic conceptualization of people as being either interested or uninterested in science needs to be re-considered. This study started with such a dualistic conceptualization, which led to the design of the four groups (male interested, female interested, male uninterested, female uninterested) used in the study. Yet the findings of the study have revealed that interest in science is a much richer construct than what can be captured in this dualistic view. Many people who belonged to the uninterested group were actually quite interested in some areas of science in some contexts (Yang, 2010). In other words, even though one person belongs to the uninterested group in general, it does not necessarily mean that his or her interest in science is non-existent. As directly mentioned by some participants, their current existing interest, even though it might not be as strong or as broad as that of someone else who is strongly interested in science, comes as a result of early interest-raising experiences/relationships. Therefore, the fact that many people who had interest-raising relationships ended up in the uninterested group does not necessarily mean that these relationships were not important. Quite the opposite, without them, these people's current interest could have been even lower than what was reported in the study (Yang, 2010).

Second, some students said that they thought a particularly good interest-raising experience could have been an exception. They believed most other science courses/teachers would be dry and hard. In other words, one or a few interest-raising experiences/relationships might not be enough when the overall image of science and people in science was interest-lowering. It would be sensible to pursue a future study that aims at assessing not only the student's interest-raising experiences and interest-lowering experiences as separate events, but also the student's overall schema about science, people in science, and his or her perceived self in regard to science.

The method by which the participants were recruited may be one limitation of this study. The participants were 24 college students taking certain psychology courses. They might have shared certain common interests; various reasons might also have affected their motivation to participate in this study. Some detailed characteristics of the participants (e.g., their motivation to take the psychology course, the science courses they had taken, their science GPA and self-efficacy in science) were not collected at the time of the study. Therefore, one cannot claim that the group recruited was an unbiased subgroup of the university student population. At the same time, it is important to point out that the intention of this study was not to recruit a large and representative sample of any population in order to establish generalizable findings for that population; it was to understand how interpersonal relationships might affect the development of some college students' interest or lack of interest in science from their own perspective. The results of the study could be generalized to a theory through analytical generalization (Firestone, 1993). According to Firestone, "to generalize to a theory is to provide evidence that supports (but does not definitively prove) that theory" (Firestone, 1993, p. 17). Through analytical generalization, the findings of this study, taken together with findings related to the same issues obtained in other contexts, will contribute to the developing of a theory, identifying the scope of the theory, and establishing the generalizability of the theory. Through analytical generalization each reader of the article could also assess the findings' applicability to his or her teaching situation and find their usefulness.

The reliance of this study only on retrospective self-reports of interest without triangulation by other measurements may be another limitation. Although it is reasonable to assume that a student could develop an interest in science because he or she had a good relationship with an influential person who was also interested in science, it is also possible that the student's retrospective perception of the quality of the relationship was itself influenced by his or her experience of similarity with the "influential" person. In order to address this concern and further explore the effect of interpersonal relationships on the development of student interest in science, it is important to study the related phenomena in classrooms as they occur (Urdan & Schoenfelder, 2006; Urdan & Turner, 2005). Following this line of thinking, the following questions are proposed for future studies:

(1) In what ways are the interest-raising components mentioned in this study present in teacher-student relationships in science classrooms?
(2) When these interest-raising components are practiced by the science teachers as they interact with their students, is there an increase in their students' interest in science?
(3) It seems that not all students of a teacher with optimal interest-raising characteristics would become strongly interested in science. What are the reasons to account for the individual differences in students' response to the optimal interest-raising characteristics?

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